March 27, 1928. 1,664,136

G. R. SHAW ET AL.

METHOD AND APPARATUS FOR TREATING FILAMENTS

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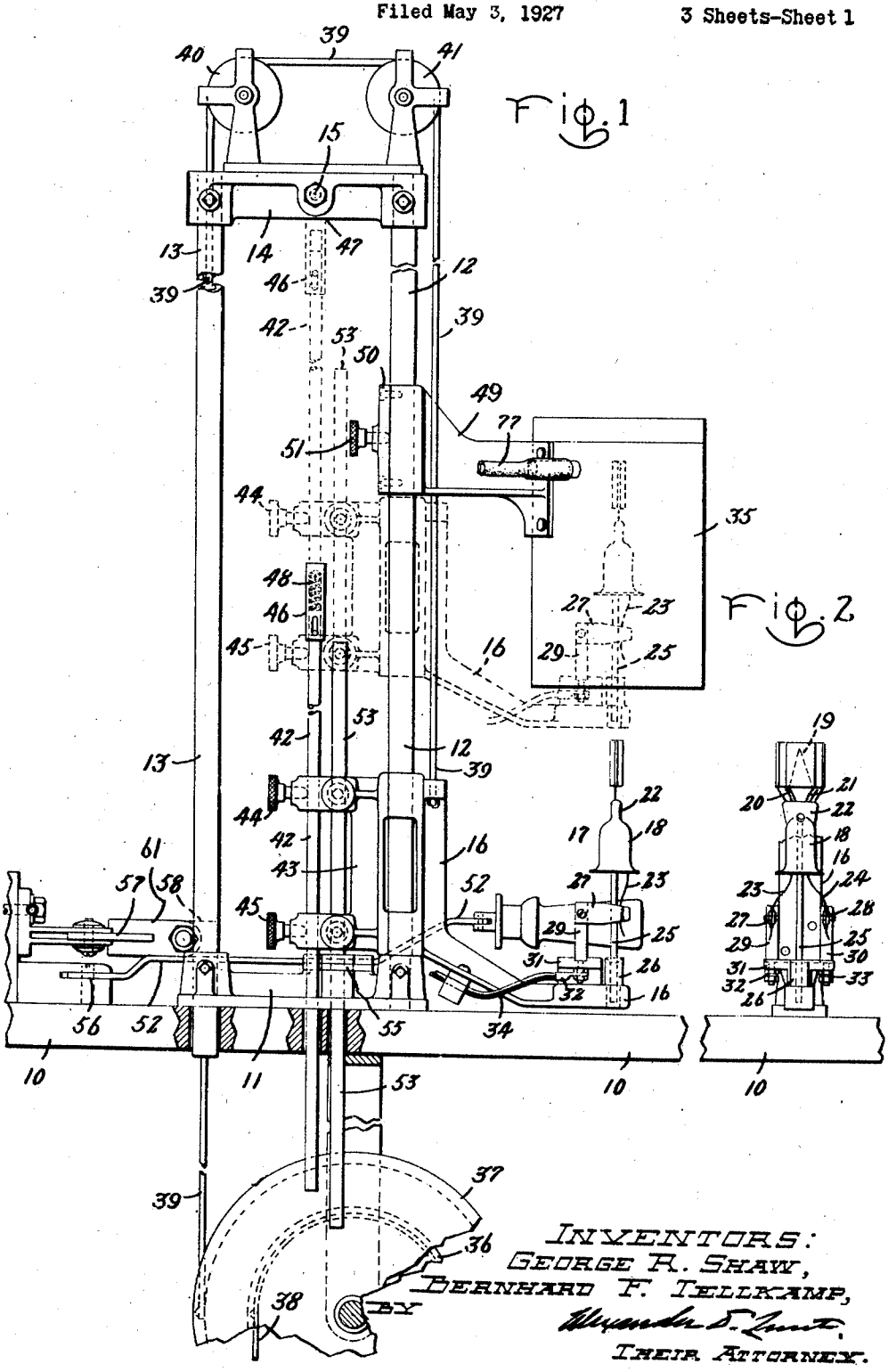

