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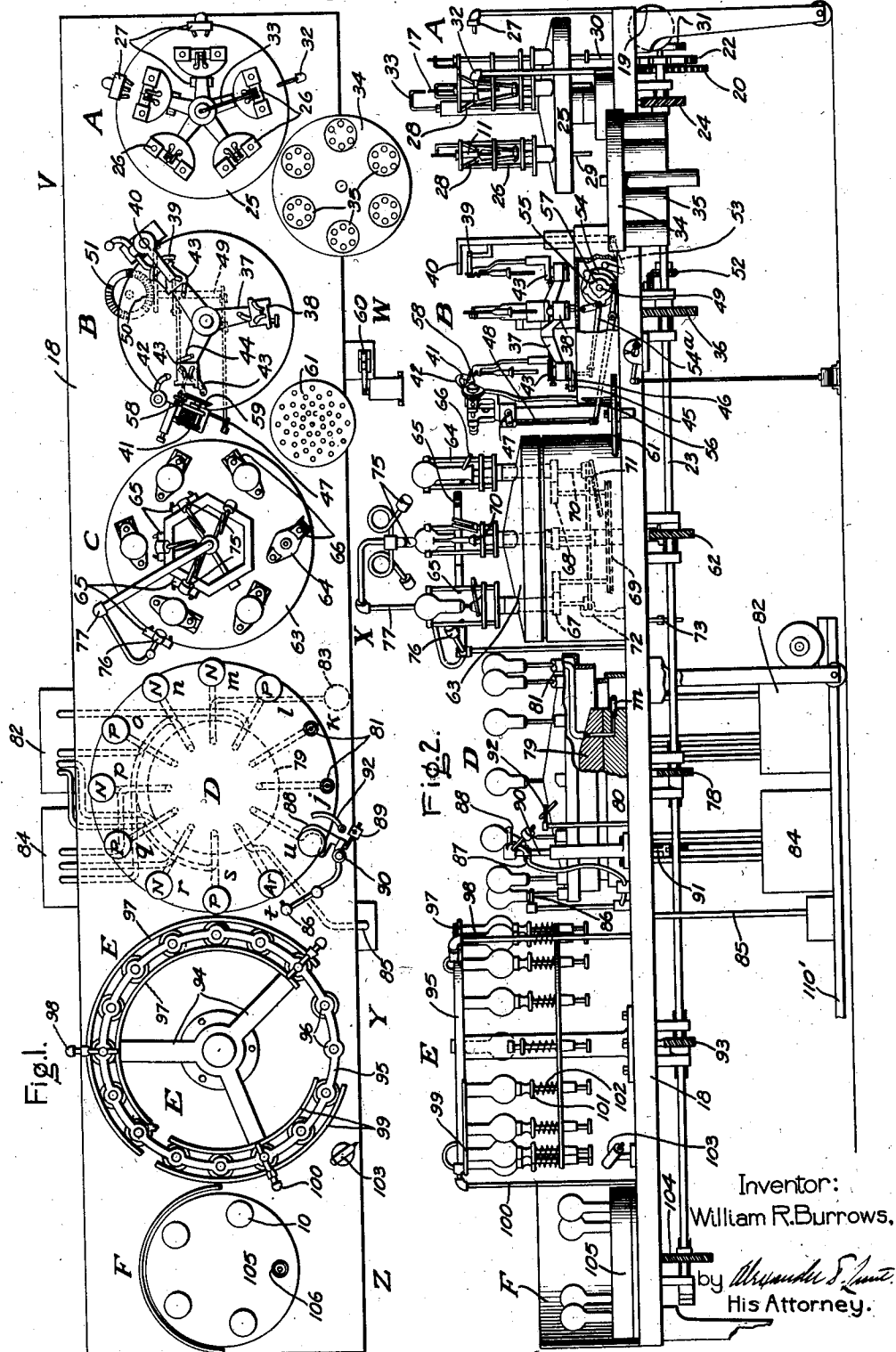
W. R. BURROWS

