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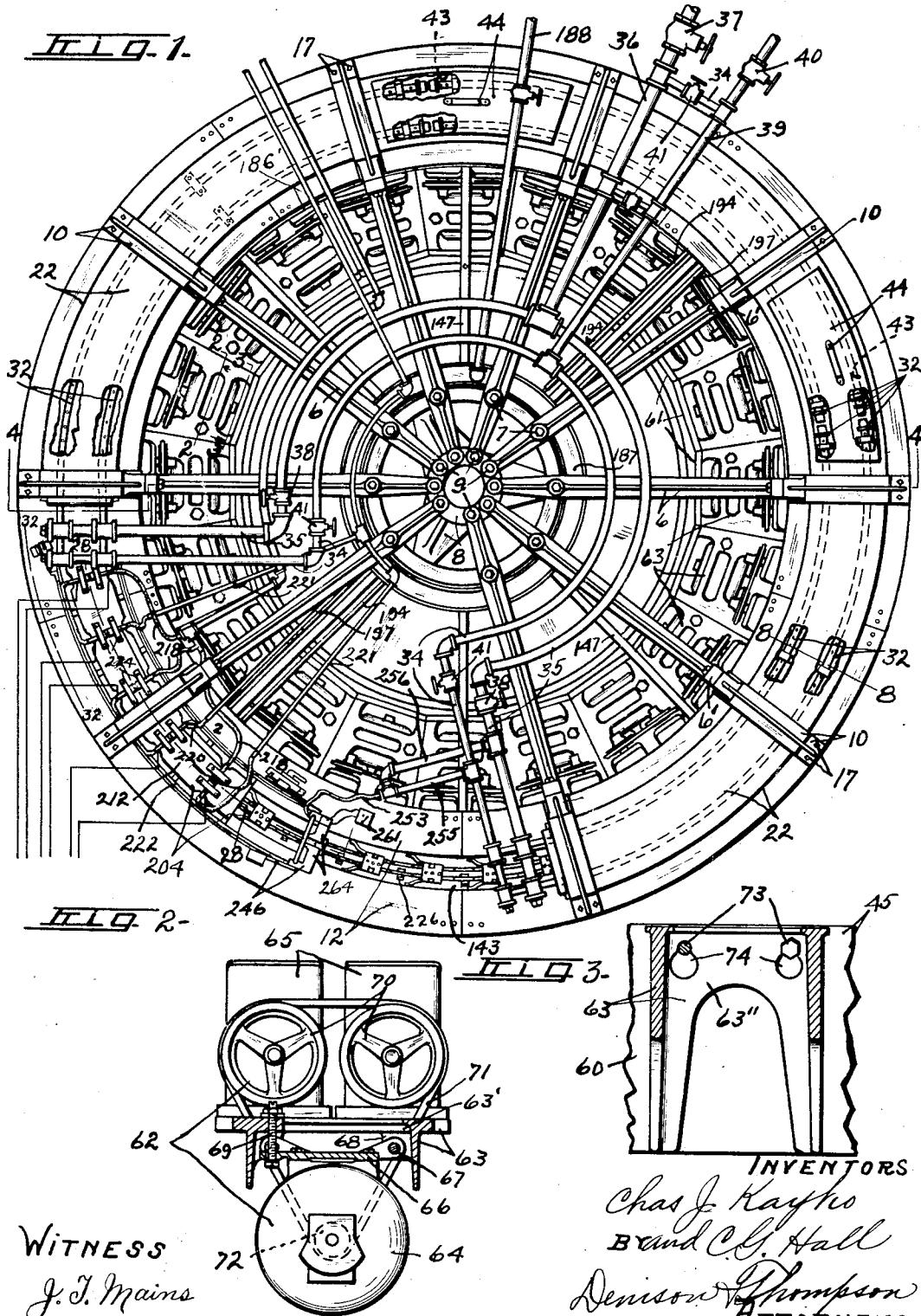
C. J. KAYKO ET AL

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ELECTRIC TUBE EVACUATING APPARATUS

Filed July 13, 1931

10 Sheets-Sheet 1



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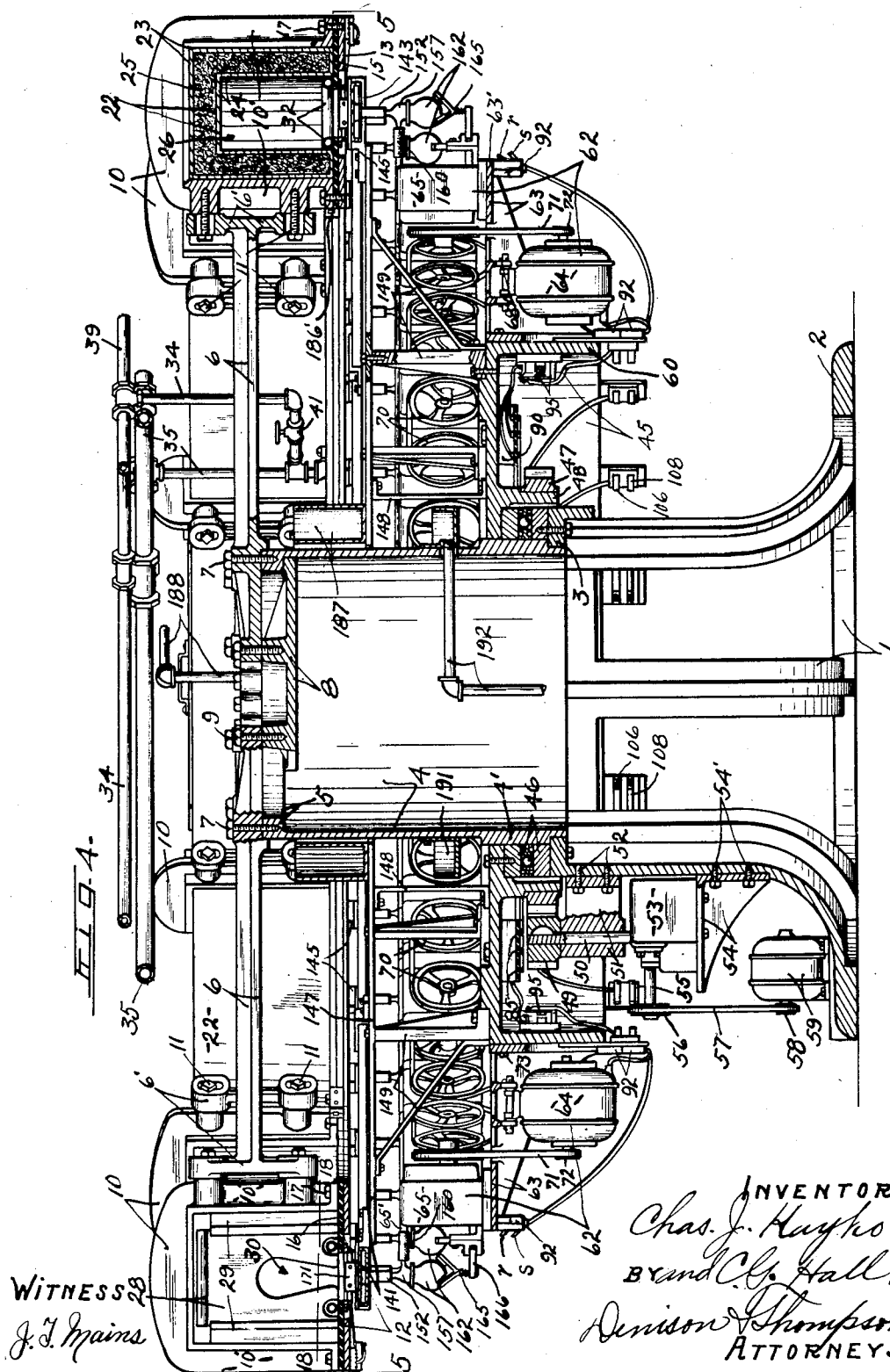
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10 Sheets-Sheet 2