Fig. 1

Fig. 2

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Fig. 3

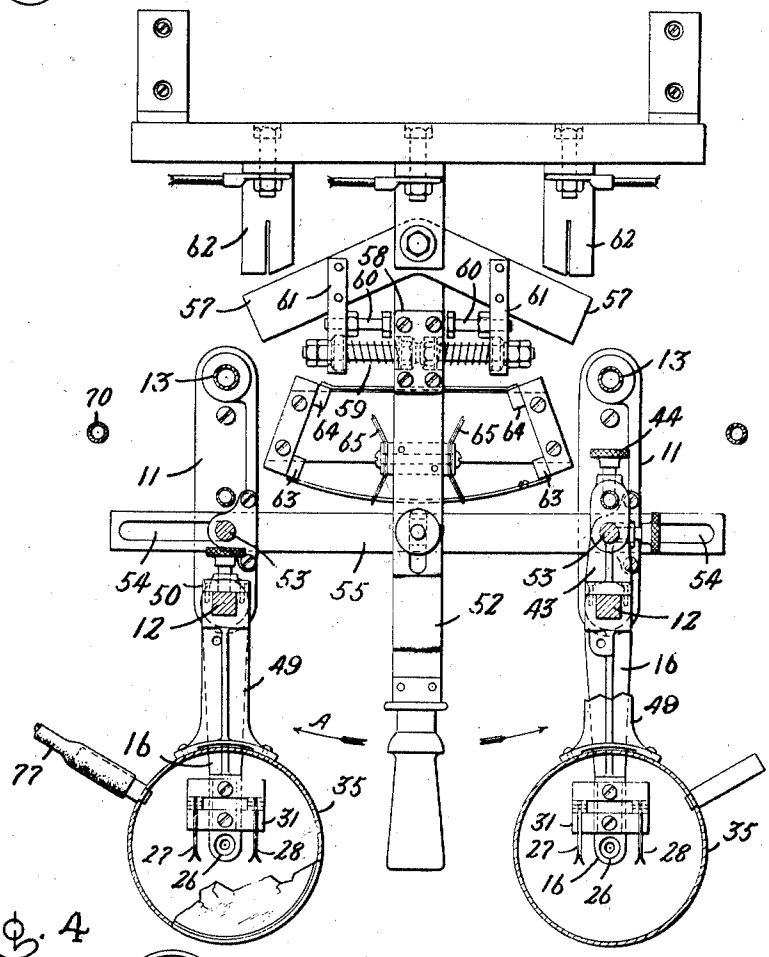
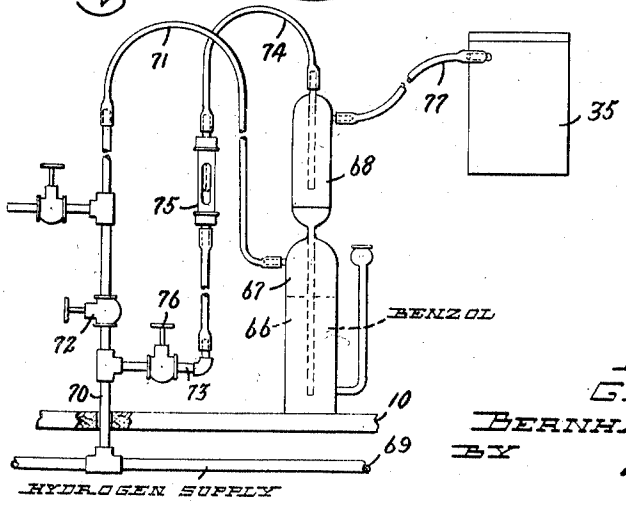


