

Nov. 19, 1940.

H. SWANSON

2,222,093

PIN HEAD ELECTRIC LAMP AND METHOD OF MANUFACTURE

Filed April 18, 1940

6 Sheets-Sheet 1

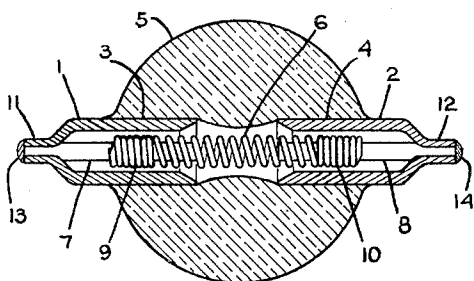


Fig. 1

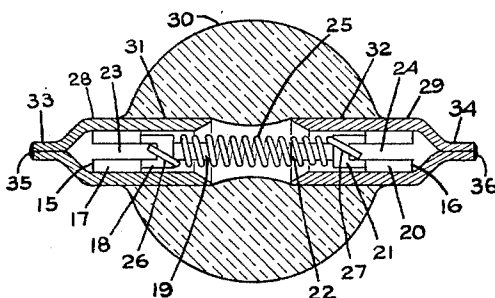


Fig. 2

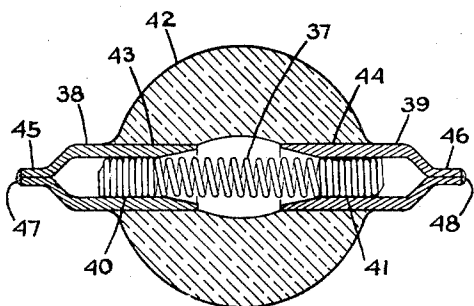


Fig. 3

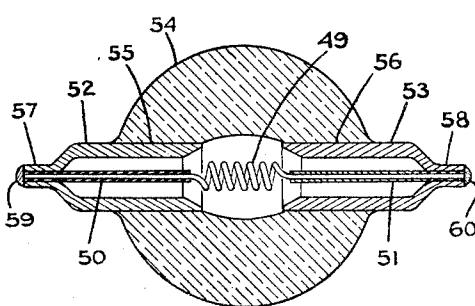


Fig. 4

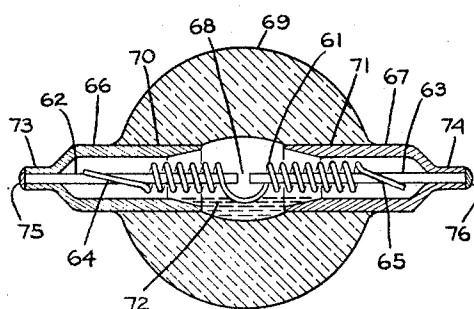


Fig. 5

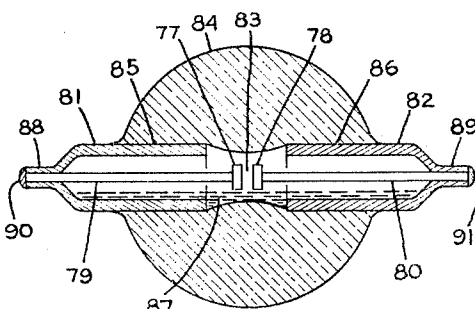


Fig. 6

Witnesses:

Gustave W. Hilston
Florence Hilston

Inventor

Harold Swanson

Nov. 19, 1940.

H. SWANSON

2,222,093

PIN HEAD ELECTRIC LAMP AND METHOD OF MANUFACTURE

Filed April 18, 1940

6 Sheets-Sheet 2

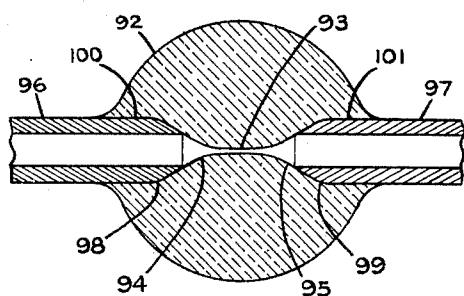


Fig. 7

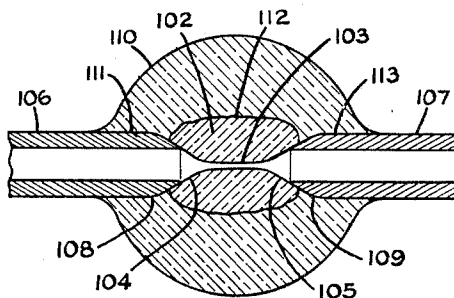


Fig. 8

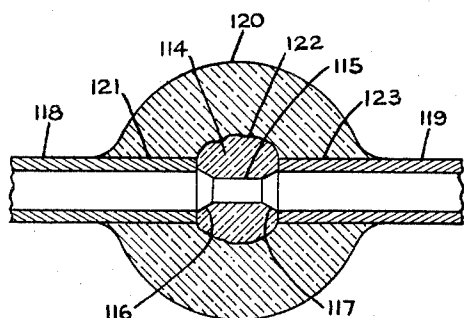


Fig. 9

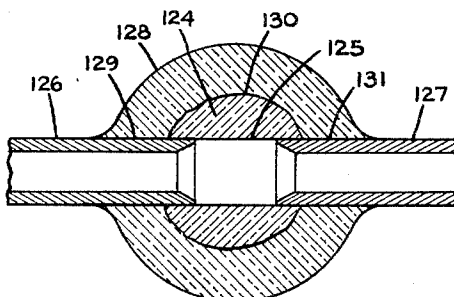


Fig. 10

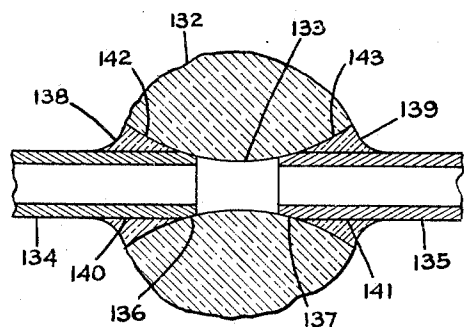


Fig. 11

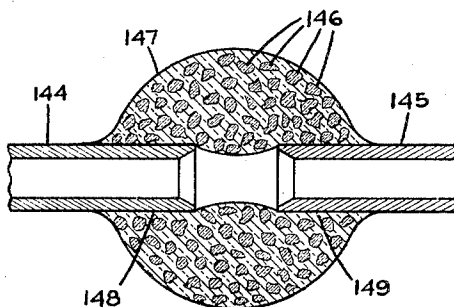


Fig. 12

Witnesses:

Gustave W. Hilston
Florence Hilston

Inventor

Harold Swanson

Nov. 19, 1940.

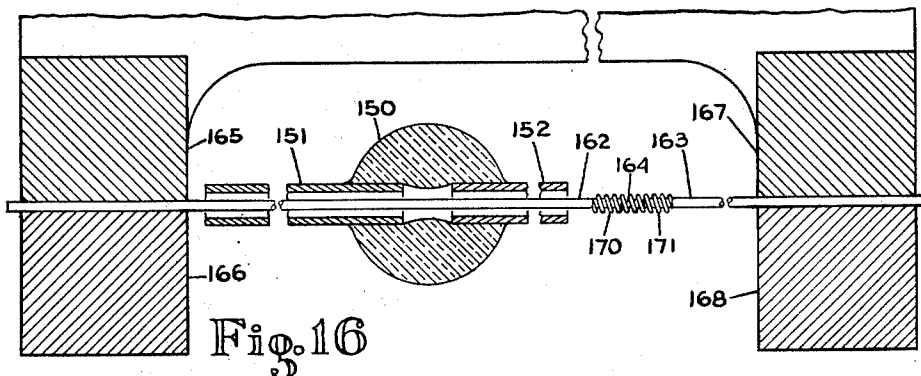
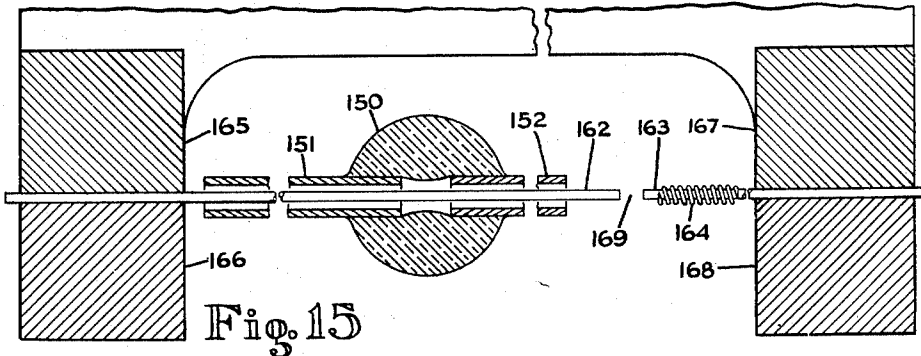
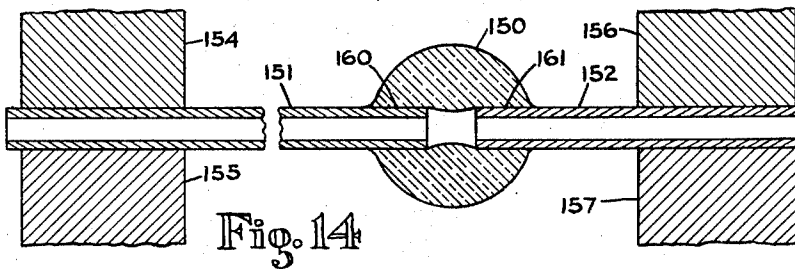
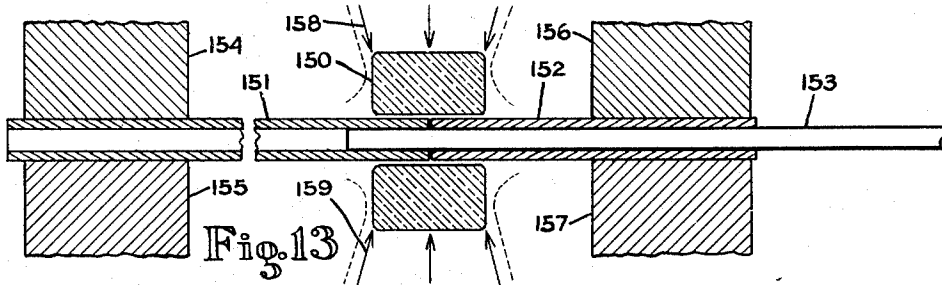
H. SWANSON