1,736,767

METHOD OF MAKING INCANDESCENT LAMPS

Original Filed July 27, 1925

2 Sheets-Sheet 1



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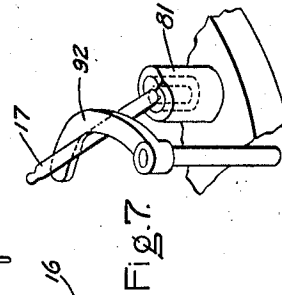
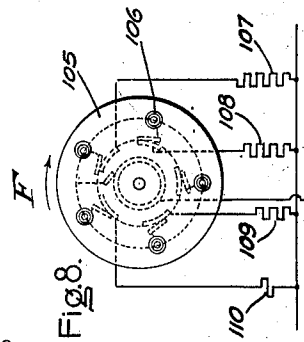
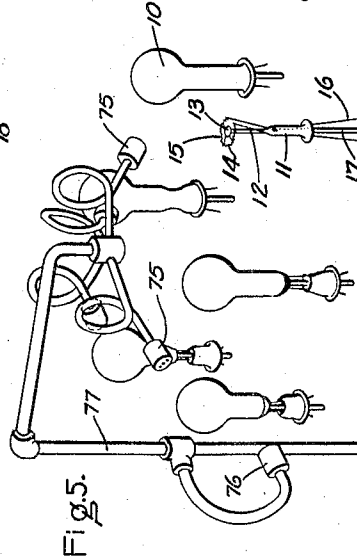
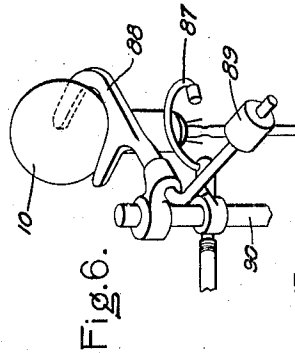
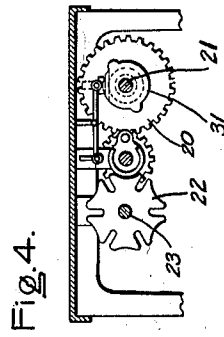
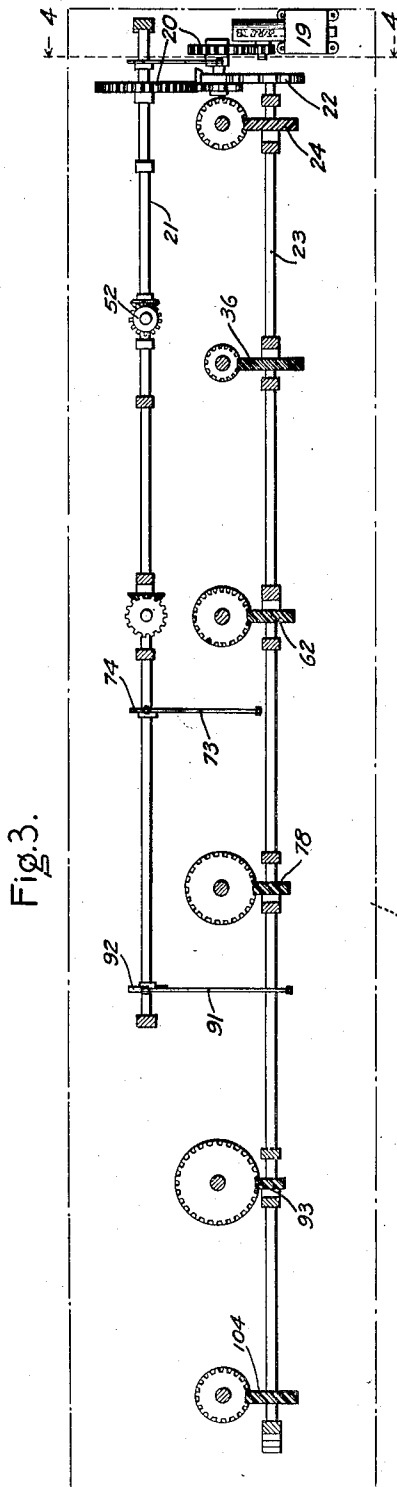
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METHOD OF MAKING INCANDESCENT LAMPS

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2 Sheets-Sheet 2



Inventor:
William R. Burrows.
by *Howard F. Smith*
His Attorney.

UNITED STATES PATENT OFFICE

WILLIAM R. BURROWS, OF NEWARK, NEW JERSEY

METHOD OF MAKING INCANDESCENT LAMPS

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The manufacture of incandescent lamps and many similar devices requires a large number of operations, many of which involve the heating and manipulating of glass tubing and cane. The standard practice in manufacturing incandescent lamps on a large scale is to perform each of the operations in a separate department. For example, in making the mount, some tubing, a piece of glass rod and some leading-in wires will be welded together in the stem making department, then the anchors for holding the filament will be inserted in the glass rod by the hook inserting department and then the filament is placed on the anchors in the winding department. The finished mount is then sealed into the bulb in the sealing-in department, the un-based lamp exhausted in the exhaust department, the base applied in the basing department, the lamp aged in the aging department, inspected in the final inspection department and finally packed in the packing department. The machines in these various departments are of different capacities as several machines may be required in one department to keep one machine in the next department supplied. Each department is provided with enough machines to make all of its particular product that is required by the entire factory. By the standard practice a stock of parts in process of manufacture is maintained between departments to take care of temporary excess or deficiency of output of any department so that temporary trouble in one department does not stop the factory. The output of each department is also large enough to warrant the expense of inspection. In the standard practice above outlined there is much handling of fragile parts before the lamp is assembled, causing breakage and loss, and much other handling of the assembled lamp. The stem maker takes the stem from the stem making machine and puts it in a tray. The tray is carted to the next department, where an operator takes the stem out of the tray, puts it in the anchor inserting machine, takes it out with the anchors inserted, and puts it back in the tray. In the next department the stem is taken out of the tray, the filament applied, and the mount put back in the tray. At the sealing-in machine the mount is taken out of one tray, the bulb out of another tray, and then the sealed-in lamp put back into a tray. From then on the operation of taking the lamp out of a tray and putting it back in the tray is performed many times, first by the exhaust machine operator who takes the lamp out of a tray, exhausts it and puts it back in the tray and then by the exhaust inspector, by the basing operator, by the flash aging operator and by the final inspector after which the lamp is taken out of a tray and packed. Due to the stock of parts maintained between departments, the lamp parts require on the average in a large factory from one half day to one day and a half to move from one department to the next and while in stock accumulate dust and dirt which lowers the quality of the lamp. At every operation the lamp or some part of it is taken out of a tray and put back. This repeated handling, together with the repeated transfers between departments, causes a very considerable breakage and injury of the fragile parts such as the mount. All losses from every cause, commonly referred to as shrinkage, amount on the average in the best factories operated in accordance with the standard practice above outlined to from 9% to 12%. By my process incandescent lamps and similar devices may be manufactured on a large scale with about one-half the shrinkage of the standard practice above outlined, and the lamps produced will be on the average of better quality. My invention increases the productivity of each operator about 30% and decreases the floor space required for a given output about 30%. Well known glass working and lamp assembling machines and devices may be used and in accordance with my invention are so arranged and coordinated that the glass stem of the mount passes from the stem making machine through the other machines and devices necessary to the making of a complete lamp, the other parts of the lamp being added to it as it passes along and upon the termination of any operation upon a lamp part or of any step in its manufacture, particularly prior to the exhaust and sealing