Fig. 4



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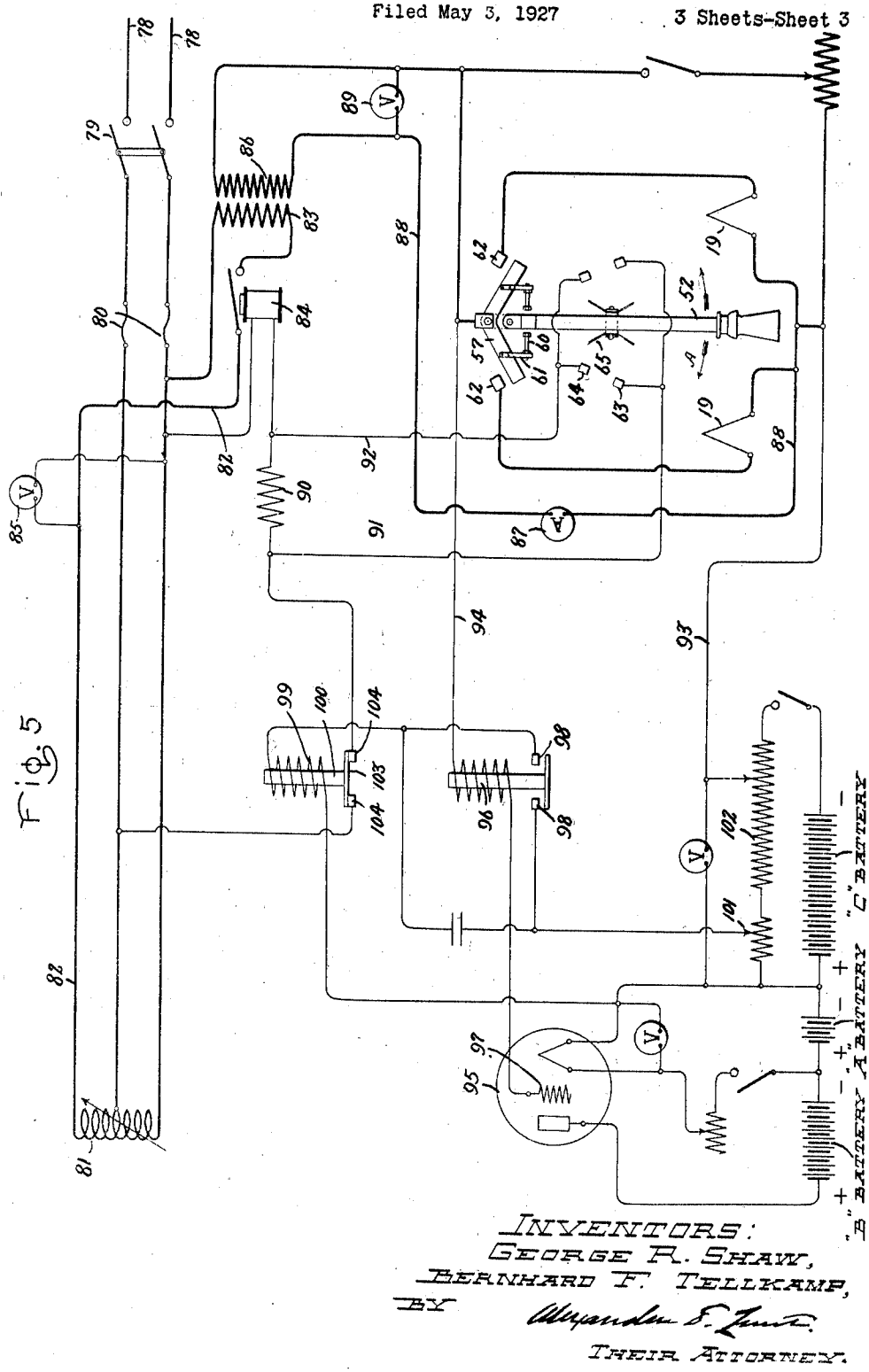

Fig. 5

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METHOD AND APPARATUS FOR TREATING FILAMENTS.

Application filed May 3, 1927. Serial No. 188,550.

Our invention relates to methods and apparatus for incorporating a non-metallic element with a metallic filament, and more particularly to such methods and apparatus for the incorporation of elements such as carbon in filaments for so-called vacuum tubes. Still more particularly our invention relates to methods and apparatus for the incorporation of carbon in filaments consisting principally of tungsten. According to our invention the filament is exposed while in an incandescent state in an atmosphere of a vapor of gas containing the carbon, and the carbonization is automatically stopped when the desired amount of carbon has been incorporated. Since the carbonization causes an increase in resistance of the filament, this is utilized to control the energy supplying circuit. According to the preferred form of our invention, means are provided whereby while one filament is being carbonized, another filament may be mounted, and accordingly a portion of our apparatus is in duplicate. We prefer to utilize a vacuum tube in the control circuit on account of its sensitiveness. In the preferred form the current supply to the filament is maintained constant and the voltage increases as the resistance increases. The vacuum tube is included in the circuit so that there is impressed on the grid a voltage corresponding to that across the filament. The grid is given a negative bias, and when the voltage impressed on the grid is greater than the negative bias, the supply to the filament is interrupted. Further features and advantages of our invention will appear from the detailed description of a species thereof.