2,222,093

PIN HEAD ELECTRIC LAMP AND METHOD OF MANUFACTURE

Filed April 18, 1940

6 Sheets-Sheet 3



Witnesses:

Gustave W. Hilston
Florence Hilston

Inventor

Harold Swanson

Nov. 19, 1940.

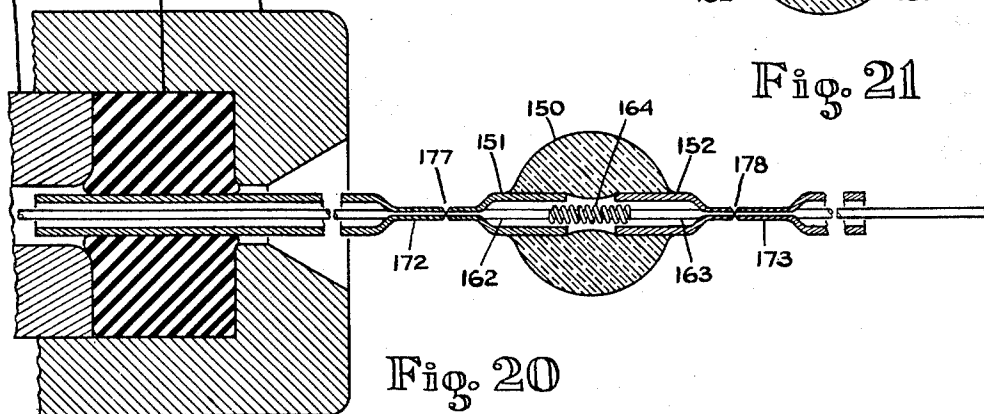
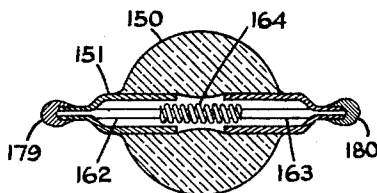
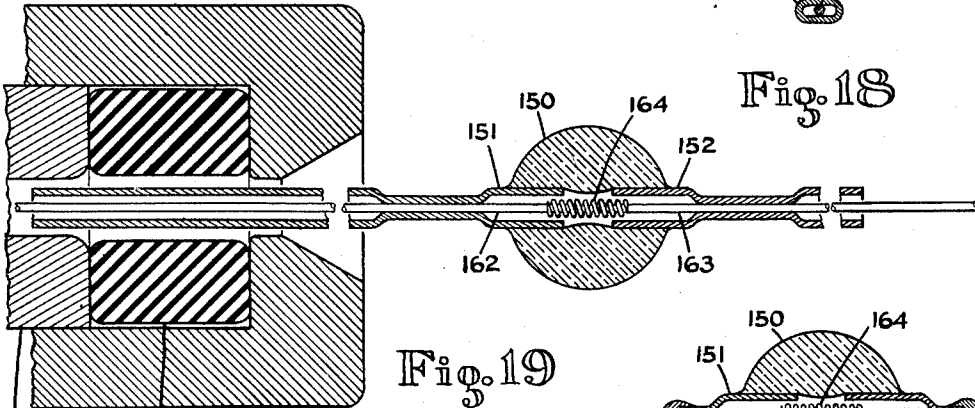
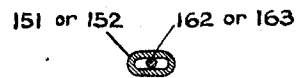
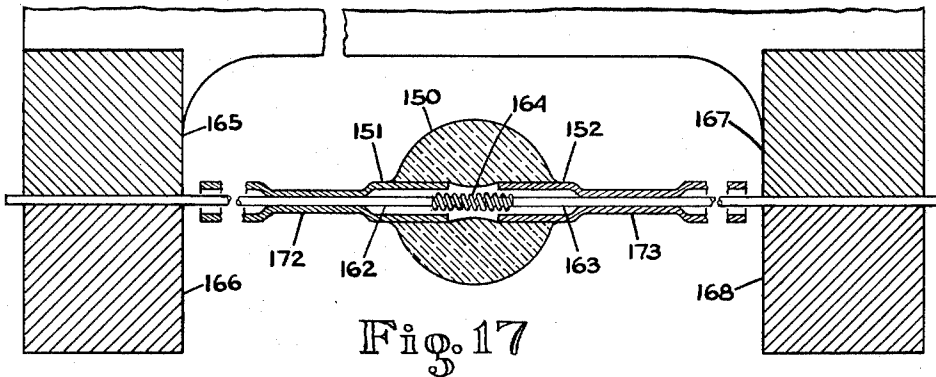
H. SWANSON

2,222,093

PIN HEAD ELECTRIC LAMP AND METHOD OF MANUFACTURE

Filed April 18, 1940

6 Sheets-Sheet 4



Witnesses:

Gustave W. Hilston
Florence Hilston

Inventor

Harold Swanson

Nov. 19, 1940.