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10 Sheets-Sheet 3

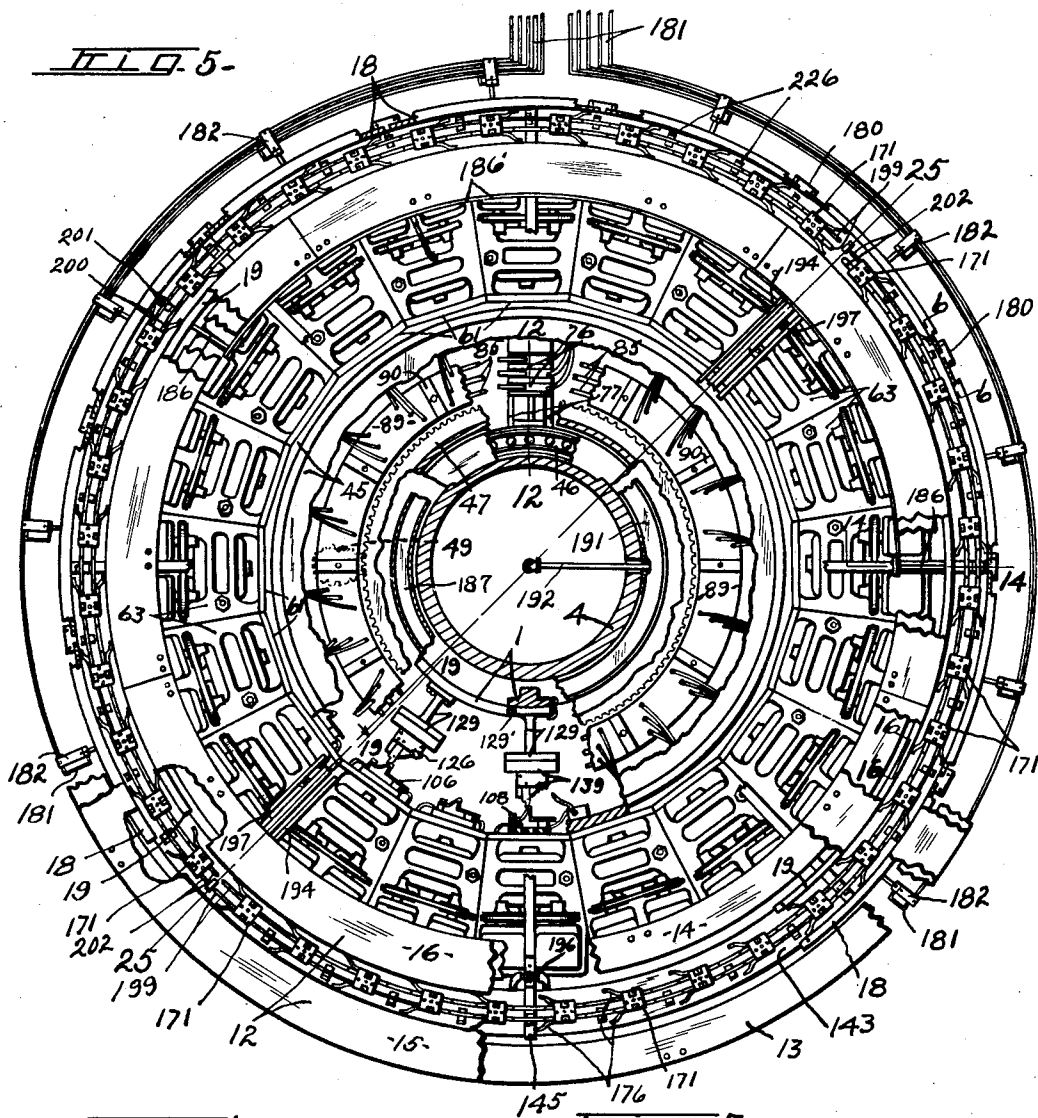
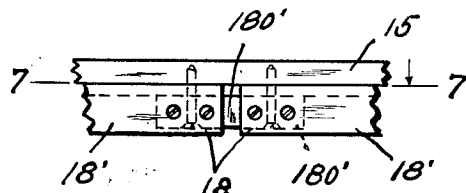


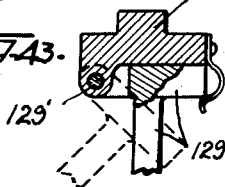
FIG. 6.



WITNESS

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FIG. 7.



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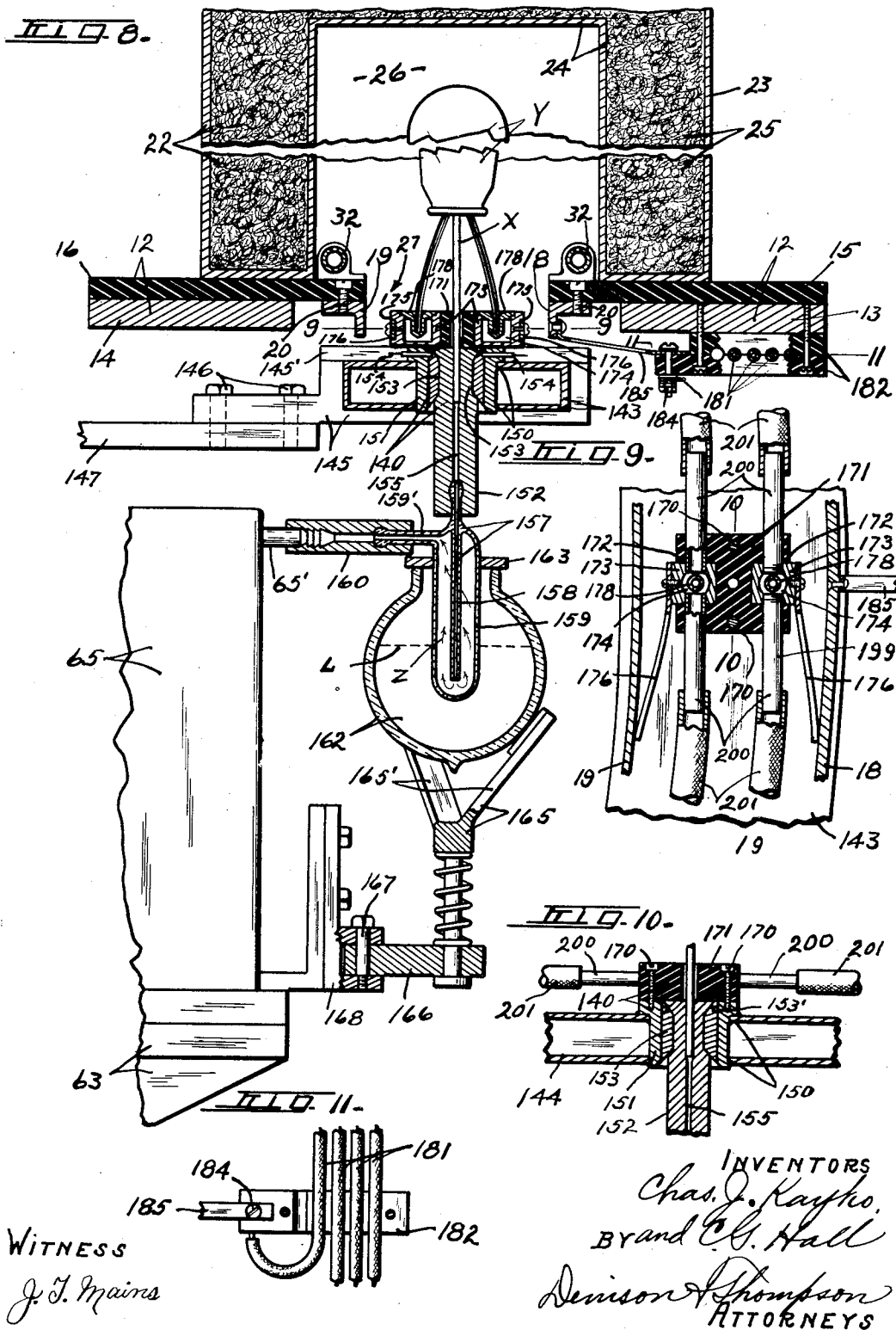
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ELECTRIC TUBE EVACUATING APPARATUS

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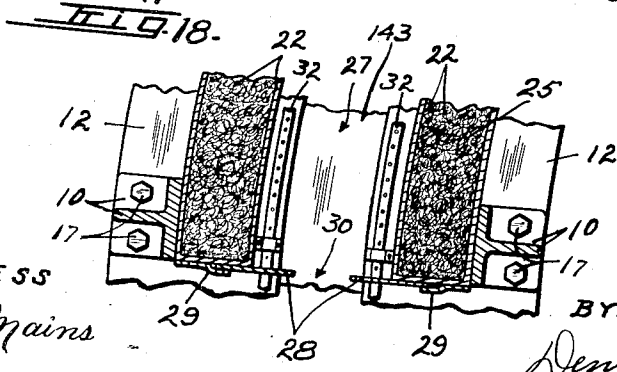
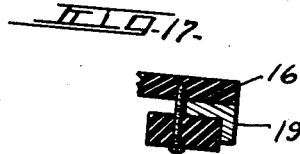
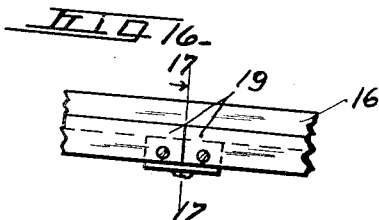
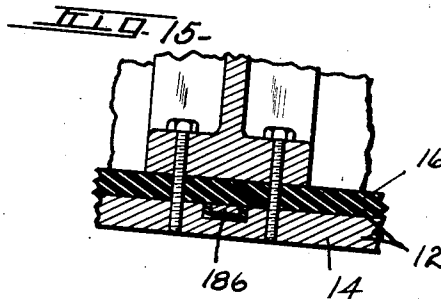
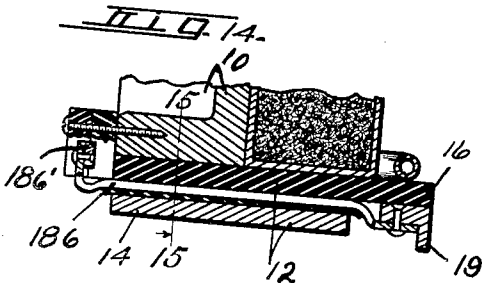
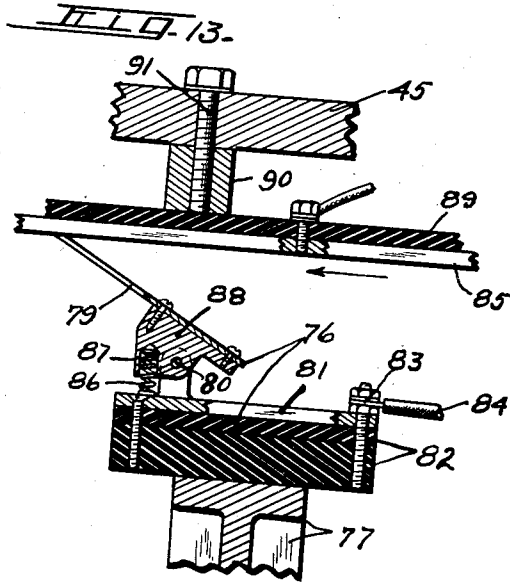
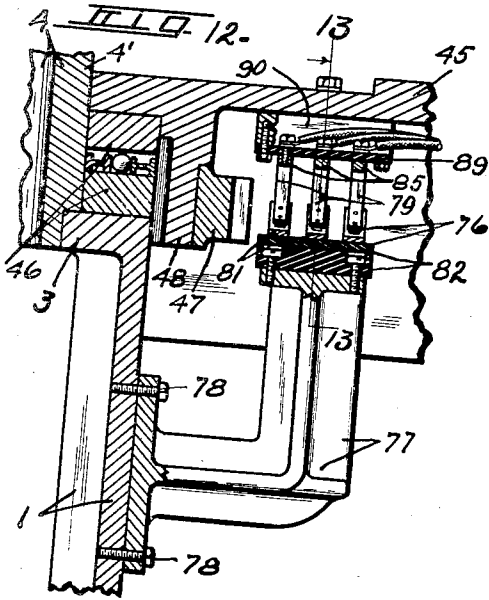
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10 Sheets-Sheet 5