off of the lamp, the part is immediately and directly transferred to the succeeding machine or device where the next operation begins without delay. A lamp part removed from one of the machines or devices is transferred directly and immediately to the succeeding device where it is placed or positioned where work is to be done upon it so that it is in readiness for the next operation. Where this transferring is done by hand, the operator in unloading a part from a machine delivers it directly and as a part of the unloading operation to the place where the next operation is to be performed, thereby eliminating the repeated handling and the lost motion of the standard practice.

My process is a continuous one in which the various steps necessary to the manufacture of a lamp follow one another so directly and immediately that beginning with the stem-making the manufacture of a complete lamp may be completed in only a few minutes whereas the standard practice heretofore followed is an intermittent process involving such long waits between steps that to make a lamp requires days.

Most of the steps or separate operations necessary for lamp making, particularly those which involve heating or working of glass, are by my invention carried out in direct sequence and with such slight delay between operations that any glass part which is once heated during the lamp making operations and thereby freed of moisture does not absorb moisture or occlude gases before the lamp has been exhausted of the air in it. Keeping the glass hot during the making of the lamp greatly reduces the range of temperature changes to which it is subjected during lamp making and lessens the breakage caused in the standard practice by the repeated heating of cold glass from room temperature to the softening point, followed by its cooling down to room temperature again.

By my invention the glass is substantially gas free when the lamp is sealed, as all or substantially all of it is heated so hot during the making of the lamp that practically all the occluded gases are driven out of it. Most of the glass in the mount and some of that in the bulb is heated to the plastic or welding temperature, and all of it is heated until it is substantially moisture and gas free, and after the glass is once heated, it does not deteriorate by absorbing moisture or occluding gas before the air has been removed from the bulb and the bulb hermetically sealed.

The glass-working operations incident to the manufacture of the mount may be carried out on various well known types of machines and devices for performing the successive steps of mount-making, these machines and devices being so coordinated in accordance with my invention that within a

short time which may be only a few minutes after the initial heating of any of the glass parts of the mount on the stem-making machine there arrives at the sealing-in machine a freshly made substantially gas free mount. This mount is in excellent condition to be put into the bulb, and is then, in accordance with my invention and while still substantially gas and moisture free sealed into a hot substantially gas free bulb from which the air is immediately exhausted while all of the glass of the lamp is still very hot and substantially gas free.

The bulb into which the mount is sealed may be an ordinary bulb heated throughout to such a temperature at the sealing-in operation that it is practically gas free. The sealing-in fires for welding the mount into the neck of the bulb heat the bulb to some extent but by my invention the body of the bulb is subjected to additional heating while it is on the sealing-in machine and prior to the closing down of the neck of the bulb on the edge of the flare. Of the total heating of the lamp on the sealing-in machine a good deal, in some cases about one-half, is due to this additional or extra heating, the remainder being due to the sealing-in fires. The heating not only drives the occluded gases out of the glass of the bulb, but expels a great deal of those gases by causing the air in the bulb mingled with the gases driven out of the glass, to expand and most of it escapes freely while the neck of the bulb is of full diameter and neither the expelled gases nor other deleterious gases have an opportunity to re-enter the bulb. If the bulb is sufficiently gas free the additional heating on the sealing-in machine may be dispensed with but with most bulbs the additional heating is necessary in order to get a high quality lamp.

My invention may be practiced to best advantage when the various machines and devices used are placed adjacent to each other with the delivery position of one in such relation to the loading position of the next that the lamp part can be transferred from any one to the next directly and with a minimum of lost motion. This transfer may be made automatically or by an operator and the machines and devices are so timed and synchronized that as any one delivers a part the next is ready to take that part.

The mount, from the time the glass parts of it are first positioned in the stem-making machine, progresses step by step through each machine and from one machine or operation to the next, each step bringing it that much nearer to a finished lamp and all the steps, particularly those between machines or operations, being taken as directly and with as little delay as possible.

During the manufacture of lamps on a large scale there are for each complete lamp pro-

duced a certain number of parts in process of manufacture and in various stages of completion. By the standard practice there are a great number of parts in process of manufacture, most of which are in stock between departments and a great many trays are required to store and transport these parts, but by my invention only a few parts are in process and the only trays needed are those for carrying and storing bulbs. For example, a factory having an output of about 30,000 lamps per day which follows the standard practice will have in process of manufacture lamp parts of a value of about \$14,000 and will use about 3200 trays for bulbs and about 1100 trays for mounts. A factory having the same output, but operated in accordance with my invention, will have in process of manufacture such a small number of parts that their value is only about \$1,500, and will have only 1000 trays, which are used for storing and handling bulbs.

By my continuous process the quality of the lamp is improved, shrinkage is lessened and much better and quicker service to the customer may be given as finished lamps of any particular type ordered are obtained within a very short time after manufacture begins. By the standard practice a number of days is required to manufacture even a very small number of lamps owing to the length of time necessary for the various parts required for the order to move from one department to the next.