In the accompanying drawings Fig. 1 is a fragmentary side elevation of a machine embodying our invention; Fig. 2 is a fragmentary front elevation of a portion thereof; Fig. 3 is a fragmentary plan view partially in section; Fig. 4 is an elevation of the hydrogen and benzol supply apparatus; and Fig. 5 is a wiring diagram of electrical connections.

Referring to the drawings, and more particularly to Figs. 1 to 3 inclusive in which is shown one form of apparatus for carbonizing filaments in accordance with our invention, a base or table 10 is provided with suitable frame work comprising a pair of lower brackets 11 each of which has extending upwardly therefrom front and rear supporting rods 12 and 13 respectively, the upper ends of which are bridged by a pair of upper brackets 14 rigidly supported by means of a tie rod 15. Slidably mounted on each of the supporting rods 12, which are preferably square in cross section, are holders 16 each of which is adapted to receive a mount 17 comprising a stem 18 and the filament 19 which is to be treated. As shown, the said filament is mounted upon the upper ends of a pair of conductive supports 20—21 which extend through the flattened glass portion 22 of the stem. Current is supplied to the filament 19 through the leading-in conductors 23—24 which are connected to the lower ends of the conductive supports 20—21. As shown, the stem is of the tipless lamp type such as disclosed in Mitchell and White Patent No. 1,423,956 and has the usual depending exhaust tube 25.

Prior to operating our apparatus, a mount 17 is placed on one of the holders 16 where it is supported in a substantially vertical position through its exhaust tube 25 which in turn is supported by a cup 26 forming part of the holder. The leading-in conductors 23—24 are placed in contact clips 27—28 carried by the posts 29—30 extending from the insulating block 31. The lower ends of these posts are electrically connected to an electric supply circuit through their terminals 32—33 which receive the conductors 34. The mount being properly placed upon the holder 16, and its leading-in conductors connected to the electric supply circuit, the said holder is raised to the position shown in dotted lines in Fig. 1 so as to position the mount inside of a treating chamber 35. The raising of the holder 16 is accomplished by means of a foot pedal (not shown) which when depressed causes a rotation of a pair of discs 36—37, the smaller disc 36 being connected to the foot pedal through the cord 38 and the larger disc 37 being connected to the holder 16 through the cord 39 which extends up through the rear supporting rod 13 and over a pair of pulleys 40—41. The upward movement of the holder is limited by means of a stop rod 42 which extends

through the back plate 43 attached to the holder. The stop rod 42 is adjustably supported in the plate 43 by means of the thumb screws 44—45 and carries on its upper end a plunger 46 which, on its upward movement, strikes against a stop 47 formed on the bottom of upper frame bracket 14 and the impact of the said plunger is cushioned by the spring 48. Each of the treating chambers 35 is adjustably supported on a rod 12 through a bracket 49 which is attached to a plate 50 which in turn is clamped to the rod 12 by a thumb screw 51.

The filament now being properly positioned within the treating chamber 35, a switch lever 52 is moved in the direction of the arrow (A) Fig. 3 so as to close the electric circuit thus allowing current to flow through the filament in order that it may be heated in the presence of carbon contained in a mixture of benzol and hydrogen which is continuously flowing through the treating chamber 35. However, prior to the raising of the holder 16, the switch lever 52 is locked by means of a pair of vertical interlocks 53. This prevents the current from being applied to the filament and injuring it while it is in the air. These vertical interlocks 53 are carried by the holders 16 and are arranged so as to extend through slots 54 formed into a horizontal interlock 55 carried by the switch lever 52. When one of the holders 16 is raised its vertical interlock is withdrawn from its slot in the horizontal interlock thereby allowing the switch lever to be moved in the direction of the raised holder. As shown in Fig. 1, the switch lever 52 is pivotally mounted at 56 and operates a switch blade 57 through an insulated block 58 carried by the said lever. As the lever is moved in the direction of the arrow (A), it compresses a spring 59 and a continued movement of the lever causes the block 58 to strike a rod 60, said rod being carried by a post 61 extending from the switch blade 57. The lever is moved until one arm of the blade is forced into the contact 62 thereby closing this switch, the last of the movement of the lever closing another switch momentarily. The latter switch comprises the contacts 63—64 which are bridged by the fingers 65 carried by the lever 52. As pressure is removed from the lever, the spring 59 having been previously compressed forces the lever outwardly thereby carrying the fingers 65 away from the contacts 63—64 so as to re-open this circuit. But during this short period of contact a magnetic switch, hereinafter described, which is normally open is caused to close thus allowing current to flow through the filament. During the heating of the filament the current is maintained constant so that the increasing resistance of the filament, due to the absorption of carbon thereby, will cause an increasing voltage across it, and when the voltage reaches a certain value a relay is operated which causes the magnetic switch to again open thereby cutting off the supply of current to the filament and thus automatically stopping the carbonization process. During this time the blade 57 has remained in the contact 62 and is now withdrawn.