WITNESS
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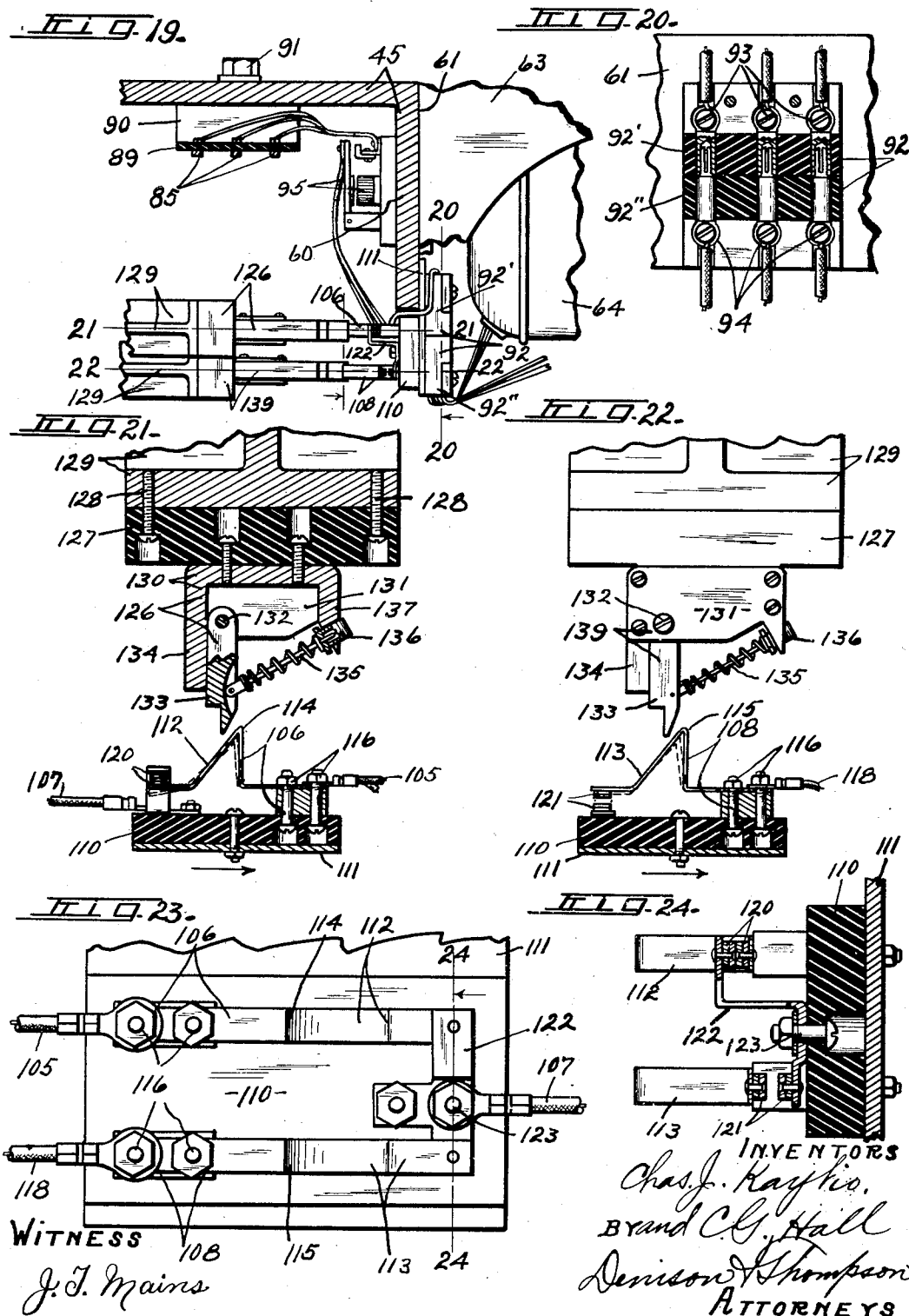
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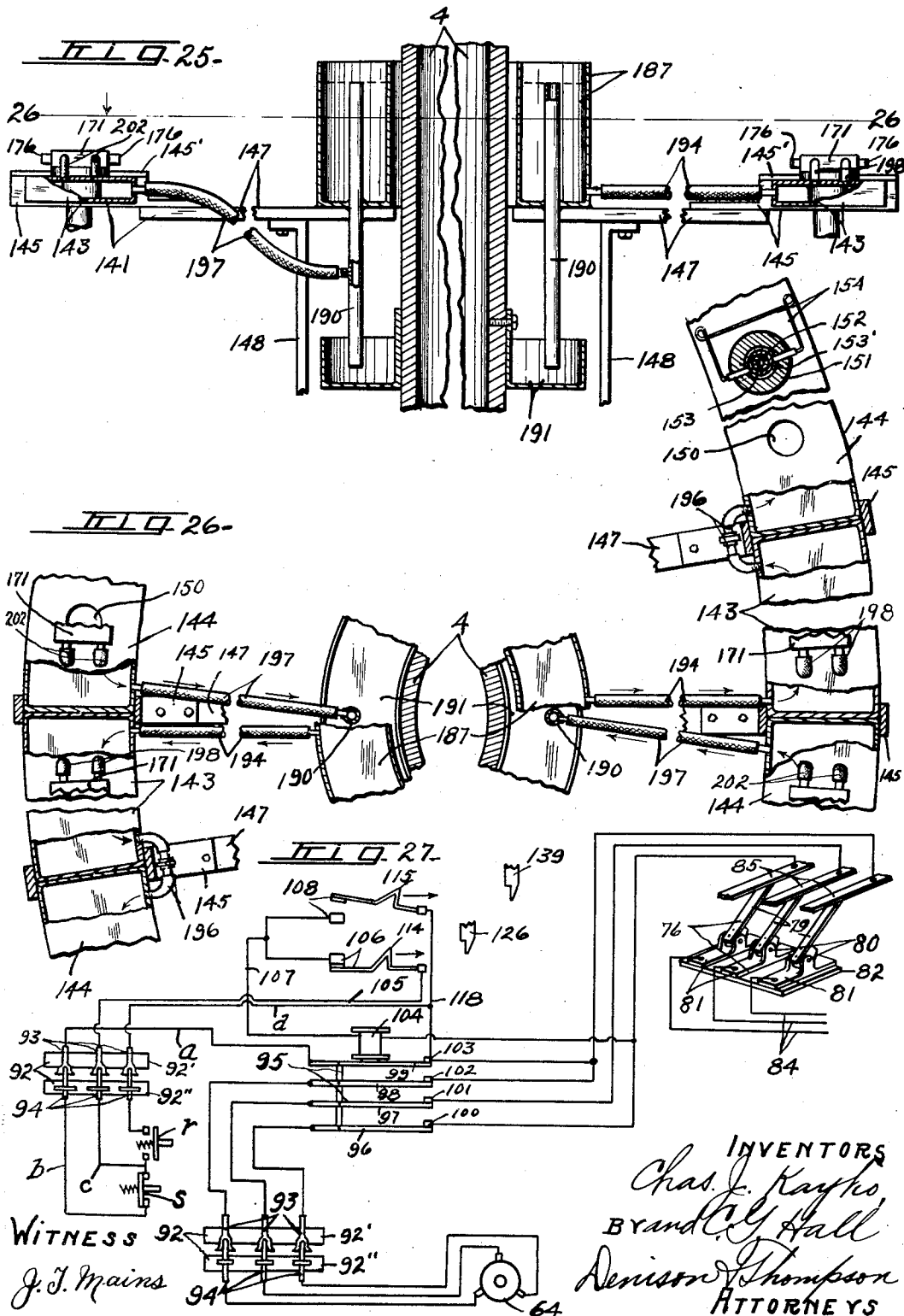
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