Although my improved process of manufacturing lamps may be carried out in many different ways and with many different types of machines, I prefer to use an apparatus or machine which I have invented and in which the various devices or mechanisms for making the lamp parts and for assembling them into a complete lamp are tied together or interlocked, either electrically or mechanically, to compel all of the mechanisms to operate in synchronism and in definite time relation one to the other. In the machine which I prefer various lamp-making mechanisms are mechanically interlocked through a common actuating or driving means, which in effect, ties all of the mechanisms together and compels all of them to operate in a predetermined and unvarying relation. These mechanisms or devices are mounted adjacent to each other with the delivery position of each one in such a relation to the loading position of the next that a lamp part can be transferred from one mechanism to the next with minimum movement and delay. I prefer to mount all of these mechanisms on a common base or table and to drive them from a common shaft carried by the table and in this way, I obtain a self-contained portable unitary lamp-making machine which can be installed merely by connecting to it the power and the gas and air

supply for the burners and which can easily be moved when desired.

The common driving shaft interlocks all of the mechanisms and keeps them in synchronism preferably by being connected to them by gearing and where the various mechanisms are of the step by step type a convenient way is to drive the common driving shaft through intermittent gearing, so that for each step of the driving shaft all of the mechanisms connected to it make one step. In this manner I provide a unitary complete machine to which the glass parts of the mount may be supplied at one end, various other parts of the lamp being added to the mount as it progresses step by step through the various mechanisms and from one mechanism or operation to the next, all these parts being combined to form the finished lamp, which is delivered at the other end. The various mechanisms are so proportioned that as each one delivers a lamp part upon which it has been operating the next one is ready to receive that part and to begin the next operation.

To supply the additional heat to the bulb on the sealing-in machine during the sealing-in operation, I prefer to use auxiliary burners mounted to heat the body of the bulb and so distributed that the bulb is very thoroughly heated before it reaches the final sealing-in position where the neck collapses. In this way I am able to deliver to the exhaust machine a sealed-in lamp hot enough to be exhausted and thereby I eliminate the oven which has heretofore been considered an essential and necessary part of an exhaust machine.

The exhaust mechanism is preferably so arranged that it can be used either to exhaust vacuum lamps or to exhaust lamps and then fill them with some inert gas such as argon to make gas filled lamps with the result that either vacuum or gas filled lamps can be made on my self-contained portable lamp-making machine with a minimum delay and shrinkage, each lamp being completed within a short time after its manufacture is begun.

For a better understanding of my invention reference may be had to the accompanying drawings in which merely for purposes of illustration, I have shown one form of machine embodying my invention and by means of which my improved method can be practiced to advantage. In the particular machine illustrated Figure 1 is a plan view of the machine; Fig. 2 is a side view and elevation with some parts broken away better to show the structure; Fig. 3 is a longitudinal section immediately below the top of the table to show the arrangement of the driving mechanism; Fig. 4 is a vertical section along the line 4-4 of Fig. 3, showing the gear for driving the main and auxiliary shafts; Fig. 5 is a view in perspective show-

ing the various steps of assembling the lamp and the auxiliary burners for imparting additional heat to the lamp during the sealing-in operation; Fig. 6 is a perspective view of a part of the automatic tipping off device; Fig. 7 is a perspective view of means for removing the waste ends of the exhaust tubes from the exhaust machine; and Fig. 8 is a diagram showing the connections for the flash aging machine.

Merely to explain one way in which my invention may be practiced, I have illustrated the manufacture of an incandescent lamp of the tipless type, best illustrated in Fig. 5. The glass bulb 10 of this lamp contains a mount made up of a glass stem tube or flare 11 and a glass rod or hub 12 joined at one end to the stem tube and having at the other end an enlargement or button 13 in which are embedded a number of tungsten or molybdenum anchors 14 to carry the filament 15 which is preferably coiled and arranged in the form of a ring. The ends of the filament are clamped or secured to leading-in wires 16 hermetically sealed into the glass stem tube 11. This tipless lamp is exhausted through an exhaust tube 17 which extends up into the stem tube 11. This particular type of lamp and stem is illustrated more in detail in the United States Patents to Mitchell and White Nos. 1,423,956 and 1,423,957, July 25, 1922.

In the particular type of machine illustrated in the drawing the various devices for making the lamp parts and assembling them are mounted upon a common portable base such as a table 18 and are all driven by motor 19 through common driving means which interlocks the mechanisms and comprises spur gearing 20, a continuously rotating auxiliary driving shaft 21, intermittent gearing 22, and an intermittently moving main driving shaft 23 driven step by step by the intermittent gearing. The various lamp-making devices and mechanisms mounted on the table 18 are driven in definite relation to one another and kept in step and synchronism by the driving shaft 23.