In Fig. 4 is shown the apparatus for supplying hydrogen and benzol to the treating chambers 35. A supply of benzol 66 contained in the bottle 67 is forced up in a mixer 68 to the proper working level by pressure derived from the hydrogen supply line 69. Hydrogen passes through the pipe 70 and flexible tubing 71 to the top of the bottle 67, the proper level of benzol being obtained by manipulating a valve 72. The hydrogen which is to carry the benzol to the treating chamber 35 comes from the supply line passing through pipes 70—73 which leads to the mixer 68 through a flexible tubing 74. A gauge 75 is placed in the path of this hydrogen so as to determine its rate of flow to the bottle 68, said flow being regulated by the valve 76. A mixture of hydrogen and benzol passes from the mixer 68 to the treating chamber 35 through the flexible tubing 77.

Referring to the wiring diagram shown in Fig. 5, current is supplied to the apparatus from a 110 v. 60 cycle A. C. line passing through conductors 78, switch 79 and fuses 80. The current is controlled by an induction regulator 81 which is of the buck and boost type. The output of the regulator passes through conductor 82 which is connected to the primary 83 of a constant current transformer through a magnetically operated switch 84 and a voltmeter 85 is connected across the primary supply to this transformer. The primary voltage may be held constant at any desired value by operating the regulator 81. The secondary 86 of the transformer is connected through an ammeter 87 to the terminals of the filaments 19, one of which is in circuit at a time. A voltmeter 89 is connected across the secondary 86 of the transformer so as to indicate the voltage drop across the filament in circuit while the ammeter 87 indicates the heating current.

In operation a mount is placed in one of the holders 16 and the leading-in wires 23—24 of the filament are attached to the contact clips 27—28. By depressing a foot pedal (not shown), the holder is raised so as to bring the mount and its filament within one of the treating chambers 35 such as shown in dotted lines in Fig. 1. Within this chamber the filament is heated in the presence of carbon contained in benzol vapor, a carrier such as hydrogen being used to allow a low con-

centration of this vapor at atmospheric pressure to continuously flow into the treating chamber through tube 77. By moving the switch lever 52 in the direction of the raised holder, the switch blade 57 is forced into its contact 62 and a continued movement of the lever 52 causes the fingers 65 carried thereby to bridge the contacts 63—64 thereby short circuiting the resistor 90 through the conductors 91—92 so as to close the magnetic switch 84. The removal of the hand from the lever 52 causes the spring 59 to force the lever outwardly carrying the finger 65 away from the contacts 63 and 64 so as to again open this circuit, the magnetic switch now being held closed by current passing through the resistor 90. The filament 19 is now heated by the secondary current which passes to it through conductor 88. During the heating of the filament its resistance increases according to the amount of carbon incorporated therewith and when this resistance arrives at a pre-determined value, the heating circuit is automatically broken stopping the carbonization process.