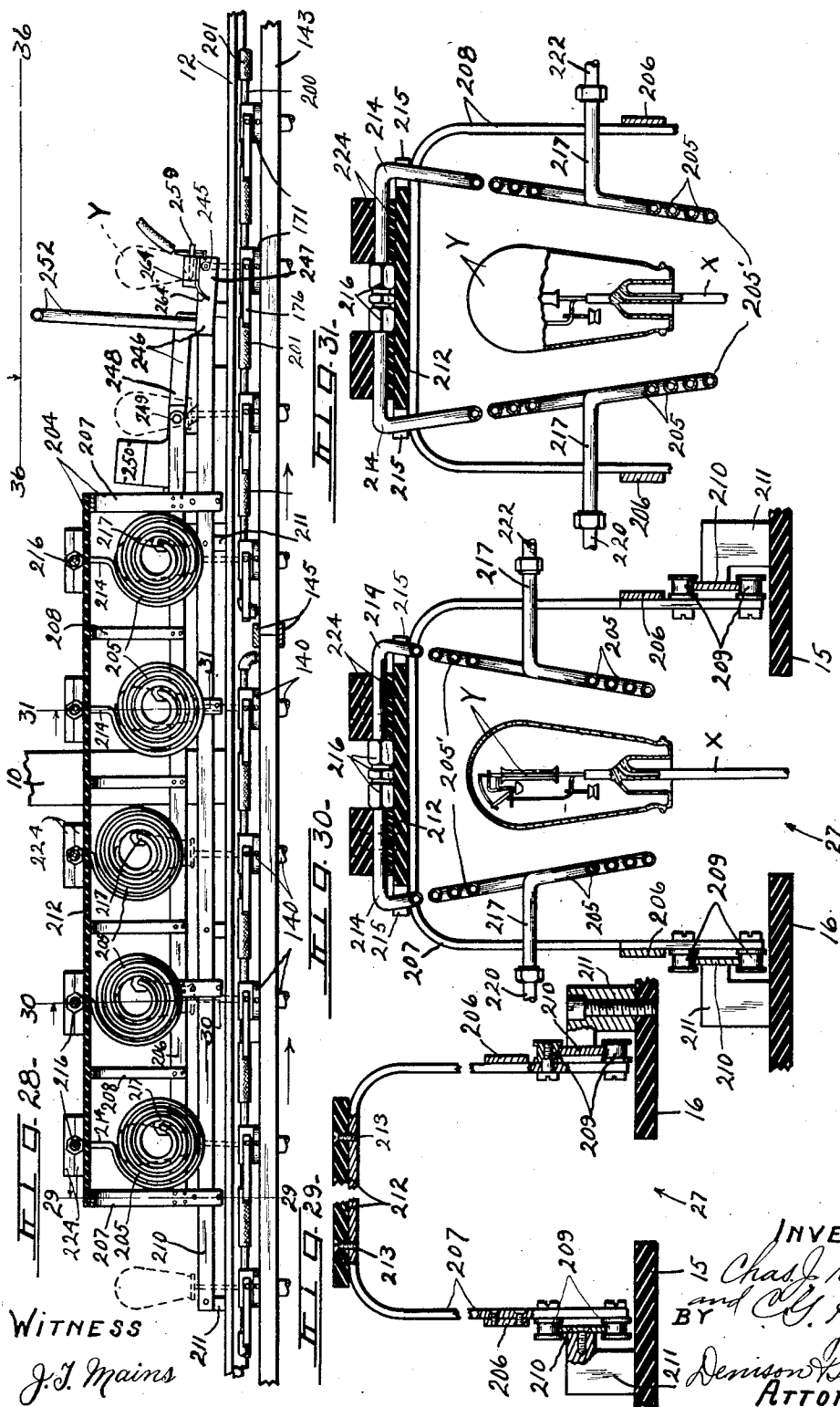
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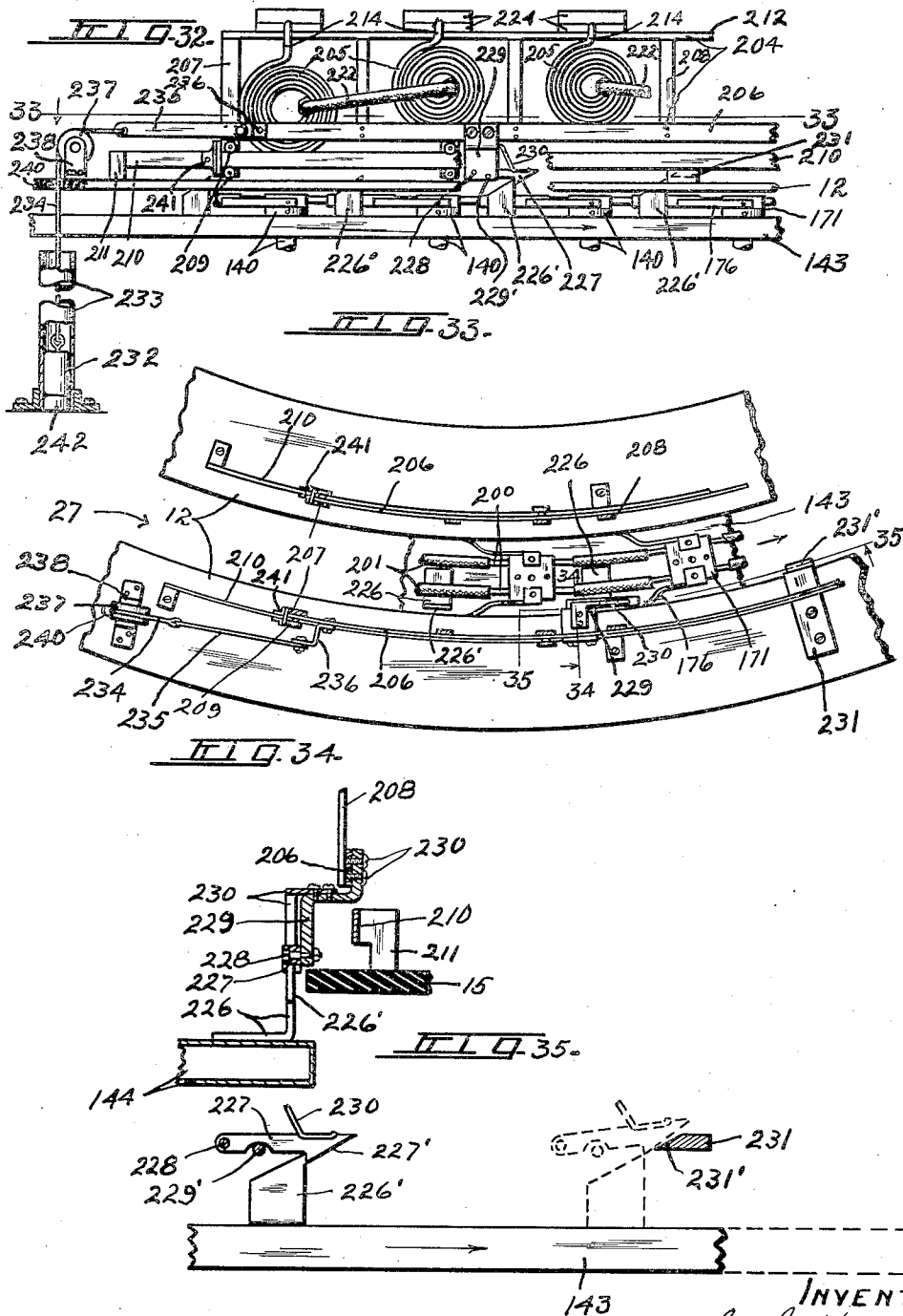
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ELECTRIC TUBE EVACUATING APPARATUS