In the particular machine illustrated the manufacture of the mount begins on the stem-making machines A, on which the operator at station V assembles the flare or stem tube 11 the glass rod or cane to form the hub 12 the exhaust tube 17 and the leading-in wires 16. This particular stem-making machine is driven from the intermittently actuated driving shaft 23 by gearing, such as the spiral gears 24, which impart the step by step movement of the driving shaft to a spider 25 provided with five heads 26 which hold the parts of the stem in proper relation. The intermittent movement of the spider brings each head in succession within range of the burners or fires 27 and holds it stationary until the adjoining ends of the stem tubing, the ex-

haust tube, and the cane or hub are nearly at the melting point, whereupon all of these parts are pressed together and the leading-in wires embedded in the glass by pinching jaws 28 mounted on the head and actuated through a push rod 29 which in turn is actuated by a lifter 30 mounted in the table 18 and driven by a cam 31 on the continuously running shaft 21. The head then moves to the next position where a burner 32 directs a pointed flame upon the stem between the leading-in wires and air under pressure is delivered through a jet 33 to the interior of the exhaust tube 17 to blow a hole through the solid mass of hot glass formed by the pinching jaws. Many other forms of stem-making machines can be used. The form of stem-making machine illustrated is suitable for the practice of my invention and is described more in detail in United States patent to Mitchell and White, No. 1,423,957, July 25, 1922.

I may to advantage arrange the machine as shown in U. S. Patent 860,977, Howell and Burrows, July 23, 1907, so that the operator loads it with short pieces of stem tubing which are then flared on the machine before the leading-in wires are placed in position thereby eliminating the preliminary operation of making flares.

The stem making operation heats the adjoining ends of the stem tube, of the exhaust tube and of the hub until they are plastic and therefore free from gases and water vapor. The stem with these parts still hot is transferred by the next operator at station W to the hook inserting machine B which makes the button 13 and inserts the anchors 14. Before the stems are put into the hook inserting machine they may be annealed by an annealer consisting essentially of a horizontally rotatable table 34 provided with pockets or holders 35 in which the stems may be placed to be heated by auxiliary gas burners if desired, although ordinarily such extra heating is not required.

The hook inserting machine is a simple and well known form suitable for stems having only one button and one set of anchors, although similar machines are well known which are constructed to form two buttons and insert two sets of anchors. Either type of machine may be used, depending upon the type of lamp which is being made. The particular hook inserting machine B which is illustrated in the drawing is intermittently driven by the drive shaft 23 through spiral gears 36 which are connected to a three arm spider 37 having a rotatable stem carrying head 38 on the free end of each arm. As each head comes to the loading position in front of the operator at station W a stem from the stem making machine A is placed in the head. This loaded head is then automatically carried to the next position, where the upper or free end of the hub 12 is heated almost to the

melting point by a burner 39 and is then compressed to form the button 13 by a vertically reciprocating press arm 40 driven automatically. The head then moves to the next position where the anchors are inserted one at a time by an anchor inserting mechanism 41, such as that illustrated in the U. S. patent, Frech and Fagan, 1,220,836, March 27, 1917. A particular point on the button 13 is heated by a burner 42 until it is plastic and then the anchor is automatically thrust into the softened glass and thereby embedded in it. To present the different points on the button to the burner 42 and to the hook inserting mechanism each head is automatically rotated step by step at the hook inserting position. For simplicity I have illustrated a lamp provided with only three anchors set 90° apart. To insert these anchors I rotate the stem holding head at the hook inserting position by some intermittently acting mechanism such as a four tooth ratchet wheel 43 controlled by a locking pawl 44 mounted on the spider arm and a driving pawl 45 mounted on the outer end of a swinging arm 46 which is carried on a shaft coaxial with the head when it is in hook inserting position and which is driven automatically in any suitable way. As the head moves into and out of hook inserting position the ratchet wheel 43 comes within and passes out of range of the driving pawl 45.

The hook inserting mechanism illustrated in the Frech and Fagan U. S. Patent 1,220,836 is operated from a rock shaft which is rocked by a handle. In the particular machine I have illustrated this rock shaft of the hook inserting mechanism is automatically rocked by a corresponding arm 47 moved by a rod 48 actuated automatically by any suitable mechanism. The necessary movements can be given to the parts of the hook inserting machine by many forms of automatic mechanism. Merely for the purposes of illustration I have shown an actuating mechanism comprising a cam shaft 49 which makes one revolution while the spider 37 is stationary and then is stationary while the spider is shifting to the next position.

This relative movement of the cam shaft 49 and of the spider may be obtained in many different ways, but merely for purposes of illustration I have shown the cam shaft driven through a pinion 50 which meshes with a mutilated gear 51 driven through bevel gears 52 from the auxiliary shaft 21 at the same speed as that shaft. The mutilated gear 51 has two sets of teeth each equal in number to the teeth on the pinion 50 and two blank spaces between the sets of teeth, each blank space being long enough to permit the pinion 50 to stand idle while the spider 37 is shifting one step.

The button presser 40 is reciprocated once for each revolution of the cam shaft 49

through a bell crank lever 53 actuated by a cam 54 on the cam shaft. The stem carrying head 38 while in hook inserting position is intermittently rotated, one complete revolution in four steps as the result of four oscillations of the swinging arm 46, which is oscillated through a push rod 54^a from an edge cam 55 having four points on it. The hook inserting mechanism is actuated three times in synchronism with the stem holding head 38 each time inserting an anchor in the button 13 while the head 38 is stationary, these three anchors being 90° apart, and then skipping the insertion of the fourth anchor to leave room for the ends of the leading-in wires. The hook inserting mechanism is actuated by moving the arm 47 to insert an anchor through a rocking lever 56 and a cam 57 having three points 90° apart to cause the anchor inserting mechanism to insert three anchors and then skip one for each revolution of the cam shaft.