H. SWANSON

2,222,093

PIN HEAD ELECTRIC LAMP AND METHOD OF MANUFACTURE

Filed April 18, 1940

6 Sheets-Sheet 5

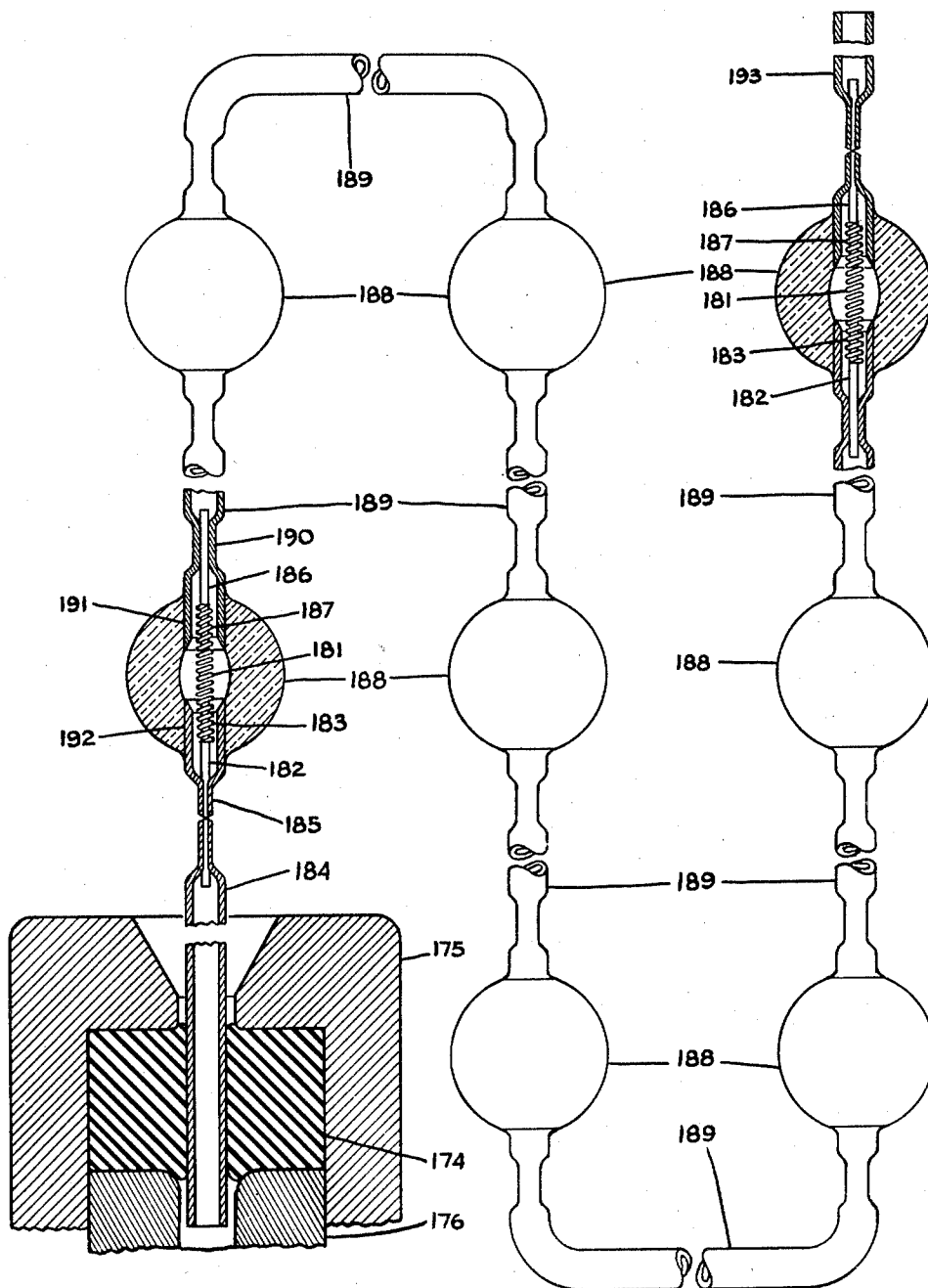


Fig. 22

Witnesses:

Witnesses:
Gustave W Hilston
Florence Hilston

Inventor

Inventor
Harold Simon

Nov. 19, 1940.

H. SWANSON

2,222,093

PIN HEAD ELECTRIC LAMP AND METHOD OF MANUFACTURE

Filed April 18, 1940

6 Sheets-Sheet 6

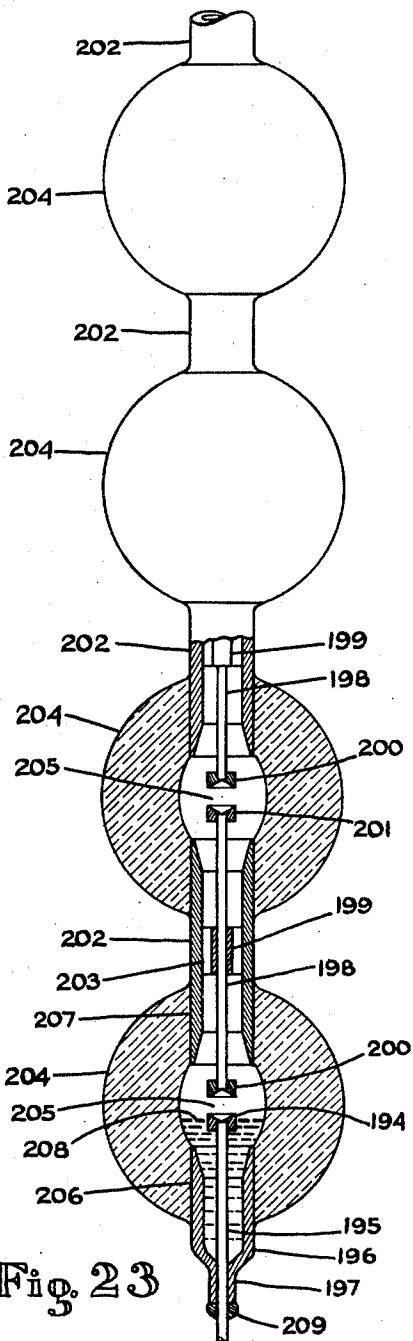


Fig. 23

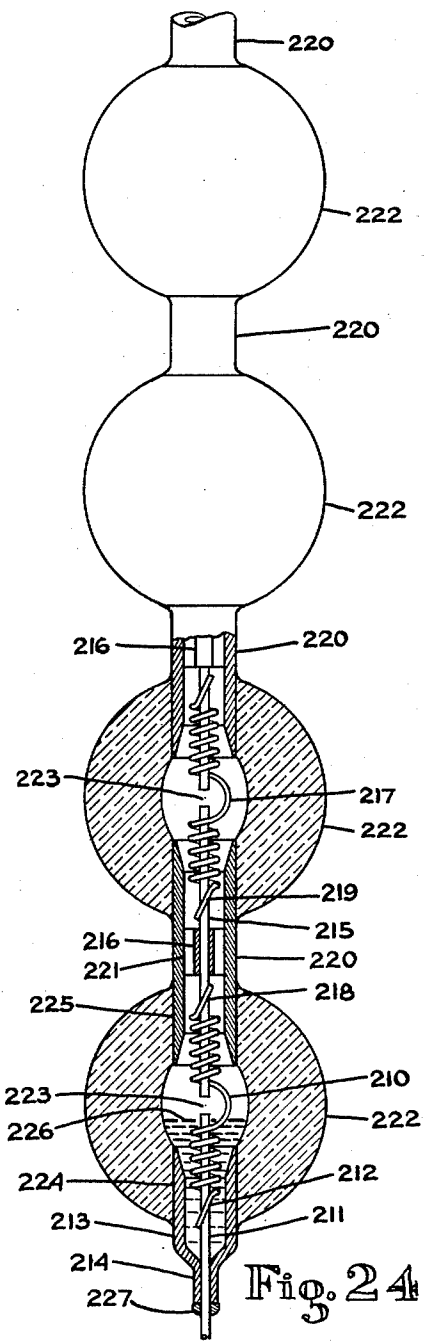


Fig. 24

Witnesses:

Kustave W. Nilston
Florence Nilston

Inventor

Harold Swanson

UNITED STATES PATENT OFFICE

2,222,093

PIN-HEAD ELECTRIC LAMP AND METHOD
OF MANUFACTURE

Harold Swanson, Cleveland, Ohio

Application April 18, 1940, Serial No. 330,247

17 Claims. (Cl. 176—16)

This invention relates to improvements to construct extremely small electric lamps and similar articles.

One object of this invention is to show a practical means of constructing an electric lamp and similar articles that compares in size with the dimensions of the head of a common household or clothing pin.

A further object is to show that the improvements set forth in my original application, Serial Number 744,598, filed Sept. 18, 1934, now a patent for an electric incandescent high pressure gas lamp, Patent Number 2,097,679, patented Nov. 2, 1937, and continued in application, Serial Number 166,347, filed Sept. 29, 1937, Patent Number 2,137,732, patented Nov. 22, 1938, and also continued in application, Serial Number 190,615, filed Feb. 15, 1938, Patent Number 2,154,542, patented April 18, 1939, are adaptable to make extremely small electric lamps and similar articles.

A further object is that this invention shall be a continuation of my earlier inventions mentioned in the preceding paragraph, in respect to where any improvements or subject matter of my earlier inventions can be used to an advantage with the improvements of this invention, particularly the use of hollow metal wires and their many features which are described in the previous applications or patents and in this application.

A further object is that the small electric lamps described herein can be substituted for the small electric lamps as mounted and described in the applications and patents referred to in the two preceding paragraphs.

A further object is to show that by using the improvements described herein, it is possible to build electric lamps that will be smaller as to minuteness than any electric lamp which is constructed by previously known means; therefore these small electric lamps which I choose to call herein pin-head electric lamps, might be appropriately called the smallest lamps in the world.

A further object is that these pin-head electric lamps can be constructed as; electric incandescent lamps of vacuum, low pressure gas, or high pressure gas types; electric metallic vapor filament type lamps; electric metallic vapor arc lamps of the low pressure or the high pressure types; electric glow lamps of the low pressure gas or the high pressure gas types.

Other objects of this invention will appear more fully described and illustrated hereinafter.

While it is practical to adapt the improvements of this invention to a large variety of small

electric lamps, the present Patent Office regulations restrict the claims that are allowed in a single patent which illustrates more than three types. In the accompanying drawings I have illustrated several types to show that I have not overlooked the possibility of many variations in types of lamps to apply these improvements; however in the drawings, several features are common with those types illustrated by the following in which:

Fig. 1 to Fig. 6 are enlarged sectional views of individual pin-head electric lamps.

Fig. 7 to Fig. 12 are enlarged sectional views of the bulbs for pin-head electric lamps.

Fig. 13 to Fig. 21 are enlarged sectional views of the progressive operations in constructing one of the individual pin-head lamps.

Fig. 22 is an enlarged sectional and elevational view of a multiple string of pinhead electric lamps arranged in position for exhausting, filling and final sealing.

Fig. 23 and Fig. 24 are enlarged sectional and elevational views of multiple strings of pin-head electric lamps.