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10 Sheets-Sheet 9



WITNESS
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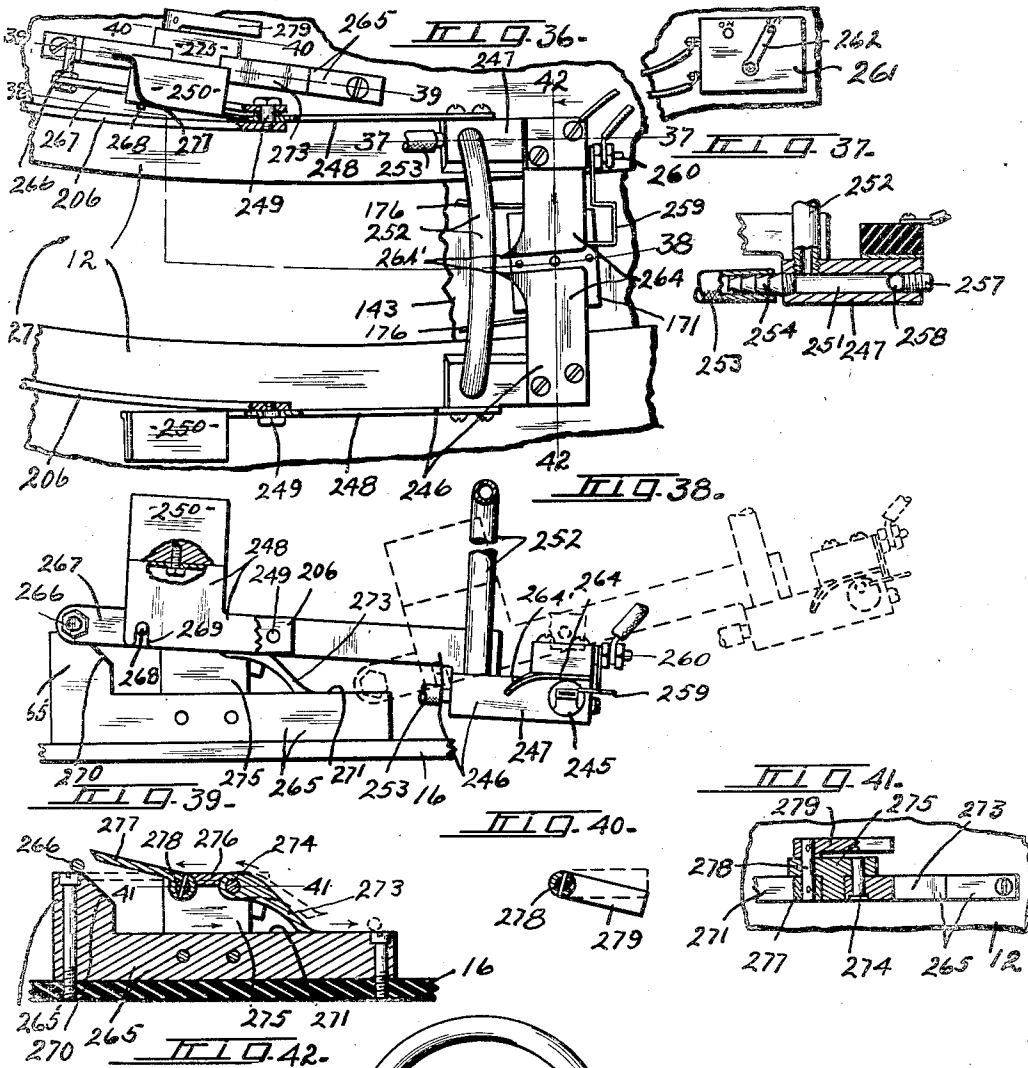
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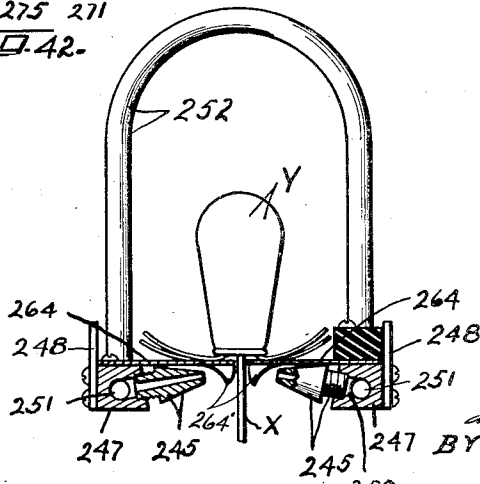
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10 Sheets-Sheet 10



WITNESS

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UNITED STATES PATENT OFFICE

2,006,771

ELECTRIC TUBE EVAPORATING
APPARATUS

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Application July 13, 1931, Serial No. 550,488

28 Claims. (Cl. 250—27.5)

This invention relates to improvements in an electric tube evacuating apparatus in which a plurality of heating elements co-operate with vacuum-producing means for drawing moisture and occluded gases from the glass and metallic units within the tube.

The main objects of this invention are to provide a machine of the above-mentioned class which will be rapid, economical and accurate in operation and that may be economically, simply and compactly constructed.

In carrying out these objects, we have constructed a machine wherein the tubes are continuously moved during the evacuating process, thus eliminating the time necessarily consumed in the usual intermittently operated exhaust device, in starting and stopping and also during the vertical movements of the bombardment coils when being brought into and out of operative relation with the tubes. The vacuum pumps are mounted in close relation with the tube exhaust ports which permits a very short connection between the tubes and pumps thereby eliminating long and complicated connections with the resultant leakages and thus shortening the evacuating time. Furthermore, there is an individual pump for each tube exhaust port which eliminates tube waste if a leak occurs by preventing the destroying of a number of tubes at a time, as happens in other types of exhausting machines where a plurality of tubes are connected with each pump unit.

The vacuum pump units are all mounted independently of each other and in such a manner as to permit the ready replacement of any one of these pumping units without in any way interfering with the operation of the remaining units in case of accident or breakdown. We obtain further economy by using three-phase relatively small motors for operating the vacuum pumps which eliminates starting windings on the motors, large feed wires, trick throw-out switches, etc.

Another object is to conserve energy by providing simple means for automatically shutting off the respective pump motors during the unloading and loading of the tubes.

Still another object is to eliminate mercury fumes by providing means for cooling the mercury cups through which electrical connection is made with the tube filaments.

A further object is to provide simple and efficient means for automatically sealing the tube whereby the seal-off tube will be cut in close proximity to the base of the tube.

A still further object is to provide an exhaust apparatus which may be easily and quickly adjusted for different types and sizes of electric tubes.

Other objects and advantages relating to the details of the structure and the form and relation of the parts thereof will more fully appear from the following description, taken in connection with the accompanying drawings in which:

Figure 1 is a top plan, partly broken away, of an apparatus embodying the various features of this invention.

Figures 2 and 3 are enlarged detail sectional views taken respectively on lines 2—2 and 3—3, Figure 1, illustrating one of the pump units and manner of mounting the same on the machine.

Figure 4 is an enlarged transverse vertical sectional view taken substantially on line 4—4, Figure 1.

Figure 5 is a horizontal sectional view taken on line 5—5, Figure 4, in the plane of the top of the stationary table, with various portions broken away to more clearly disclose certain of the underlying parts.

Figure 6 is an enlarged detail inner face view of adjacent ends of a pair of the segments comprising the outer electrical pick-up bar for supplying current to the tube filament, taken substantially on line 6—6, Figure 5, and illustrating the manner of mounting these segments in insulated relation.

Figure 7 is a sectional view taken on line 7—7, Figure 6.

Figure 8 is an enlarged transverse vertical sectional view through the oven and one of the tube exhaust ports taken on line 8—8, Figure 1, and illustrating the manner of connecting the tubes with respective vacuum pumps.

Figure 9 is a horizontal sectional view taken in the plane of the line 9—9, Figure 8.

Figure 10 is a vertical sectional view taken on line 10—10, Figure 9.

Figure 11 is a horizontal sectional view taken on line 11—11, Figure 8.

Figure 12 is an enlarged detail vertical sectional view taken in the plane of the line 12—12, Figure 5, illustrating the manner of mounting the collector brushes for the motors for the pump units.

Figure 13 is an enlarged vertical sectional view taken in the plane of the line 13—13, Figure 12.

Figure 14 is an enlarged detail vertical section taken on line 14—14, Figure 5, illustrating the manner of electrically connecting the inner pick-up bar with the return bar.

Figure 15 is a detail sectional view taken on line 15—15, Figure 14.

Figure 16 is a face view of adjacent ends of a pair of the segments comprising the inner electrical pick-up bar for the tube filament wires taken substantially in the plane of the line 16—16, Figure 5.

Figure 17 is a sectional view taken on the line 17—17, Figure 16.

Figure 18 is a horizontal detail sectional view through the rear end of the oven, taken on line 18—18, Figure 4.

Figure 19 is an enlarged detail vertical sectional view through the rotary table taken substantially in the plane of line 19—19, Figure 5, and illustrating in elevation, one of the pump motor control units together with the automatic throw-out and starting members.

Figure 20 is a vertical sectional view through the three wire connector taken on line 20—20, Figure 19.

Figure 21 is a horizontal sectional view through one of the motor switches and the throw-out member taken on line 21—21, Figure 19.

Figure 22 is a similar view to Figure 21, taken substantially on line 22—22, Figure 19, showing one of the motor switches in connection with the automatic starting member.

Figure 23 is a face view of one of the pump motor three-wire control switches.

Figure 24 is an enlarged sectional view taken on line 24—24, Figure 23.

Figure 25 is a detail transverse sectional view taken in the plane of the line 25—25, Figure 5, illustrating the water connections for the water manifold.

Figure 26 is a detail horizontal sectional view taken on line 26—26, Figure 25.

Figure 27 is a diagrammatic view illustrating the electric circuit for each pumping unit motor.

Figure 28 is an enlarged vertical sectional view through the bombarding carriage taken in the plane of the line 28—28, Figure 1.

Figures 29, 30 and 31 are enlarged vertical sectional views taken respectively on lines 29—29, 30—30 and 31—31, Figure 28.

Figure 32 is a side elevation of the rear portion of the bombarding carriage showing portions thereof broken away to better disclose the actuating means.

Figure 33 is a horizontal sectional view taken in the plane of the line 33—33, Figure 32.

Figures 34 and 35 are vertical sectional views taken respectively on lines 34—34 and 35—35, Figure 33.

Figure 36 is a top plan of the forward end of the bombardment carriage showing the seal-off mechanism.

Figure 37 is a vertical detail sectional view taken on line 37—37, Figure 36.

Figure 38 is a vertical sectional view taken on line 38—38, Figure 36.

Figures 39 and 40 are detail vertical sectional views taken respectively on lines 39—39 and 40—40, Figure 36.