It may be considered desirable to form on the ends of the anchors a closed loop or hook instead of the open hook formed by the shapes illustrated in the Frech and Fagan U. S. Patent 1,220,626, and in such cases I may close the open hooks by hand when the operator puts the filament in the anchors, or I may close the hooks on the machine by some automatic means, such as a rotatable bender 58 which has projecting from its end one pin concentric with its axis to form or support the loop of the hook and another pin eccentric to the axis to carry the free end of the hook around the first pin when the bender is rotated at the proper time by gearing 59 actuated in proper time relation to the rest of the anchor inserting mechanism. The bender 58 is carried on an arm which is swung about the shaft of the large gear of the gearing 59 as an axis by a suitable cam to bring the bender up into operative relation to the anchor to bend the hook and then to drop it back out of the way.

After the anchors are inserted the head 38 carrying the stem returns to the loading position in front of the operator, who removes the stem from the head and replaces it with a fresh one. He then fastens the filament to the leading-in wires by some suitable means such as the pinchers 60 or an electric welder mounted in the same position as the pinchers. The mount is now completed. It may be, if desired, placed in a rotatable holder 61 so as to be convenient for the sealing-in and exhaust operator at position X.

The mounts are sealed into the bulbs by a sealing-in machine C intermittently driven by the drive shaft 23 through spiral gears 62 which drive a spider 63 provided with rotatable heads 64 for holding the bulb and mount in proper relation during sealing in. Each head at all positions except the loading posi-

tion is rotated with the neck of the bulb within range of the sealing-in fires 65.

The sealing-in fires heat the glass at the various positions and at the final position weld the mount into the neck of the bulb. The bulb is steadied and the surplus neck pulled off by a pivoted fork 66. Each head may be rotated by a friction wheel 67 which engages friction wheels 68 when the spider is stationary the wheels 68 being driven by gearing 69 from the continuously running shaft 21. Each head has a vertically movable tubular mount carrier 70 which holds the mount and which may be constructed in well known ways for instance, as shown in United States patent to James E. Marshall, No. 1,475,192, November 27, 1923.

This mount carrier is lowered at the loading position to permit easy insertion of the mount, and is automatically raised at the other positions as its lower end rides up on a circular cam track 71 which extends under all the positions of the heads except the loading position. After the head leaves the final position the lower end of the mount 70 runs off the end of the cam track 71 into a control fork 72 which takes hold of it and lowers the mount carrier thereby leaving the sealed in lamp free. The control fork is actuated by a rock lever 73 from a cam 74 on the shaft 21.

An important feature of my invention is the use of a substantially gas free bulb. The mount arrives at the sealing in machine with all of its glass parts substantially free from strains and from water vapor and occluded gas, due to the short intervals between the various stem making operations and the quick transfer of the stem to the sealing-in machine. I may use cold bulbs made and stored in the usual manner by subjecting the bulbs and the other glass parts to a very thorough heating on the sealing-in machine. If the bulb is substantially free from gases and water vapor the heating caused by the sealing-in operation during which a zone on the neck of the bulb is heated until the glass is plastic will be sufficient, but for bulbs of the usual sizes and quality additional heat is necessary to produce the highest quality of lamp.

In accordance with my invention all parts of the bulb are very thoroughly heated during the sealing-in operation and before the neck of the bulb collapses upon the flare of the mount, thereby causing the occluded gases and water vapor to be driven out of the walls of the bulb and to mingle with the air, in the bulb. This air being strongly heated, expands and much of it passes out of the bulb while the neck is of full size so that the escape of the heated air with its entrapped gases and water vapor is practically unobstructed. By the time the bulb reaches the final position where the final fires cause the neck to collapse upon the flare and be welded to it, the

bulb contains only attenuated heated air and the walls are practically free from gases and water vapor. In addition the intensely heated air in the bulb heats the stem and hub of the mount, thereby not only maintaining the temperature of the glass parts of the mount but raising their temperature until they are extremely hot. This additional heat may be supplied in various ways, but I prefer to use auxiliary burners such as the burners 75 best shown in Figure 5 so arranged that in each of four positions and before its neck has collapsed the bulb is subjected to a well distributed hot flame which heats the body of the bulb very thoroughly. In addition, in the final position, I further heat the bulb by means of an auxiliary burner 76 which directs its flame upon that part of the neck between the zone rendered plastic by the sealing-in fires and the body of the bulb. A very complete and uniform heating of all parts of the bulb and of the mount is thus obtained. The auxiliary burners 75 and 76 may be supported in any convenient way, as for example, by means of the supply pipe 77. By means of these auxiliary burners I raise the temperature of all of the glass parts of the lamp to about 310° C. when the lamp is finally sealed in at the final position and at this temperature all of the glass is practically free from gases and water vapor. Without the auxiliary burners enough water vapor might remain in the glass to injure the quality of the lamps.

The sealed in lamps while still extremely hot are taken from the sealing-in machine by the operator at station X. The hot lamps are handled by tongs or in some similar manner, and are transferred directly and as quickly as possible to the exhaust machine D where the air is quickly exhausted from the lamp so that it is free from air, water vapor, and injurious gases. If the lamp is a vacuum lamp it is then sealed off or if it is a gas filled lamp is exhausted, filled with some inert gas, such as argon, and then hermetically sealed. In either case the deleterious gases and water vapor are driven out of the glass and removed from the lamp before the bulb is sealed off. No oven or similar heating means on the exhaust machine is required as by my invention the lamps arrive at the exhaust machine hot enough for exhaust. This is a marked advantage and causes a marked saving in cost of machinery, and reduces the shrinkage due to heating up sealed-in lamps which have become cold.