Referring to Fig. 1 which is an enlarged sectional view of a pin-head electric incandescent lamp; having two hollow metal wires 1 and 2 hermetically sealed by glass fusion into the glass bead at 3 and 4 to form the lamp bulb 5; a coiled lamp filament 6 is slipped over the ends of two electric lead-in wires 7 and 8 that are separated a sufficient distance for the lamp filament's lighting requirements, and spot welded or fastened to the lead-in wires at 9 and 10 forming the filament mount; the filament mount is placed within the lamp bulb 5 and the hollow metal wires 1 and 2 are compressed against the lead-in wires 9 and 10 to hold the filament mount in place without entirely closing off the passage for exhaust (see Fig. 18); after which the lamp bulb is exhausted to a vacuum, or exhausted and filled with an inert gas at either low or high pressures through the hollow metal wires 1 and 2 which are swaged around or flattened and cut off with the lead-in wires 9 and 10 to form the preliminary seals at 11 and 12, after which the final seals at 13 and 14 are made by either electric welding, brazing, soldering or otherwise closing the ends air tight; thus making the electric lamp.

Referring to Fig. 2 which is an enlarged sectional view of a pin-head electric incandescent lamp; having two filament supports 15 and 16 that are made from nickel or any low thermal expansion metal rod, each turned on the outside diameter to form steps 17, 18, and 19, on one sup-

port and steps 20, 21, and 22 on the other support, with slots 23 and 24 cut in each; a coiled lamp filament 25 is slipped over the filament supports 15 and 16 on their respective steps 19 and 22 and spot welded thereto at 26 and 27 to form the filament mount; the filament mount is placed within two hollow metal wires 28 and 29 that are separated a sufficient distance for the lamp filament's lighting requirements and spot welded or slightly compressed against the supports 15 and 16 on their respective steps 17 and 20 to hold the filament mount in place; a glass bead or bulb 30 is placed over the hollow metal wires 28 and 29 and hermetically sealed thereto by glass fusion at 31 and 32; after which the lamp is exhausted to a vacuum, exhausted and filled with an inert gas at either low or high pressures through the hollow metal wires 28 and 29 which are swaged or flattened and cut off to form the preliminary seals at 33 and 34, after which the final seals at 35 and 36 are made by either electric welding, brazing, soldering, or otherwise closing the ends air tight; thus making the electric lamp.

In Fig. 1 and Fig. 2, it is obvious that the lamp filaments can be made of close wound coils and mounted on the filament supports within the hollow metal wires butted end to end (see Fig. 13); then when the glass bead or bulb is hermetically sealed and is still in a plastic state, the hollow metal wires can be pulled apart with the filament supports, thereby separating the lamp filament coils where they are free to slip on the ends of the filament supports. The finished lamps will be the same as is shown in Fig. 1 and Fig. 2.

Referring to Fig. 3 which is an enlarged sectional view of a pin-head electric incandescent lamp; having a close wound coil lamp filament 37 inserted into the ends of two hollow metal wires 38 and 39 that are butted end to end and spot welded or slightly compressed to hold the lamp filament 37 in place at 40 and 41; a glass bead or bulb 42 is placed over the hollow metal wires 38 and 39 at their junction and hermetically sealed thereto by glass fusion at 43 and 44 and while the glass bead or bulb 42 is still in a hot plastic state, the hollow metal wires 38 and 39 are pulled apart, thereby separating the coils of the lamp filament 37 and exposing them for their light to pass through the bulb 42 which can be blown, to enlarge if desirable; after which the lamp is exhausted to a vacuum, or exhausted and filled with an inert gas at either low pressure or high pressure through the hollow metal wires 38 and 39 which are swaged or flattened and cut off to form the preliminary seals at 45 and 46, after which the final seals at 47 and 48 are made by either electric welding, brazing, soldering or otherwise closing the ends air tight; thus making the electric lamp.

When inserting the close wound coil lamp filament 37 in the ends of the hollow metal wires 38 and 39, a close fitting removable mandrel within the coil filament 37 will facilitate its insertion into the hollow metal wires; or the coil filament 37 can be tightly wound upon a lead, tin, or any other low fusing metal mandrel than can be removed by melting when the glass bulb 42 is heated, or it can be removed by vaporizing with an electric induction furnace with the hollow metal wires 38 and 39 connected to a vacuum line before or after the hermetic seals at 43 and 44 are made.

Referring to Fig. 4 which is an enlarged sectional view of a pin-head electric incandescent lamp; having a coil lamp filament 49 with two filament support tubes 50 and 51 spot welded or

clamped over the ends to form the filament mount; the filament mount is placed within two hollow metal wires 52 and 53 that are separated a sufficient distance for the lamp filament's lighting requirements and compressed against the filament supports 50 and 51 to hold the filament mount in place without entirely closing off the passage for exhaust (see Fig. 18); a glass bead or bulb 54 is hermetically sealed by glass fusion at 55 and 56 to the hollow metal wires 52 and 53; after which the lamp is exhausted to a vacuum, or exhausted and filled with an inert gas at either low or high pressures through the hollow metal wires which are swaged or flattened and cut off to form the preliminary seals at 57 and 58, after which the final seals at 59 and 60 are made by either electric welding, brazing, soldering, or otherwise closing the ends air tight; thus making the electric lamp.

In Fig. 4 it is obvious that the lamp filament 49 can be made a close wound coil with other operations performed for sealing and separating the coils as previously referred to for the lamps in Fig. 1 and Fig. 2.

Referring to Fig. 5 which is an enlarged sectional view of a pin-head electric incandescent and metallic vapor arc lamp; having a coiled lamp filament 61 slipped over two tungsten or high temperature heat resisting arcing electrodes 62 and 63 that are free from contact with the filament 61 except where they are spot welded together at 64 and 65; mounting the electrodes 62 and 63 with the filament 61 thereon within two hollow metal wires 66 and 67 that are separated a sufficient distance for the lamp's lighting requirements and clamped against the electrodes 62 and 63 to hold the filament 61 and set the arcing space 68 in place without entirely closing off the passage for exhaust (see Fig. 18); a glass bead or bulb 69 is hermetically sealed by glass fusion at 70 and 71 to the hollow metal wires 66 and 67; after which the lamp is exhausted to a vacuum and filled with a quantity of mercury 72 that is equal to approximately one-tenth ($\frac{1}{10}$) of the entire inside volume of the lamp, through the hollow metal wires 66 and 67 which are swaged around the electrodes 62 and 63 to form the preliminary seals 73 and 74, after which the final seals at 75 and 76 are made by electric welding or otherwise closing the ends air tight; thus making the electric lamp.

In Fig. 5 it is obvious that the lamp can be made to operate as a high pressure mercury arc lamp or a low pressure mercury arc lamp; which depends upon the relative parts of the lamp together with conditions under which the lamp operates, such as the lamp operating voltage and current supply amperage, the filament size and length, the size of the electrodes and the arcing space distance, quantity of mercury therein, if the lamp has a vacuum or is gas filled, or the electronic emission from the lamp filament and the electrodes. The lamp can be filled with a predetermined high pressure gas such as hydrogen to build up a very high arc resistance or it can be filled with a low pressure ionizing gas such as neon to make a low arc resistance; then by mixing two or more inert gases (meaning chemically inert to the lamp parts) and by varying the gas pressure within the lamp, a very wide combination of operating characteristics of the lamp can be obtained; also the lamp filament 61 and the electrodes 62 and 63 can be coated with electronic emission substances, such as compounds of thorium, polonium, uranium, or radium in small

quantities, ionium, or any radioactive rare-earth compounds, or impregnated (sometimes called alloyed) with such electronic emission substances by mixing them with reduced metallic powder from which the filament 61 or electrodes 62 and 63 are made during their manufacturing processes to give a high electronic emission when they are heated within the lamp. This high electronic emission from the filament 61 and the electrodes 62 and 63 rapidly ionizes the gases within the lamp which in turn starts the electronic flow to produce the electric arc across the arcing space 68 between the electrodes 62 and 63 and radiates light.

Referring to Fig. 6 which is an enlarged sectional view of a pin-head electric glow or metallic vapor arc lamp; having two arcing electrode buttons 77 and 78 fastened to two electrode rods 79 and 80; mounting the electrode rods 79 and 80 with the electrode buttons 77 and 78 thereon within two hollow metal wires 81 and 82 that are separated a sufficient distance for the lamp's lighting requirements and clamped against the electrode rods 79 and 80 to hold the electrode buttons 77 and 78 that set the arcing space 83 in place without entirely closing off the passage for exhaust (see Fig. 18); a glass bead or bulb 84 is hermetically sealed by glass fusion at 85 and 86 to the hollow metal wires 81 and 82; after which the lamp is exhausted and filled with neon or any other ionizing gas or mixture of gases at either low or high pressures, and also filled with a quantity of mercury 87 that is equal to approximately one-tenth ($\frac{1}{10}$) of the entire inside volume of the lamp, through the hollow metal wires 81 and 82 which are swaged around the electrode rods 79 and 80 to form the preliminary seals at 88 and 89, after which the final seals at 90 and 91 are made by electric welding or otherwise closing the ends air tight; thus making the electric lamp.

In Fig. 6 it is obvious that the lamp can be made to operate as a low pressure gas glow lamp, a high pressure gas glow lamp, a high pressure mercury arc lamp, or a low pressure mercury arc lamp; having other variable features and characteristics as previously referred to in connection with the lamp in Fig. 5.