Figure 41 is a horizontal sectional view taken on line 41—41, Figure 39.

Figure 42 is a transverse vertical sectional view taken on line 42—42, Figure 36.

Figure 43 is an enlarged detail sectional view illustrating the manner in which the starting trip member supporting bracket is hingedly mounted.

The machine illustrated in the drawings is adapted more particularly for evacuating electron tubes containing a plurality of metal parts such

as a filament, plate, grid, etc. as used in radio tubes, and is comprised of substantially four units, namely, a vacuum-producing or pumping means, a heat-producing medium for treating the glass tubes and filaments, an electrical bombardment means for heat treating the metallic portions of the tube such as the plate, grid etc., and a seal-off means closing and severing the seal-off tube, all of which function for successively and continuously treating the tubes as they travel through the machine from the starting position to the finish or seal-off position.

These units are mounted upon and supported by a circular stationary table and a rotary carrier mounted for movement in a plane below the stationary table. Upon the rotary carrier is mounted to move therewith the pumping units together with the tube-supporting exhaust ports.

Each of the pumping units, in this instance, consists of a pair of pumps capable of producing a high vacuum in the tubes and an electric motor for operating the pumps, there being one-half as many pump units as tube exhaust ports, with one pump operably connected with a respective exhaust port. Upon the stationary table in operative relation with the tube exhaust ports is positioned a furnace or oven adapted to have the tubes continuously moved in sequence there-through and a bombardment carriage.

The oven, in this instance, extends substantially two-thirds the distance circumferentially over the stationary table and is provided with suitable heat-producing means for causing a sufficiently high temperature in the oven for baking the glass bulb as the tubes are passed through the oven to such an extent as to free the glass of the absorbed gases.

The carriage is mounted for oscillatory movement upon the stationary table at the discharge end of the oven and is provided with suitable fixed bombarding coils between which the tubes are caused to travel as they are being continuously moved away from the discharge end of the oven. As the tubes pass between the coils, they are subjected to powerful high frequency currents induced by the coils. The intense heat thus created in the metallic parts of the tube frees said parts of the occluded gases which are immediately evacuated from the tubes by the pumps. The tubes then pass between another pair of coils carried by the carriage and which are positioned at the level of the getter cup which flashes a gas-absorbing element such as magnesium, barium or the like.

The seal-off mechanism is operably secured to the discharge end of the carriage for automatically severing the seal-off tube as the vacuum tube passes from the bombardment zone after which the tube is replaced by an unexhausted tube.

Referring now more specifically to the construction of the apparatus as disclosed in the drawings, 1 represents a vertically disposed base having its lower end curved outwardly to form an annular supporting flange 2. The upper end of the base has an inwardly extending annular flange 3 upon which is mounted an upwardly extending tubular column 4 which, in turn, has the upper end thereof provided with an inwardly extending flange 5 for supporting a plurality of, in this instance nine, outwardly extending radial arms 6, see Figures 1 and 4.

These arms 6 extend across the upper end of the column 4 and are secured thereto by bolts or screws 7 screw-threaded in the flange 5 and by

a supporting spider 8 positioned within the upper end of the column 4 with the ends of the arms thereof engaging the underside of the flange 5 and to which the inner ends of the arms 6 are secured by suitable bolts or screws 9. The outer ends of each of the arms 6 terminate in a vertically extending head 6' to which is adjustably secured an inverted U-shaped bracket 10 by means of a pair of screws 11 passing through elongated slots provided in the head 6' and screw-threaded in the adjacent side of the bracket.

The arms 6 and the brackets 10 are for the purpose of supporting the stationary table as 12, see Figures 4 and 5. The table 12, in this instance, consists of a pair of concentric annular supporting plates 13 and 14 positioned concentric with the base 1 and a pair of similar plates 15 and 16 composed of any suitable insulating material such as that commonly known as transite or the like.

The supporting plates 13 and 14 are disposed in a horizontal plane in radial spaced relation with each plate positioned beneath a respective leg 10' of the brackets 10 while the insulating plates 15 and 16 are positioned over a respective supporting plate and are secured to said plates and to the supporting brackets 10 by means of bolts or screws 17 passing through registering holes in the brackets and adjacent insulating plates, and screw-threaded in the respective supporting plates, as shown more particularly in Figure 4. These insulating plates 15 and 16 have their adjacent edges extending inwardly beyond the adjacent edges of the supporting plates 13 and 14 for the purpose of supporting a pair of electric pick-up bars 18 and 19 composed of brass or other suitable material equally well adapted for conducting electricity, see Figures 4 and 8. These bars 18 and 19 may be secured to the respective plates 15 or 16 in any suitable manner as by bolts or screws 20 and are arranged to extend circumferentially of these plates with their inner adjacent edges in vertical alignment with the inner adjacent edges of said plates for the purpose of permitting a continuous electrical connection with each of the tube exhaust ports during the rotation of said exhaust ports in a manner hereinafter more fully explained.

Mounted upon the table 12 is the oven 22 which is maintained in position upon said table by the brackets 10 through which the furnace passes. The furnace, in this instance, is inverted U-shaped in cross section and is composed of an outer and inner case 23 and 24 respectively which are insulated from each other by any suitable insulating material such as mineral wool 25.

The cross section of the furnace is substantially the same in form and size as the inner cavity of the brackets 10 so that when said brackets and the stationary table 12 are secured together, the oven 22 will be securely clamped therebetween.

The furnace, as hereinbefore stated, extends circumferentially over a greater portion of the table 12 and has the lower end thereof partly enclosed by the insulating plates 15 and 16 of the table 12 which extend inwardly some distance beyond the respective side walls of the furnace so as to form a bottom for the inner chamber as 26 in the furnace having the lower or bottom side thereof provided with a circular slot 27 extending circumferentially from one end of the furnace to the other. As shown, this slot extends entirely around the stationary table 12 for permitting the tubes to extend through said table

and into the furnace during the continuous movement of the tubes.

The ends of the furnace are closed by suitable end plates 28 slidably mounted in vertical guides 29 secured to opposite side walls of the respective ends of the furnace, see Figures 4 and 18. Each of these end plates 28 is provided with an opening 30 which extends upwardly from the lower edge thereof and having the contour thereof conforming with the contour of the tubes for permitting the tubes to be continuously moved into and out of the oven through said end plates.

Any suitable means may be utilized for producing the required amount of heat in the oven 22 such as electrical heating elements, or as shown 15 in the drawings, the oven may be provided with perforated tubes or burners 32 which are, in this instance, arranged in three sets of two tubes each with a tube of each set positioned at the bottom of the oven chamber 26 adjacent the outer and inner wall of said chamber, two of the sets of tubes extending inwardly from respective ends of the oven to substantially a third of the distance around the chamber 26 while the third set of tubes is positioned at the central portion of the oven between the two outer positioned sets of tubes, as illustrated more clearly in Figure 1, for producing a uniform flame throughout the oven chamber.

The gas may be supplied to the burners under 30 pressure through suitable conduits or pipes 35 which are connected with any suitable source of gas supply not shown, by a common conduit 36 to which the conduits 35 are connected.

The conduit 36 may be provided, as shown in 35 Figure 1, with a suitable valve 37 for controlling the supply of gas to the tubes 35, and the tubes 35 in turn may be provided with suitable valves 38 for controlling the amount of gas supplied to the burner tubes 32 connected therewith. Any suitable means for supplying air to the burners 32 may be provided such as the pipes 34 which are, in turn, connected with a common air supply pipe 39 adapted to be connected with a pump not shown or other suitable means for supplying air 45 under pressure.

The pipe 39 may be provided with a control valve 40 for governing the amount of air supplied to the pipes 34 while each of the pipes 34 may also be provided, as shown, with suitable 50 control valves 41 for governing the supply of air to the respective burners connected therewith. In order that access may be had to the interior of the oven, the upper wall of said oven may be provided with a plurality of, in this instance two, 55 openings 43 which may be closed by suitable cover plates 44 formed with insulated spaced walls similar to the construction of the walls of the oven 22 and which are adapted to extend into the openings 43 for preventing the escapement 60 of heat through said openings.

Carrier

Below the stationary table 12 is a rotary carrier composed primarily of a rotatable table 45 65 and a tube carriage 46. The rotary table 45 is mounted in a horizontal plane near the base of the column 4 and is provided with a central opening therethrough for receiving the lower enlarged portion 4' of said column. The table 45 is mounted 70 for rotation upon a ball-bearing 46 which is mounted upon the upper surface of the flange 3 of the base 1.

The table 45 is rotated, in this instance, by means of a ring gear 47 secured to the outer 75

periphery of a dependent annular flange 48 secured to or made integral with the table 45 and which surrounds the bearing member 46.

A pinion 49 for driving the gear 47 is secured to the upper end of a vertically disposed shaft 50 which is rotatably mounted in a suitable bearing 51 secured to the base 1 by screws 52 or their equivalent, as shown more clearly in Figure 4.

The lower end of the shaft 50 is operably connected with a suitable speed-reducing gearing 53 which is mounted on a horizontally disposed bracket 54 secured by screws 54' to the vertical portion of the base 1 below the bearing member 51. The drive shaft as 55 for the speed reducing gear 53 extends outwardly, in this instance, in a horizontal plane from said gearing, and has secured to the outer end thereof a pulley 56 which is connected by a suitable belt 57 to the drive pulley 58 mounted upon the armature shaft of a motor 59 secured to the flange 2 of the base 1.