The particular type of exhaust machine D which I prefer to use is driven by the drive shaft 23 through spiral gears 78, and consists essentially of a flat valve 79 provided with a series of ports equally spaced on the circumference of a circle as indicated in Figure 1 and cooperating with a flat valve seat 80 also provided with ports arranged with the same

radial and circumferential spacing as the ports in the valve so as to register with them. As shown in Figure 2, each port in the valve is connected to a tube holder 81 for holding the exhaust tube of the lamp. The particular machine illustrated in the drawing is suitable for manufacturing gas filled lamps and the valve is provided with twelve ports so arranged with reference to nine similar ports in the valve seat 80 that as the valve makes one revolution any one port registers in succession with the nine ports in the valve seat and then passes through three idle positions where it does not register with any ports at all. These idle positions provide one unloading and two loading positions.

The valve 79 rotates step by step in a counter-clockwise direction, and the hot lamp direct from the sealing-in machine C is placed in the exhaust machine by inserting the exhaust tube 17 in an exhaust tube holder 81 at one of the idle positions *j* and *k*. If the flat valve 79 is moved intermittently and step by step from the driving shaft 23 the lamp eventually comes to the first active position *L* where it is connected to the exhaust pump 82 and in this position the air is exhausted from the bulb. By the next step the valve carries the lamp to the second active position *m* where the lamp is connected to a leak detector 83 or some similar device for showing whether the lamp leaks. The next step brings the lamp to the third active position *n* where it is filled with nitrogen from a nitrogen supply manifold 84.

At the next four positions *o*, *p*, *q*, and *r* it is connected alternately to the pump and to the nitrogen supply and finally in the eighth active position *s* to the pump 82. By this time the lamp has been thoroughly washed out with nitrogen, and all of the water vapor and deleterious gases driven out of the lamp have been completely removed. The next step carries it to the ninth active position *t* where it receives a charge of argon through an argon supply pipe 85 and at the same time the exhaust tube is heated to some extent by a preliminary torch 86. In this figure the lamps connected to the pump are marked P, those connected to the nitrogen supply are marked N and that connected to the argon is marked Ar.

The lamp is now ready to be sealed off and at the next step it comes to the idle position *u* where its ports is on a blank part of the valve seat 80 and consequently the charge of argon is trapped and held in the lamp. In this final position it is sealed off in any suitable manner, preferably by an automatic tipping off device which consists essentially of a tipping off torch 87 indicated more or less diagrammatically in Figure 6, and constructed to melt the contraction of the exhaust tube, thereby hermetically sealing the lamp. A pivoted lifting fork 88 provided

with a weight 89 engages the bulb in the sealing off position and raises it a short distance when the exhaust tube is melted at the contraction.

The tipping off torch 87 and lifting fork 88 are raised and lowered bodily by some automatic mechanism. They may, for example, be mounted on a vertically reciprocating rod 90 actuated by a rocking lever 91 from a cam 92 on the drive shaft 21. As the rod 90 rises the fork 88 engages the bulb and further upward movement of the rod raises the weight 89, which is then ready to raise the bulb as soon as the exhaust tube is melted at the contraction, leaving the stub of the tube in the holder 81. The automatic sealing off mechanism is the same in principle as that disclosed in my U. S. Patent No. 1,013,124, January 2, 1912.

After the lamp has been sealed off and lifted by the lifting fork 88 from the stub of the exhaust tube the valve 79 moves to the next idle position *j* and during this movement the stub of the exhaust tube is caught by a stationary finger 92 and pulled out of the tube holder 81 as indicated in Figure 7. The thick walled rubber tubing used in the tube holder is so mounted as to be flexible and yielding enough to permit this action to take place.

When the machine is to be used for making vacuum lamps the ports in the valve seat may be connected to the pumps in various ways, as will be obvious to those skilled in the art. For instance, the ports at positions *s* and *t* may be connected to the final pump and those at position *n*, *p*, and *r* to a source of hot dry air, instead of nitrogen, to give the lamps a dry air wash during exhaust; or the ports at positions *n* and *o* may be connected to the preliminary pump and those at *p* and *q* to the final, the tipping off torch being placed at position *q* and either some provision made for carrying the sealed off lamps to the basing operator at station X or the stations Y and Z placed in the same side of the table as the pump 84 to enable the operator at station Y to take the lamps sealed off at position *q*. Suitable connections of the ports to the pumps for exhausting the lamps are disclosed in U. S. patent to Massey, 996,936, July 4, 1911, and in my U. S. Patent, 1,013,124, January 2, 1912.

The sealed off lamp is taken off by the operator at station Y who applies to it a metal base lined with soft cement and places the leading-in wires properly on the base. The lamp and base is then placed in the basing machine E which is driven through spiral gears 93 from the drive shaft 23 and consists essentially of a horizontal wheel 94 having an iron rim 95 provided with a series of pockets 96 which receive the bases of the lamps. Each pocket is heated during its travel to bake the cement and is then cooled.

This may be done in many ways. In the machine shown the pockets are carried by the intermittent rotation of the rim between two semi-circular concentric gas burners 97 which are supported by the supply pipes 98 and heat each pocket 96 and the base in it to bake the cement which fastens the base to the bulb. In this particular machine each pocket is within range of the burners for 8 positions and then for the next 6 positions it is between two concentric air pipes 99 which are carried by the supply pipe 100 and direct cooling air upon the pocket. By the time the lamp has completed one circuit of the basing machine and returned to the loading position, the base has been baked on and the lamp is ready to be removed. The lamps are held with the bases in the sockets by some suitable holders such as the vertically movable holders 101 provided with springs 102 to yieldingly hold the bases in the sockets and the bulbs in the bases until the cement hardens.