In Fig. 5 and Fig. 6, for convenience of drawing the illustration, I have shown the mercury 72 and 87 in a level pool within the lamp. After the lamp has once been lighted the mercury would be in the form of little droplets or globules clinging all over the inside surfaces of the lamp. Also the quantity of mercury within each lamp could vary from a trace up to a maximum amount needed which very rarely would exceed one-tenth ($\frac{1}{10}$) of the entire inside volume of each lamp. It is also evident that other low vaporizing metals such as sodium, potassium, or any other metal or alloy could be substituted for the mercury 72 and 87 within the lamps.

Referring to Fig. 7 which is an enlarged sectional view of a pin-head electric lamp bulb; having a glass bead or bulb 92 which is bored out mechanically or drawn out by heating to a plastic state as in glass blowing methods to form the small capillary hole 93 and also the bell-mouth enlargements 94 and 95 extending therefrom; two hollow metal wires 96 and 97 with ends tapered and rounded at 98 and 99 are inserted into the bell-mouth enlargements 94 and 95 and hermetically sealed by glass fusion with the glass bead or bulb 92 at 100 and 101; thus making the electric lamp bulb.

Referring to Fig. 8 which is an enlarged sec-

tional view of a pin-head electric lamp bulb; having a quartz pebble or transparent gem 102 which is bored out mechanically to form the small capillary hole 103 and also the bell-mouth enlargements 104 and 105 extending therefrom; two hollow metal wires 106 and 107 with the ends tapered and rounded at 108 and 109 are inserted into the bell-mouth enlargements 104 and 105; the gem 102 is cleaned and the outside surface is coated with a film of sodium silicate solution and dried for glass fusion with it; the gem 102 with the hollow metal wires 106 and 107 inserted therein are placed within a glass bead or bulb 110 and all hermetically sealed together by glass fusion at 111, 112 and 113; thus making the electric lamp bulb.

In Fig. 7 and Fig. 8, the pin-head electric lamp bulbs are intended to be used with small electric incandescent high pressure metallic vapor filament lamps, or they can be substituted for a metallic vapor filament capillary tube as described in my invention previously referred to as Patent Number 2,154,542, patented April 18, 1939.

Referring to Fig. 9 which is an enlarged sectional view of a pin-head electric lamp bulb; having a quartz pebble or transparent gem 114 which is bored out mechanically to form the hole 115 with chamfers 116 and 117; the gem 114 is cleaned and the outside surface is coated with a film of sodium silicate solution and dried for glass fusion with it; two hollow metal wires 118 and 119 are butted against the gem 114 and placed within a glass bulb 120 (two removable pointed mandrels in the hole chamfers 116 and 117 of the gem 114 passing through the hollow metal wires 118 and 119 will hold them centrally) which are all hermetically sealed together by glass fusion at 121, 122 and 123; thus making the electric lamp bulb.

Referring to Fig. 10 which is an enlarged sectional view of a pin-head electric lamp bulb; having a quartz pebble or transparent gem 124 which is bored out mechanically to form the hole 125 that will closely fit with the ends of the two hollow metal wires 126 and 127 (the ends of the hollow metal wires 126 and 127 can be fitted to the hole 125 in the gem 124; or the hole 125 in the gem 124 can be made slightly tapered from the outside to the center to fit the ends of the hollow metal wires 126 and 127); the gem 124 is cleaned and the outside surface is coated with a film of sodium silicate solution and dried for glass fusion with it; the gem 124 with the hollow metal wires 126 and 127 inserted therein are placed within a glass bulb 128 and all hermetically sealed together by glass fusion at 129, 130 and 131; thus making the electric lamp bulb.

Referring to Fig. 11 which is an enlarged sectional view of a pin-head electric lamp bulb; having a quartz pebble or transparent gem 132 which is bored out mechanically to form the bell-mouth hole 133; two hollow metal wires 134 and 135 with the ends tapered at 136 and 137 are fitted to the bell-mouth hole 133; the gem 132 is cleaned and the bell-mouth hole 133 is coated with a film of sodium silicate solution and dried for glass fusion with it; glass beads 138 and 139 are hermetically sealed by glass fusion with the hollow metal wires 134 and 135 at 140 and 141 and are inserted into the hole 133 of the gem 132 and also hermetically sealed by glass fusion at 142 and 143; the surplus sodium silicate within the bell-mouth hole 133 can be washed away by forcing chemical solutions and rinsing with pure water through the hollow metal wires 134 and

135; a dilute solution of water and sulphuric acid with a little hydrofluoric acid added makes one type of chemical solution; any slight dissolving of the inside of the hollow metal wires 134 and 135 will not be objectionable; thus making the electric lamp bulb.

Referring to Fig. 12 which is an enlarged sectional view of a pin-head electric lamp bulb; having two hollow metal wires 144 and 145 butted end to end (see Fig. 13) with a removable mandrel therein; grains or particles of crushed quartz pebble or transparent gem 146 (several shown) are cleaned and immersed in a dilute solution of sodium silicate so as to have a very thin film coating of it thereon and dried for glass fusion with them; mixing powdered glass with the grains 146 and forming into a moulded bead or bulb 147 under mechanical pressure; the moulded bead or bulb is placed over the hollow metal wires 144 and 145 at their junction and hermetically sealed thereto by glass fusion at 148 and 149 and while the glass of the bead or bulb 147 is still in a hot plastic state, the hollow metal wires 144 and 145 are pulled a fixed distance apart; the bead or bulb can also be made by building up and fusing the grains 146 with the powdered glass on the ends of the hollow metal wires 144 and 145; thus making the electric lamp bulb.

In Fig. 12, the pin-head electric lamp bulb will give light diffusion without much light absorption. If the fusing processes are done in a high vacuum, the bulb will be more transparent with less light diffusion, otherwise the bulb is milky or white with light diffusion. About five percent (5%) of the light is lost but maximum light diffusion is obtained.

Referring to Fig. 13 on through to Fig. 21 which are enlarged sectional views of the progressive operations in constructing a pin-head electric incandescent lamp; having identical parts numbered with the same number where they appear in any of the views even though those numbers are not mentioned in the descriptive caption for the figure where those numbers are repeated; and having in Fig. 13 a glass bead or bulb 150 slipped over two hollow metal wires 151 and 152 butted end to end with a removable heat resisting mandrel 153 inserted through them and clamped between jaws 154, 155, 156 and 157 of one fixture; the glass bead or bulb 150 is placed over the junction of the hollow metal wires 151 and 152 and the gas flames 158 and 159 are directed thereon until the bulb 150 is hermetically sealed by glass fusion to the hollow metal wires 151 and 152 in Fig. 14 at 160 and 161 and while the glass bead or bulb 150 is still in a hot plastic state, the hollow metal wires 151 and 152 are pulled a fixed distance apart with their respective jaws 154, 155, 156 and 157 of the fixture; thus making the lamp bulb assembly. In Fig. 15 the lamp bulb assembly is slipped over one electric lead-in wire 162 and a coiled lamp filament 164 is slipped over another electric lead-in wire 163; the lead-in wires 162 and 163 are clamped between the jaws 165, 166, 167 and 168 of another fixture so as to set the filament space 169. In Fig. 16 the filament 164 is placed centrally over the filament space 169 (see Fig. 15) and clamped or spot welded at 170 and 171 to form the filament mount. In Fig. 17 the lamp bulb assembly is centrally placed over the lamp filament 164 and the hollow metal wires 151 and 152 are compressed against the lead-in wires 162 and 163 at 172 and 173 to hold the filament mount in place

without entirely closing off the passage for exhaust as shown by cross-section in Fig. 18; thus making the lamp bulb and filament mount assembly which is removed from this fixture. In Fig. 19 the hollow metal wire 151 of the lamp bulb and filament mount assembly is freely inserted into an exhaust and gas filling adaptor that is connected to gas filling equipment, in which a compression type rubber ring 174 is held in a fixed sleeve 175 that encloses the compression plunger 176. In Fig. 20 the compression plunger 176 compresses the rubber ring 174 and by volume displacement the rubber ring 174 compresses and closes in around the hollow metal wire 151. The lamp bulb and filament mount assembly is heated to drive off moisture and air that is held against the inside surfaces by capillary, surface and static attraction, and at the same time a hydrogen gas is forced through the lamp in and out simultaneously through the hollow metal wires 151 and 152 to drive out the air and moisture and also clean the filament 164 as an electric current lights up the filament 164 to incandescence by connecting the electric supply line to the hollow metal wires 151 and 152 for a short interval of time; a nitrogen flushing gas drives out the hydrogen and then an argon flushing gas drives out the nitrogen, displacing the inside volume with argon (usually a mixture of argon, 20% nitrogen, and traces of rare atmospheric gases such as neon, krypton and others makes the best inert filling gas); the hollow metal wire 152 is then mechanically flattened at 173 to prevent too much filling gas from escaping and also to form one preliminary seal; when the filling gas has reached the desired pressure (either low or high pressure) within the lamp, the other hollow metal wire 151 is mechanically flattened at 172 to form the other preliminary seal; the lamp is then removed from the gas filling adaptor by releasing the compression plunger 176 which allows the compression rubber ring 174 to open itself; the ends of the hollow metal wires 151 and 152 and the lead-in wires 162 and 163 are cut off at 177 and 178. In Fig. 21, the final seals at 179 and 180 are made by either electric welding, brazing, soldering, or otherwise closing the ends air tight; thus making the electric lamp.