The outer edge of the table 45 terminates some distance within the vertical plane of the stationary table 12 and is provided with a pendant flange or skirt 60 which has the outer peripheral surface thereof formed with a plurality of, in this instance twenty, flattened surfaces 61 formed at right angles to a radial line passing through the center thereof, see Figure 5. These flattened portions 61 are for the purpose of supporting a respective pump unit 62 which, in this instance, consists of a supporting bracket 63, an electric motor 64 and a pair of vacuum pumps 65, see Figures 2, 3 and 4.

The motor 64 is secured to a plate 65 which has one end thereof pivotally connected at one side at 67 to downwardly extending lugs 68 formed on the underside of the horizontal portion 63' of the bracket 63 while the other end of the plate 65 is adjustably secured to the bracket 63 by means of a screw 69 so that the motor may be adjusted relative to the drive pulleys as 70 of the pumps 65 for adjusting the tension of the drive belt as 71 for the pumps which pass around the drive pulley as 72 of the motor and over each of the pump pulleys 70.

Each of the pump units 62 is removably secured to the table 45 by means of a pair of screws 73 which pass through respective slots 74 provided in the vertical portion 63' of the bracket 63 and is screw-threaded in the apron 60 of the table 45. Each of the slots 74, in this instance, has the lower portion thereof enlarged to receive the head of the respective screw 73 so that all that is necessary for removing the pump unit from the table 45 is to loosen the screws 73 sufficiently to permit the pump unit to be raised until the heads of the screws are in registration with the enlarged portion of the slot 74 whereupon the pump unit may be readily removed, and it is evident that a pump unit may be as readily secured in place to the table 45 by the reverse operation.

Pump motor circuit

It will be readily understood that the pump units 62 will be continuously rotated by the table 45, and in order to continuously operate each of these pump units during the rotation of the table 45 and independently of each other, there has been provided the following novel construction for supplying electrical energy to these motors and which is illustrated more clearly in Figures 4, 12, 13, 19 to 24 inclusive and Figure 27 of the drawings.

Each of the motors 64 being a three-phase motor, we have provided a brush unit 76 which

is supported upon a bracket 77 in insulated relation thereto, said bracket being secured by screws 78 to the vertical portion of the base 1 at any convenient location as at the rear thereof, as shown more clearly in Figures 1 and 12.

The brush unit 76, in this instance, is provided with three brushes 79 which are pivotally mounted at 80 to a respective metal base 81, said brushes and bases being arranged in electrically spaced relation upon supporting plates 82 composed of insulating material, and each base 81 is provided with an electric terminal 83 adapted to be conveniently connected to one end of a wire 84 leading to a suitable source of potential not shown. The upper ends of each of the brushes 79 are yieldingly maintained in sliding contact with a respective bus-bar 85 by means of a compression spring 86 having one end positioned in a socket 87 provided in a brush support 88 with which each brush proper is connected and the other end resting upon the adjacent portion of the base 81, as shown more clearly in Figure 13.

The bus-bars 85 extend concentrically about the base 1 in radially spaced relation from each other, and they are secured in electrically spaced relation to the underface of a bus-bar supporting ring 89 which is composed of any suitable insulating material such as ebonite or the like. This bus-bar supporting ring 89 is, in turn, secured to a plurality of, in this instance twelve, insulating spacing blocks 90 which are secured in uniform circumferentially spaced relation to the underside of the table 45 between the flange 48 and apron 60 by means of screws 91.

It will now be understood that the brushes 79 being secured to the base 1, will remain in a fixed position, while the bus-bars 85 being secured to the table 45, will be rotated thereby relative to the brushes 79 but will be maintained in fixed relation with the pumping units 62, and by electrically connecting each of the pumping unit motors 63 with the bus-bars 85, electrical energy may be continuously supplied to each of said motors, and in accomplishing this result, we utilize a three-wire connector 92 which is illustrated in Figure 20 and diagrammatically in Figure 27, and which in this instance consists of a pair of terminal supports 92' and 92'' composed of any suitable insulating material, and each of these terminal supports is provided with three terminal units 93 and 94 respectively which are adapted to be removably connected with each other. One of the terminal supports as 92' is connected by screws or otherwise to the skirt 61 of the table 45 adjacent the respective pump units, while the other terminal support 92'' is frictionally maintained in operative relation with the terminal 92' by the engagement with each other of the terminals 93 and 94 thereby permitting the ready connecting or disconnecting of the circuit wires for the motor when mounting or de-mounting the pump units.

Each of the connectors 92 has one set of terminals 94 thereof connected in circuit to a respective set of brushes of the corresponding pump motor 64 while the other set of terminals 93 of the connector is connected in circuit with respective contact members of a three-phase four-wire 440 volt contactor 95, see Figure 27. Each of the contact members as 96, 97, 98 and 99 of the contactor is maintained in electrical connection with respective terminals 100, 101, 102 and 103 by means of a relay 104 which is normally maintained in an energized condition by a current passing from one of the bus-bars 85 through

the terminal 103, contact member 99 and wire *a* to a respective terminal unit 93—94 of a second three-wire connector 92 constructed similarly to the hereinbefore mentioned connector 92 for the motors 64 and which is shown as being connected adjacent the respective pump unit upon the outer edge of the pump bracket 63, Figure 4.

From the terminal unit 94, the current passes through a wire *b* and a manually operated switch *s* and wire *c* to a second terminal unit 93—94 of the second-mentioned three-wire connector 92 and thence through the wire 105, cut-out switch 106 and wire 107 to the relay 104 and thence to the ground circuit of the motor 64 as shown.

It will be noted that the switch *s* is normally maintained in the closed position so that if, at any time, it is desired to stop the operation of the motor 64 and pump connected therewith in case the pumping unit breaks down or fails to properly function for any reason, the operation of said unit may be discontinued independently of the remaining pump units and the respective unit replaced without in any way interfering with the operation of the remaining units by merely opening the switch *s* which will break the circuit passing through the relay 104 causing said relay to be de-energized and permitting the contactor 95 to move to the open position thereby breaking the circuit for operating the respective motor 64.

If, however, the circuit for any one of the pump motors 64 is broken, said pumping unit controlled thereby is idle due to the respective relay 104 becoming de-energized with the consequent opening of the respective contactor 95, and if it is desired to put said pumping unit into operation, all that is necessary is to cause the energizing of the relay 104 by closing a manually operated switch *r* connected in series with the cut-out switch 106. When the switch *r* is closed, the current then will pass from one of the bus-bars 85 through the terminal 103, wires 110 and *d* through a respective terminal unit 93—94 of the second-mentioned three-wire connector 92 and thence through the switch *r*, line *c*, terminal units 93—94, wire 105 and thence through the normally closed cut-out switch 106 and wire 107 to the respective relay 104 and then to the ground circuit leading from the motor 64 whereupon the relay 104 will again become energized and cause the closing of the respective contactor 95 which will again establish a current through the respective pump motor 64 and cause the respective pump unit to resume operation.

As hereinbefore stated, there is one of the automatic cut-out and starting switches for each pump unit and they are constructed in the following manner: A base as 110, Figures 19, 21, 22, 23 and 24, composed of suitable insulating material such as ebonite or the like, is secured to a plate 111 which, in turn, is secured to the skirt 61 of the table 45 in proximity to the corresponding pump unit.

Upon the base 110 is mounted in spaced relation a pair of contact members 112 and 113 which consists of relatively thin narrow strips of spring metal with their intermediate portions bent to extend outwardly to form respective cam members 114 and 115. One end of these contact members is secured by bolts or screws 116 to the base 110. The other end of each of the contact members is provided with a lug to form one-half of respective contact points 120 and 121, the other half of which is secured to respective ends of a common terminal bar 122 which extends trans-

versely of the base 110 at one end thereof and to which said bar is secured by a screw 123.

It will be noted that the automatic cut-out switch 106 is normally in the closed position, while the automatic starting switch 108 is normally in the open position.

By referring to Figure 27, it will be understood, as previously explained, that with the cut-out switch 106 in the closed position, the relay 104 is maintained in an energized condition which maintains the gang switch 95 in the closed position and thereby maintains a closed circuit for the respective pump motor 64. When it is desired to stop the operation of the motor 64 and the pumps actuated thereby, it is only necessary to open the respective cut-out switch 106 which will cause the relay 104 to become de-energized and thereby permit the gang switch 95 to move to the open position and open the motor circuit, and for this purpose, there is provided a throw-out trip member 126 which is, as shown in Figure 5, so positioned as to open the cut-out switch and stop the corresponding motor at the end of the bombardment zone. This throw-out trip member 126, in this instance, consists of a base plate 127 composed of any suitable insulating material and which is secured by screws 128 to a supporting bracket 129 secured to the vertical wall of the base 1.

Mounted on the base plate 127 is a U-shaped latch bracket 130 having a pair of side plates 131 secured to opposite sides thereof. Pivotaly secured to the side plates 131 at 132 is a latch member 133 which is mounted in proximity to one of the legs as 134 of the bracket 130 and arranged so that said leg will form a stop for limiting the pivotal movement of the latch 133 in one direction, as illustrated in Figure 21.