A special controlling apparatus and circuit is provided to stop the carbonizing process when the correct value of resistance is reached by the filament. This apparatus is connected directly across the filament by the conductors 93—94 and comprises a vacuum tube 95 with plate voltage of 22½ volts, filament voltage of 6 volts and an adjustable negative grid bias furnished as by a C battery. In this control circuit is included a 20 microampere relay indicated as 96 in series with the vacuum tube grid 97 and the filament 19 which is being carbonized. Thus the alternating voltage across the filament is impressed upon the grid 97 of the vacuum tube 95 and when the positive half cycle has a crest voltage greater than the negative bias which has been set on the grid of the vacuum tube, the grid will become positive and a current will flow in the grid circuit thereby operating the relay 96 so as to bridge the contacts 98 and to close the circuit. A circuit is then made through the coil 99 of the relay 100, voltage being supplied by a tap 101 on the grid bias potentiometer 102. This has the effect of shunting part of the grid bias potentiometer which lowers the grid bias, causing a greater grid current and a firmer closing of the contacts 98 of the relay 96 once even a partial contact has been made.

The relay 100 is normally closed but when the coils 99 are energized the bridge 103 is raised from the contacts 104 thereby breaking the holding coil circuit of the magnetic switch 84 causing it to open thus stopping the supply of current to the filament 19. Due to this failure of current, the coil 99 of the relay 100 is deenergized thus allowing the bridge 103 to drop upon the contacts 104. The reclosing of the relay 100 will not reclose the magnetic switch 84 as the current is limited by the resistor 90 in the switch holding coil circuit. This current is limited to such a value as will hold the switch closed when the resistor 90 is short circuited at the beginning of the carbonization process by momentarily bridging the contacts 63 and 64 through the contact finger 65 carried by the lever 52.

As the magnetic switch opens at the conclusion of each period, the operator moves the switch lever 52 toward the center of the apparatus to its normal position whereupon the holder 16 is lowered and the mount with its treated filament removed and a new mount inserted in its place. The carbonizing apparatus as shown is constructed in duplicate so that when one filament is being treated, another filament is being placed upon an opposite holder which is alternately raised into its treating chamber upon the completion of the filament under treatment and the switch lever 52 is moved in the direction of the raised holder so as to establish a circuit through the filament to start another cycle of operations.

The above cycle of operations can be performed by the apparatus repeatedly and accurately in less than three seconds if desired, the actual opening of the circuit by the relay system requiring less than one tenth of a second from the time the voltage arrives at the cut off valve until the contacts of the magnetic switch 84 have opened.

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

1. The method of combining a non-metal with a metallic filament which consists in exposing said filament while heated to incandescence to a gas containing said non-metal and controlling the duration of said exposure by the increase in resistance of said filament.

2. The method of combining carbon with a metal filament which consists in exposing said filament while heated to incandescence to a gas containing said carbon and controlling the duration of said exposure by the increase in resistance of said filament.

3. The method of combining carbon with a tungsten filament which consists in exposing said filament while heated to incandescence to a gas containing said carbon and controlling the duration of said exposure by the increase in resistance of said filament.

4. In an apparatus of the class described, the combination of a chamber containing a gas comprising a non-metal, means for supporting a filament therein, means for supplying current to said filament and means controlled by the increase in resistance of said filament for breaking the supply circuit when the proper amount of the non-

metal has been incorporated in said filament, said means comprising a vacuum tube having a grid and a relay actuated by variations in the grid circuit.

5. In an apparatus of the class described, the combination of a chamber containing a gas comprising a non-metal, means for supporting a metal filament therein, means for supplying current to said filament and means for breaking said supply circuit when the proper amount of said non-metal has been incorporated in said filament, said means comprising a vacuum tube having a grid, means for impressing on said grid the voltage of the supply circuit, means for imparting a negative bias to said grid and a relay actuated when the said negative bias is sufficiently overcome.

6. In an apparatus of the class described, the combination of a chamber containing a gas, means for supporting a filament, means for moving said support to bring said filament into said chamber, means for supplying current to said filament and interlocking means for preventing said supply while said filament is outside of said chamber.

7. In an apparatus of the class described, the combination of a chamber containing a gas, means for supporting a filament in said chamber, means for supplying current to said filament, a relay controlling said supply circuit, a resistance in said relay circuit means for short circuiting said resistance momentarily to cause said relay to close the supply circuit and means for immediately including said resistance again in the relay circuit, said resistance being proportioned so that sufficient current will pass through it in the relay circuit to keep the supply circuit closed but not sufficient to close it initially.

In witness whereof, we have hereunto set our hands this 30th day of April, 1927.

GEORGE R. SHAW.
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