Referring to Fig. 22 which is an enlarged sectional and elevational view of a multiple string of pin-head electric incandescent lamps connected together in simultaneous exhaust, fill, and final seal arrangement; having similar parts numbered with the same number where they appear with each lamp; the lamps are made as individual lamps except that they are connected together, exhausted, filled, and finally sealed as a single unit assembly; having a coiled lamp filament 181 slipped over the end of a first electric lead-in wire 182 and clamped or spot welded together at 183 which are both inserted into the end of a first hollow metal wire 184 which is compressed against the lead-in wire 182 at 185 to hold the lamp filament 181 and the lead-in wire 182 in place without entirely closing off the passage for exhaust (see Fig. 18); a second lead-in wire 186 is slipped into the end of the filament 181 and clamped or spot welded together at 187; a glass bead or bulb 188 is slipped over the end of a second hollow metal wire 189 which is slipped over the second lead-in wire 186 and filament 181; the second hollow metal wire 189 is compressed against the lead-in wire 186 at 190 to hold the lamp filament 181 and the lead-in wire 186 in place without entirely closing off

the passage for exhaust (see Fig. 18); the ends of the hollow metal wires 184 and 189 and the ends of the lead-in wires 182 and 186 were separated a sufficient distance for the lamp filament's lighting requirements when they were previously set in place; the glass bulb 188 is centrally located over the filament 181 and hermetically sealed by glass fusion to the hollow metal wires 184 and 189 at 191 and 192 and while the glass bead or bulb 188 is still in a hot plastic state, the inside diameter can be slightly enlarged by blowing air under pressure into the bulb 188 through the hollow metal wires 184 and 189; thus making one lamp of the string. The second lamp of the string is made similar to the first lamp except that the second hollow metal wire 189 of the first lamp becomes the first hollow metal wire of the second lamp. The third, fourth, fifth, etc., lamps are made similar to the second lamp. For convenience of identification here, the last hollow metal wire is numbered 193. The entire string of lamps are exhausted, filled, and finally sealed as a unit assembly similar to a single lamp with the same operations performed as previously described for the lamp in Fig. 19, Fig. 20 and Fig. 21; thus making the string of electric lamps.

The string of electric incandescent lamps in Fig. 22 can be connected electrically to burn in either series, parallel, or series parallel circuits even though the gas chambers of each lamp are all interconnected; also the number of lamps in the string or the distance between the lamps can be as desired.

Referring to Fig. 23 which is an enlarged sectional and elevational view of a multiple string of pin-head electric glow or metallic vapor arc lamps; having similar parts numbered with the same numbers where they appear with each lamp; the lamps are made as individual lamps except that they are connected together, exhausted, filled, and finally sealed as a single unit assembly; having a first arcing electrode button 194 fastened to a first electrode rod 195; mounting the electrode rod 195 with the electrode button 194 thereon within a first hollow metal wire 196 and clamped against the electrode rod 195 at 197 to hold it in place without entirely closing off the passage for exhaust (see Fig. 18); a second arcing electrode rod 198 with a grooved sleeve 199 centrally fastened thereon and a second and third arcing electrode buttons 200 and 201 fastened on the ends thereof which are centrally placed within a second hollow metal wire 202 and clamped or spot welded at 203 to hold it in place; a glass bead or bulb 204 is centrally located over the electrode buttons 194 and 200 that are held at a fixed distance apart for the arcing space 205 and hermetically sealed by glass fusion to the hollow metal wires 196 and 202 at 206 and 207; thus making one lamp of the string. The second lamp of the string is made similar to the first lamp except that the second hollow metal wire 202 of the first lamp becomes the first hollow metal wire of the second lamp. The third, fourth, fifth, etc., lamps are made similar to the second lamp. The last lamp in the string is made the same as the first lamp, having a similar hollow metal wire 196, electrode rod 195, and electrode button 194; after which the string of lamps are exhausted and filled with neon or any other ionizing gas or gas mixture at either low or high pressures and also filled with a quantity of mercury 208, that is equal to approximately one-tenth ($\frac{1}{10}$)

of the entire inside volume of the string of lamps, through both end hollow metal wires 196 (one end shown) which are swaged around the end electrode rods 195 to form the preliminary seals at 197; after which the final seals at 209 on both ends are made by electric welding or otherwise closing the ends air tight; thus making the string of electric lamps.

Referring to Fig. 24 which is an enlarged sectional and elevational view of a multiple string of pin-head electric incandescent and metallic vapor arc lamps; having similar parts numbered with the numbers where they appear with each lamp; the lamps are made as individual lamps except that they are connected together, exhausted, filled, and finally sealed as a single unit assembly; having a coiled lamp filament 210 slipped over a first tungsten or high temperature heat resisting arcing electrode 211 that is free from contact with the filament 210 except where they are spot welded together at 212; mounting the electrode 211 with the filament 210 thereon within a first hollow metal wire 213 which is clamped against the electrode 211 at 214 to hold it in place without entirely closing off the passage for exhaust (see Fig. 18); a second tungsten or high temperature heat resisting arcing electrode 215 with a grooved sleeve 216 centrally fastened thereon is slipped into the first filament 210 while a second coiled lamp filament 217 is slipped over the other end of the electrode 215 that is free from contact with both filaments 210 and 217 except where they are spot welded together at 218 and 219; a second hollow metal wire 220 is centrally located over the grooved sleeve 216 which is clamped or spot welded thereto at 221 to hold it in place; a glass bead or bulb 222 is centrally located over the filament 210 and the electrodes 211 and 215 that were previously set at a fixed distance apart for the arcing space 223 and hermetically sealed by glass fusion to the hollow metal wires 213 and 220 at 224 and 225; thus making one lamp of the string. The second lamp of the string is made similar to the first lamp except that the second hollow metal wire 220 of the first lamp becomes the first hollow metal wire of the second lamp. The third, fourth, fifth, etc., lamps are made similar to the second lamp. The last lamp in the string is made the same as the first lamp, having a similar hollow metal wire 213 and electrode 211; after which the string of lamps are exhausted to a vacuum or exhausted and filled with an inert gas at either low or high pressures together with a quantity of mercury 226, that is equal to approximately one-tenth ($\frac{1}{10}$) of the entire inside volume of the string of lamps, through the end hollow metal wires 213 (one end shown) which are swaged around the end electrode rods 211 to form the preliminary seals at 214; after which the final seals at 227 on both ends are made by electric welding or otherwise closing the ends air tight; thus making the string of electric lamps.

It is obvious that the variable features previously referred to regarding the lamps in Fig. 5 and Fig. 6 will also apply to the lamps in Fig. 23 or Fig. 24. Another feature of these lamps is that they are adapted to be substituted for either glass capillary tube assembly that is referred to in Patent 2,154,542, patented April 18, 1939, page 1, column 2, line 15, or page 2, column 1, line 5, with one or several lamps being used as may be desired with individual lamps spot welded to-

gether or with a string of lamps as shown in Fig. 22, Fig. 23 and Fig. 24. It is also obvious that any of the other electric pin-head lamps shown herein can be substituted for the glass capillary tube, and when they are filled with high pressure gas, an even greater gas pressure can be sustained therein because of the high pressure gas surrounding them within the outer thick wall bulb.

In the descriptions of the lamps shown in Fig. 6 to Fig. 24, several different ways are shown to construct the pin-head electric lamps and it is obvious that the sequence of operations described herein can be changed without materially altering the finished lamp; also the parts of one lamp can be substituted for similar parts of other lamps, thus making other combinations of parts, for example the bulb in Fig. 10 can be substituted for the bulb in Fig. 1, Fig. 2, Fig. 3, etc., making many combinations; therefore a further object of this invention is that each part or each operation performed to assemble that part with another part shall be an improvement of this invention.