The based lamp is removed from the basing machine, the leading-in wires soldered to the base with a soldering torch 103, and the lamp then placed in the flash aging machine F which automatically passes certain amounts of current for certain lengths of time through the filament of the lamp to age it. The particular type of flash aging machine shown is a rotary machine driven through gears 104 from the drive shaft 23 and comprises an intermittently rotating table 105 provided with sockets 106 connected as shown diagrammatically in Fig. 8 to a supply circuit. The connections are such that as the table 105 rotates in clockwise direction the lamp is connected in succession through the resistances 107, 108, 109, 110, so proportioned that successively greater amounts of current pass through the filament. As the lamp completes the circuit and returns to its initial position the operator at station Z whose position is somewhat further to the left than is shown in Fig. 1 removes it from the flash aging machine, inspects it, and packs it whereupon it is ready to be put into stock.

All of the lamp making devices from A to F are driven by common drive shaft 23 which keeps them all in step and synchronism. I may so time the machine that the stem making machine A and the hook inserting machine B run about 10% faster than the remainder of the machine to allow for some slight losses in the mount making operations. The sealing-in machine C, exhaust machine D and basing machine E, and aging machine F, may to advantage be timed to move from one position to the next every 15 seconds so that if no losses are incurred the output of each machine is four lamps per minute.

The operation of my machine will be evi-

dent from the above description. All of the operations are conducted in a definite and fixed synchronism and time relation to the other operations and all lamp parts are transferred directly and immediately from one operation to the next. No stock accumulates between machines or operations and all operations and transfers are conducted with such speed that the glass in the interior of the lamp does not become contaminated by water vapor and occluded gases because of the speed with which the lamp has been assembled and the bulb has been sealed. Even after the lamps have been washed out with nitrogen on the exhaust machine D, filled with argon and sealed off, they are still too hot to handle with bare hands, while the temperature of all of the glass at the time the lamps are first connected to the pump 84 is usually in the neighborhood of 300° C.

The machine is a portable self contained unit capable of performing all the operations necessary to assemble a finished lamp. The pumps and similar parts may be mounted on the machine, as on a shelf or angle iron 110, and the table may be provided with castors to make it readily movable. The operators are so close together and all operations are conducted with so little delay between them that if the finished lamps are defective in any respect the trouble is immediately located and remedied before more than a few defective lamps are made.

I have described my improved process as applied to the manufacture of incandescent electric lamps but my invention is equally valuable in the manufacture of any similar device particularly one which has a glass bulb with a mount or interior structure containing glass.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The process of making an incandescent lamp or similar article which comprises joining a glass stem to metal wires by fusing parts of the stem and thereby heating all the glass until it is substantially moisture and gas free, securing a filament to said wires before the glass becomes cool enough to accumulate a harmful amount of moisture whereby a substantially moisture free mount is obtained, sealing said mount while still substantially moisture free into a bulb, heating the bulb hot enough to render it substantially moisture free, removing the air from the sealed in bulb while it is still hot, and sealing off the bulb while free from air.

2. The process of making an incandescent lamp or similar sealed device containing a filament supported by wires embedded in a glass stem which comprises heating part of the glass stem until it is plastic and thereby heating the remainder of the stem to a temperature such that all the glass of the stem is substantially moisture free, embed-

ding wires in the plastic glass, mounting a filament on the embedded wires while the glass of the stem is still hot enough to be substantially free from moisture, sealing the
5 freshly made mount while still hot enough to be substantially moisture free into a glass bulb by welding by fusion another part of the glass stem to the neck of said bulb, heating said bulb while it is filled with air to raise
10 all the glass of said bulb to a temperature at which it is substantially moisture free, exhausting the air from said sealed in bulb while it is still hot, and hermetically sealing off the bulb while free from air.

15 3. The process which comprises heating one end of a glass stem tube to produce a hot plastic mass of glass and embedding wires in said hot plastic mass of glass, mounting a filament on said wires while said mass is so
20 hot that it is substantially moisture free, sealing the other end of said stem tube into the neck of a glass bulb by fusion while said glass mass is still so hot as to be substantially moisture free, imparting to said bulb prior
25 to and during the sealing-in of the stem and while the bulb is open sufficient heat additional to that used for sealing in to bring all of the bulb to a high temperature and render it moisture and gas free, exhausting the air
30 from said sealed in bulb without further heating and while it is still hot from the sealing-in, and sealing off the bulb while free from air.

In witness whereof, I have hereunto set my
35 hand this 22d day of July, 1925.

WILLIAM R. BURROWS.

CERTIFICATE OF CORRECTION.

Patent No. 1,736,767.

Granted November 19, 1929, to

WILLIAM R. BURROWS.

It is hereby certified that the above numbered patent was erroneously issued to the inventor said "Burrows" whereas said patent should have been issued to "General Electric Company, a Corporation of New York", said corporation being assignee of the entire interest in said invention, as shown by the records of assignments in this office: In the heading to the drawings, sheets 1 and 2, strike out line 3, and insert instead "Original filed June 14, 1922"; In the heading to the printed specification, strike out line 4, application filed clause, and insert "Original application filed June 14, 1922, Serial No. 568,166. Divided and this application filed July 27, 1925, Serial No. 46,204. Renewed April 25, 1929"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of January, A. D. 1930.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.