In Fig. 23 and Fig. 24 are shown strings of pin-head electric lamps which are ideally suited to make improved fluorescent lamps, by substituting them for the small lamps shown mounted in my previous invention Patent Number 2,137,732, patented Nov. 22, 1938, in which a reference is made to fluorescent bulb coatings on page 3, column 2, lines 7 to 23 inclusive. The lamps best suited for fluorescent lighting would be similar to those lamps shown in Fig. 1 and Fig. 4 of Patent 2,137,732. In the ordinary fluorescent lamp, which is practically a low pressure gas glow lamp having fluorescent material coated on the inside of the bulb, there arises the difficulty of making a compact lamp of sufficient wattage or total lumen output in a single unit that will give enough light for an ordinary size household room; for example some of those single unit tubular lamps, which barely give enough light for proper illumination, are approximately one and one-half inches outside diameter by forty-eight inches long ($1\frac{1}{2}$ " O. D. x 48" Lg.) which makes them both expensive and clumsy for household lighting; also the ordinary size globular lamp seems to be impractical for constructing gas glow type fluorescent lamps. In my invention a string of these pin-head electric lamps can be designed to have wattages that are comparable with most all sizes of household electric incandescent lamps and can be substituted and mounted in place of the wire filaments within those lamp bulbs; the inside surfaces of those tubular or globular glass bulbs are coated with a thin layer of fluorescent material such as zinc silicate which phenomenally changes the energy of invisible light rays to visible light rays and increases the lighting efficiency of the lamp. While the coating of fluorescent material has a certain amount of hiding and diffusing properties for the other visible light rays, yet the gains made by fluorescence seems to offset it. In my previous invention Patent 2,137,732, the small lamps of my copending application Serial Number 190,615, now Patent Number 2,154,542, patented April 18, 1939, were mounted therein for fluorescent lighting effects and was duly referenced on page 3, column 1, lines 2 to 5 inclusive. Now I claim that these pin-head electric lamps as individual lamps as in Fig. 5 and Fig. 6 that can be connected together, or the string of pin-head electric lamps interconnected as a single

unit as in Fig. 23 and Fig. 24, are an ideal combination for making compact fluorescent, phosphorescent, or luminescent electric lamps when mounted within a large bulb as previously described.

In Fig. 22, Fig. 23 and Fig. 24, the pin-head lamps are shown with their inside volumes all interconnected, and it is a further object of this invention that this method of connecting small electric lamps together shall be one of the improvements of this invention, for example the small electric lamps shown in the previously mentioned patents (2,097,679; 2,137,732, 2,154,542) can also be interconnected by this method.

While it is obvious that the hollow metal wire is a convenient means of interconnecting the small electric lamps together, yet it is possible to interconnect them with glass tubing. One object in making a series of small pin-head lamps that are interconnected with glass tubing instead of being made in a longer tubular lamp like those in the patents mentioned in the preceding paragraph, is that the natural gem or quartz pebble bulbs can be utilized in electric lamp making that will withstand higher operating temperatures than the fused product of the same material. Some gems are generally accepted as being infusible, such as diamond which will change to graphite at about 2200 degrees Kelvin temperature, however these infusible gems can be used close to the light source in a pin-head electric lamp and glass tubing with solid lead-in wires supported therein can interconnect between the pin-head lamp bulbs. When high pressure gas is sealed within such a string of pin-head electric lamps, the end bulbs can have hollow metal wires extending therefrom for exhausting, filling, and finally sealing the gas therein, while the other lamps in the string are interconnected with glass tubing. A string of such glass tube interconnecting gem bulb lamps could be manufactured by making pieces of glass tube which have their ends cupped out sufficiently to enclose a gem that has previously been bored out for the lamp light source, inserting lead-in wires on supports within the glass tube, connecting a lamp filament or arcing electrodes to the lead-in wires, slipping the gem over the filament or arcing electrodes, butt sealing two cupped end tubes together by glass fusion to enclose the gem with the filament or arcing electrodes therein, and so on with the next lamps until the string of lamps are interconnected which can be exhausted and filled like the lamps in Fig. 22; therefore a further object of this invention is to show that the method of interconnecting the inside volume of small electric lamps together, can be applied to small lamps having glass tubes connecting them as well as hollow metal wires connecting them; also a further object is to show that gem bulbs can be made with glass tubing connecting them as well as hollow metal wires connecting them.

The size of the small spherical (tubular if desired) lamp bulbs most readily adapted to the improvements of this invention would have a range from one millimeter (1 mm.) to five millimeters (5 mm.) in diameter; however the smallest size to which it is possible to make them would depend upon the smallest size of the hollow metal wires. The smallest size or the exact limit as to how small it is possible to make a hollow metal wire or even a solid wire has never been determined; however solid platinum wire has been made as small as four microns ($4\ \mu$) in

diameter. Such small platinum wire is made by making a small platinum core within a rod of steel, copper, or any other suitable wire drawing metal; then the rod is reduced to fine wire by regular wire drawing processes, which at the same time reduces the platinum core to approximately the same proportional size in the fine wire as it was within the original rod, then by dissolving the steel or other metal sheath of the fine wire with acid or other chemicals that will not attack the platinum, an extremely fine platinum wire is made. This same method of making an extremely fine solid platinum wire can be applied to making an extremely fine platinum hollow metal wire except that a platinum hollow core is reduced within the steel or other metal fine wire. The hole in the platinum core within the steel or other metal rod is mandreled as it is first reduced to a larger wire, then reduced without a mandrel by wire drawing to a fine hollow metal wire that later has the outside sheath of steel or other metal removed by acid or other chemicals. It is not possible to make such hollow metal wire as small in diameter as a solid wire, however the experiments with the larger hollow metal wire in wire drawing show or indicate that when the wall thickness of the hollow metal wire is equal to approximately one-half ($\frac{1}{2}$) of its inside diameter the same metal can be made into a hollow metal wire which is approximately ten times ($10\times$) the diameter of a solid wire made of that same metal; for example I have had hollow metal wire made from stainless steel containing from twenty-seven to thirty percent (27 to 30%) chromium that measured eighteen-thousandths inches (.018") outside diameter with five-thousandths inch (.005") wall, whereas this same metal can be reduced to solid wire from one-thousandth to two-thousandths inch (.001" to .002") outside diameter, in each case if the metal is drawn much smaller than these dimensions, breakage increases rapidly and it seems that the grain structure of the metal bears a direct relation to the minimum size to which it can be drawn. This analogy would fix the present low limits of a platinum hollow metal wire at 40 microns (40μ) in diameter, which could be sealed within a glass bead or bulb 100 microns (100μ) in diameter, and having tungsten arcing electrodes or a straight wire filament 10 microns (10μ) in diameter which is approximately the diameter of the smallest tungsten wire or filament made, thus making the smallest electric lamp in the world.

The exclusive features of these pin-head electric lamps which permit them to be made smaller than any previously known electric lamps, can be readily understood by studying Fig. 13 to Fig. 21 inclusive, in contrast with other known methods of making extremely small electric lamps, such as the electric incandescent lamp known as the grain of wheat lamp; therefore this comparative explanation. Previously it was pointed out that the smallness of the pin-head electric lamp or bulb is controlled by the minimum size of the hollow metal wires, whose outside diameter limits the inside diameter of the glass bulb as seen in Fig. 13 and Fig. 14. Here a glass bead is made by cutting an extremely small diameter glass tube into short pieces. It is well known that glass tubes can be made one-tenth millimeter ($\frac{1}{10}$ mm.) outside diameter or even smaller, by drawing out a heated portion of a larger glass tube. Such extremely small drawn-out tubing

can be etched with a diamond point as it is rotated in a chucking device at intervals and broken off to make pieces no longer than the diameter of the tubing; thus making a glass bead which will just freely slip over the smallest hollow metal wire. The entire glass bead is heated to its fusing temperature at the junction of the two hollow metal wires and when hermetically sealed thereto while still in a plastic state the hollow metal wires are separated enough to form the pin-head electric lamp bulb. Now a bulb made entirely of glass could be made just as small as this bulb with the hollow metal wires but it is the practical operations of mounting the electric lamp light source therein that makes possible the difference respectively in each lamp size. In the pin-head electric lamp no part of the glass bulb is heated to its melting or plastic temperature once the glass bulb is made because the light source is inserted through and connected to the hollow metal wires and also exhausted, gas filled, and finally sealed thereby; whereas in the grain of wheat lamp, the ends of the glass bulb must be heated to its melting or plastic temperature to seal in the light source and its lead-in wires while the lamp is exhausted, gas filled, and finally sealed air tight. In the grain of wheat lamp, the difficulty arises to seal in the lead-in wires without heating the glass bulb to a point that it will collapse around the light source; to accomplish this the bulb must be made so much larger in proportion to the lead-in wire size that the glass will fuse to the lead-in wires before enough heat is conducted to the glass bulb to cause its collapse. In the grain of wheat lamp, there must be two separate sections where the glass bulb is heated to its fusing temperature to seal in the two lead-in wires and finally seal the lamp air tight and also a third section between them where the glass bulb is not heated enough to cause its collapse around the light source; to this extent are the features which limit the minimum size that an electric lamp can be made by those previously known methods; whereas with the improvements of this pin-head electric lamp those type of limiting features do not exist; therefore the pin-head electric lamps can be made much smaller than any other electric lamps that are known at the present time. It is also obvious that these improvements for pin-head electric lamps can be used to make lamps much larger than the grain of wheat lamp; however the methods used to construct the grain of wheat lamp could not be applied practically to construct a lamp as small as those possible with the pin-head lamp type of construction similar to those progressive methods shown in Fig. 13 to Fig. 21 inclusive except that straight wire filaments or fine wire arcing electrodes are used in place of the coiled filaments with lead-in wires therein.

In all electric lamps the lead-in wires should extend a sufficient distance beyond the lamp bulb to permit electrical connections to be made thereto and those lead-in wires are rightfully part of the lamp. In a pin-head electric lamp due to the relative rigidity of the hollow metal wires enclosing the lead-in wires, their ends can be cut off after sealing as close to the glass bulb as is practical, which permits a lamp to be mounted within a spring clip socket that resembles a pair of tweezers; thereby further reducing the actual size of the pin-head electric lamp.

A further object of this invention which has not been described in my previous inventions but

still remains an improvement of the hollow metal wires, is that a wire filament light source can be inserted through the hollow metal wires into the lamp bulb even though the glass bulb is hermetically sealed around the hollow metal wires.

The pin-head electric lamps described herein can be used for surgical electric lamps, flashlight electric lamps, dental electric lamps, or any other electric lamp that must be confined to small spaces; also they can be used within larger electric lamps that require very small intense light sources; or they can be connected in a string like beads and mounted openly or enclosed within larger lamp bulbs and surrounded by a vacuum, low pressure gas, high pressure gas, or any cooling liquid.

Whenever the word "gem" is herein referred to, it is intended to mean a natural stone that will either refract, reflect, or permit the transmission of light through it; or any stone manufactured by artificial or synthetic means to duplicate or imitate such natural stone; or any stone reconstructed by fusing natural or artificially made stones together; or stones known in the trade as precious or semi-precious stones. The chief stone which I have had in mind is the clear white transparent zircon, however other stones such as quartz, sapphire, diamond, and many others can be used, which have good optical qualities, resistant to thermal shock, withstand intense heat and are of high mechanical strength to resist fracture.

Whenever the words "hollow metal wire" or "quartz" or "glass" or "metallic vapor" or "metallic vapor filament" or "high pressure gas" or "hermetically sealed" or "final seal" are herein referred to, they are intended to have the same meaning as described in one or more of the previously mentioned patents (2,097,679; 2,137,732; 2,154,542) from which this invention is a continuation.

In view of the preceding description, it is obvious that the improvements of this invention can be used to make many more pin-head electric lamps and other electric lamps not referred to herein; therefore in anticipation of the manufacture of such lamps, it is a further object to extend the claims of this invention to include any electric lamp which uses one or more of the improvements described or claimed herein.

One of the chief features of this pin-head electric lamp invention is that it introduces a new type of electric lamp construction or method whereby it is possible to build smaller electric lamps than can be made by any other known methods of construction. While it would be possible but not economically practical to build large spherical or tubular lamps as much as one-hundred millimeters (100 mm.) in diameter or even larger by using this pin-head type of construction, yet this type or method was developed especially for lamps that are smaller than any other known heretofore, and it is upon this type of construction wherein the real invention for the pin-head lamp originates; therefore it becomes the novelty lamp for such type of construction, whose ideal size would be approximately two millimeters (2 mm.) outside diameter and in some cases smaller, and others larger, but rarely over ten millimeters (10 mm.) outside diameter. Because the ideal size of the lamps is approximately two millimeters (2 mm.) in diameter, and would compare in size with the head of a common household or clothing pin, I have

chosen the name of "pin-head" to identify these small electric lamps and the type of construction which was developed for their manufacture.

When a pin-head type of electric lamp bulb is made larger than five millimeters (5 mm.) outside diameter, the effect of internal glass strains increases with disastrous results as the mass of glass becomes larger; also as the wall of the glass bulb become thicker, making a slower heat dissipating effect, the larger mass of glass hazard increases rapidly, especially so when the wattage of a lamp is made higher for the larger size bulb. Even with thermal shock resisting glass, like fused quartz, a high wattage light source will soon melt or soften the glass to destroy the bulb if the walls are too thick. For these principal reasons the smaller sizes of pin-head electric lamps are advocated.

When a pin-head type of electric lamp is made smaller than one millimeter (1 mm.) outside diameter, it approaches a class of one that has very little practical use at the present time other than being a mere scientific toy or curiosity. I have thought and hoped that perhaps some day in the future, these extremely small pin-head electric lamps will become a part of scientific tools, unknown at present, whereby competent medical doctors and surgeons will use them to combat diseases, such as parasitic, bacterial, and virus infection, or retard cancerous proliferation, or control gangrene by actinic light treatments. Due to the extremely small size to which the pin-head type of electric lamps can be made, the surgical instrument using them could be inserted directly to the point of infection with an incision that is not larger than one made by an average size hypodermic needle; also by the use of eosin and its derivatives the penetrating effect of the actinic light can be increased many fold together with the fact that the electric lamp would be at the local point of treatment and would produce what might be called nascent actinic light. In view of these possible developments the extremely small pin-head type of electric lamp may prove to be very useful to mankind and there is still much research ahead for it.

Some of the characteristics of the pin-head electric lamps, which distinguish them from any other type of electric lamp, are as follows: due to its practical type of construction, the pin-head electric lamp can be made to smaller dimensions than any previously known electric lamp; the complete pin-head electric lamp bulb can be made without any light source parts therein; a pin-head electric lamp bulb can be made by butting the ends of two hollow metal wires together and by glass fusion, hermetically seal a glass bead at their junction, which are then separated a suitable distance while the glass is still in a plastic state to form the bulb; the light source parts can be inserted into the pin-head electric lamp bulb through the hollow metal wires; through the pin-head electric lamp development, a practical way has been found to utilize gems in making electric lamps whose light source has a higher intensity in brightness than any previously known electric lamp, because natural gems can withstand higher temperatures than glass or fused quartz when enclosing high pressure metallic vapor; the pin-head electric lamp bulb can be made with a mechanically bored hole through it to enclose the light source, in either a glass bulb or a gem bulb; due to the small volume of material comprising a pin-head

electric lamp bulb smaller than two millimeters (2 mm.) outside diameter, there will be less internal strains within the bulb than is encountered in larger masses of glass; extremely small pin-head electric lamps will dissipate their own heat faster than larger lamps, just like a small part or object will cool faster than a large one.

I claim:

1. An electric lamp bulb, consisting of, a gem having a mechanically bored hole through it to form a light source enclosure, two hollow metal wires extending from said hole in said gem, a glass bead hermetically sealed to said gem and said hollow metal wires enclosing said gem to form said lamp bulb.

2. A metallic vapor capillary bulb, consisting of, a gem having a mechanically bored bell-mouth capillary hole through it to form a metallic vapor capillary hole, two hollow metal wires fitted into said bell-mouth capillary hole in said gem, a glass bead hermetically sealed to said gem and said hollow metal wires to form said capillary bulb.

3. A pin-head electric lamp bulb, consisting of, a gem having a mechanically bored bell-mouthed hole through it to form a light source enclosure, two hollow metal wires hermetically sealed in said bell-mouth hole by glass fusion to form said lamp bulb.

4. An electric lamp bulb, consisting of, a gem having a mechanically bored hole through it to form a light source enclosure, two hollow metal wires butted against said gem in axial alignment with said hole in said gem, a glass bead hermetically sealed to said gem and said hollow metal wires by glass fusion to form said lamp bulb.

5. In combination with an electric lamp, the method of making an electric lamp bulb having a gem with a mechanically bored hole through it, said hole being the interspace of said bulb to envelope the light source of said lamp, coating said gem around the edges of said hole with a film of glass fusing flux, fusing glass to said gem around the edges of said hole by means of said flux, hermetically sealing two exhaust and gas filling tubes by glass fusion with the glass around the edges of said hole, said exhaust and gas filling tubes connecting with the interspace of said bulb.

6. In a pin-head electric lamp, the combination of, two hollow metal wires whose inner ends are in proximity with each other, an envelope of light transmitting material being hermetically sealed around the inner ends of said hollow metal wires to form a bulb, a light source within said bulb, said hollow metal wires being a means to communicate with said light source, lead-in wires being integral with said hollow metal wires for said light source, said hollow metal wires affording a means to finally seal said lamp air tight.

7. A pin-head electric lamp as set out in claim 6, wherein the envelope of light transmitting material is a glass bead.

8. A pin-head electric lamp as set out in claim 6, wherein the envelope of light transmitting material is a gem.

9. A pin-head electric lamp as set out in claim 6, wherein the space within the bulb is a near vacuum.

10. A pin-head electric lamp as set out in claim 6, wherein the space within the bulb is filled with low pressure gas.

11. A pin-head electric lamp as set out in claim 6, wherein the space within the bulb is filled with high pressure gas.

12. Several pin-head electric lamps interconnected for exhausting and filling as a single unit, wherein each lamp is as set out in claim 6.

13. A pin-head electric lamp as set out in claim 6, wherein the space within the bulb has vaporizable metal therein.

14. A pin-head electric lamp as set out in claim 6, wherein the space within the bulb is filled with an ionizable gas.

15. A pin-head electric lamp as set out in claim 6, wherein the lead-in wires are arcing electrodes.

16. A pin-head electric lamp as set out in claim 6, wherein an electric lamp filament forms the light source.

17. An intense heat resisting electric lamp bulb, consisting of, a gem having a hole through it, said hole being a cavity to enclose an electric lamp light source, two hollow metal wires in the ends of said hole, said hollow metal wires hermetically sealed to said gem.

HAROLD SWANSON.