The latch is yieldingly maintained against said lug so as to extend outwardly in a radial direction from the machine base 1 by a spring-actuated plunger 135 which has one end thereof pivotaly connected to the latch 133 and the other end slidably mounted in a guide bushing 136 secured to the opposite leg as 137 of the bracket 130.

The outer end of the latch 133 is arranged to extend in the path of movement of the cam 114 of each cut-out switch member 106 so that as each cut-out switch is moved past the throw-out trip member 126, said switches will be opened thereby sufficiently to open the circuit leading through the relay 104 thereby causing said relay to be deenergized and permit the gang switch 95 to assume the open position and cut off the supply of current to the respective pump motor.

In order that the pumps may be automatically started to operate again after the evacuated tubes have been replaced by fresh tubes and before these tubes enter the oven 22, which operation will hereinafter be more fully described, there is provided a starting trip member 139 which is positioned, as shown more particularly in Figure 5, ahead of the throw-out trip member 126 intermediate the bombarding zone and the inlet of the oven 22. This starting trip member 139 is constructed substantially in the same manner as the throw-out trip 126 and, therefore, the different parts thereof have been given the same reference numerals as the throw-out trip member 126 and need not, therefore, be further described.

The starting trip member 139 is mounted similarly to the throw-out trip member 126 except that the starting trip member is positioned so that the latch 133 thereof will be in the path of movement of the cams 115 of each starting switch

100 for automatically closing said switch, and the bracket 129 upon which said starting trip member 139 is mounted is hingedly connected as at 129', Figures 5 and 43, with the base 1 so that the starting trip member may be swung about a horizontal axis out of the path of movement of the cams 115 and thus permit the pump units to pass the inlet of the oven without starting. This is done when the machine is to be shut down so that as the tubes are sealed off and the remainder of the tubulations are removed from the respective exhaust ports, the now open exhaust ports will enter the oven with the pumps connected therewith inoperative, which will thus prevent the damaging action of otherwise drawing the hot air from the oven into the pump system.

By referring to Figure 27, it will be evident that the closing of the starting switch, when the contactor 95 is in the open position, will establish a circuit from the terminal 103 through the starting switch 108 and line 107 and then through the relay 104 to the ground line of the motor circuit. This will cause the relay 104 to be energized which in turn will bring the contactor 95 to the closed position and thereby re-establish the circuit through the respective pump motor 64, and it is evident that this motor circuit will remain closed as long as the relay 104 remains energized which condition will be maintained after the starting switch 108 has returned to the open position by the current passing through the switch contact member 99, line 105, cut-out switch 106 and line 107 until such time as the cut-out switch 106 is again opened by the action of the throw-out trip member 126.

Tube carriage

The vacuum pumps 65 may be of any well-known construction adapted to produce a high degree of vacuum in the tubes and, therefore, it is not necessary herein to illustrate or describe these pumps in detail. The suction port of each of the vacuum pumps 65 is provided with a nozzle 65' which is connected to a respective exhaust port 140 secured to the tube carriage as 141 mounted on the rotating table 45 in the following novel manner: The tube carriage 141, in this instance, consists of an annular water manifold 143 formed of a plurality of, in this instance eight, hollow segments 144 rectangular in cross section and maintained in fixed operative relation end to end beneath the fixed table 12 and in vertical alignment with the slot 27 in said fixed table by means of a plurality of, in this instance eight, brackets 145.

These brackets 145 are arranged one at each of the meeting ends of the adjacent segments, as shown more clearly in Figures 5 and 26. Each of these brackets is provided with a slot in the upper surface thereof of substantially the same width and depth as the manifold 143 for receiving the ends of the adjacent manifolds which are secured in place and to the brackets by a cover plate 145' which extends over the top of the manifold ends and is secured by screws or otherwise to the bracket proper.

Each of the manifold brackets 145 is secured by screws 146 to the outer end of a horizontally disposed arm 147 which extends outwardly in a radial direction from the column 4 in a plane some distance above the rotor table 45.

The arms 147 are secured to the rotating table 45 in uniform circumferential spaced relation to rotate therewith by means of upwardly extending posts or brackets 148 and 149. These brackets

are arranged in radial spaced relation upon the table 45 beneath a respective arm 147 and are secured to the table at one end while the other ends of these brackets are secured to a respective arm 147, as indicated more particularly in Figure 4.

Each of the manifold segments 144 is provided with a plurality of, in this instance five, vertical openings 150 therethrough arranged in uniform spaced relation circumferentially about the manifold and in a plane midway between the side walls thereof, see Figures 8, 10 and 26. In each of the holes 150 is secured in a liquid-tight manner, a flanged bushing 151 which has mounted therein a vertically disposed exhaust tube 152 composed of rubber or other resilient material. These tubes 152 are each removably secured in the respective bushings by means of a collar 153 composed of brass or other suitable material and which has a loose sliding fit in the bushing 151, while the opening through the collar is of less diameter than the tube 152 for frictionally engaging said tube, as shown in Figures 8 and 10.

Each of these exhaust tubes 152 is removably secured in the respective bushings 151 by means of a resilient retaining member 154 which, in this instance, is composed of spring wire bent to form a rectangular outline of sufficient size to extend beyond the peripheral edge of the bushing 151, while the ends of the wire are arranged in spaced relation at one side of the rectangle and are inserted through respective diametrically opposed holes provided in the flange of the bushing 151 and extend into an annular peripheral groove 153' provided near the outer end of the collar 153, as shown more particularly in Figures 8 and 26.

The tubes 152 each have a central opening as 155 extending longitudinally therethrough, of substantially the same or of slightly less diameter than the seal-off tube as X of the vacuum tube Y being treated so as to tightly receive and grip said seal-off tube for the purpose of holding the tube vacuum tight in the operative position upon the tube carriage 141. The upper ends of these tubes 152 are arranged flush with the upper ends of the bushings 151 while the lower ends of said tubes extend some distance below the manifold 143 and are connected with respective suction nozzles 65' of the adjacent vacuum pumps 65 by means of a tubular trap 157 composed of glass or other suitable material.

The trap 157, in this instance, is composed of two tubes 158 and 159 of different cross sectional areas. The smaller tube as 158 extends through one end of the outer tube 159 and has the inner end thereof extending to within a relatively short distance of the opposite end of the outer tube 159 while the other end of the tube 158 extends beyond the tube 159 to form the inlet of the trap, and is secured in the lower end of the central opening 155 of the tube 152.

The outer tube 159 of the trap is also provided with a laterally projecting tube 159' which extends at right angles to the inner tube 158 from that end of the outer tube through which the inner tube passes and is connected with the respective suction nozzle 65' by means of a hose or flexible tube 160 so that air or gas drawn from the vacuum tube Y will pass through the inner tube 158 to near the lower portion of the outer tube 159 of the trap 157 and thence upwardly through the tube 159, as indicated by arrows Z,

Figure 8, through the outlet 159' and tube 160 to the respective pump 65.

The lower end of the trap 157 is positioned in a spherical vessel 162 also composed of glass or like material adapted to contain a suitable cooling element such as liquid air which is normally maintained at a level above the lower end of the trap 157 as indicated by the dotted line L in Figure 8 for the purpose of maintaining the lower end of the trap at a very low degree of temperature for cooling and condensing the heated gases being drawn from the tube and thereby assisting in maintaining a very high degree of vacuum in the vacuum tube being exhausted.

The upper end of the vessel 162 may be provided with a cover as 163 provided with a central opening therethrough for receiving the lower end of the trap 157 and which may have a relatively tight connection with the trap 157 and vessel 162 for the purpose of preventing the decomposition of the cooling element contained in the vessel 162 to the maximum degree.

The vessel 162 may be removably maintained in operative relation with the trap 157 by any suitable means such as a spring-actuated bracket 165 having a plurality of, in this instance three, upwardly extending diverging arms 165' adapted to engage the vessel 162, the bracket being slidably mounted in a swinging arm 166 which is pivotally connected at 167 to a bracket 168 secured to each pump 65.

Secured to the upper end of each bushing 151 in the manifold 143 by screws 170 is a terminal support 171 composed of any suitable insulating material, see Figures 8, 9 and 10. Each of these supports 171 has its opposite side walls provided with an inwardly extending slot 172 in which is positioned a terminal block 173 composed preferably of stainless steel and which have an inner chamber 174 extending downwardly from the upper surface thereof.

The outer vertical wall of each of the terminal blocks 173 extends a relatively short distance beyond the adjacent face of the terminal support 171 and is provided with a longitudinally extending horizontally disposed slot 175 for receiving therein one end of a respective pick-up brush 176 which has the other end thereof extending rearwardly and normally spring-pressed outwardly for slidably engaging the adjacent pick-up bar or track 18 or 19.

The upper end of each terminal block chamber 174 is enlarged to form an annular recess for supporting therein the upper end of a mercury cup 178 which is adapted to extend downwardly into the respective chamber 174. These mercury cups 178 are for the purpose of receiving the terminal wires of the tubes during the evacuating process for the purpose of electrically connecting them with a source of potential so that these wires may become heated for the purpose of driving the gases out of the coating of the filament, and in order that this connection may be readily made without the use of clamps, screws or the like, the cups are partially filled with a conducting liquid such as mercury so that when an electric circuit is connected with, for instance, the outer pick-up ring 18, current will pass through the outer brush 176 to the respective terminal block 173 and thence through the mercury cup 178 and mercury contained therein to the wires positioned in said cup; thence through the filament to the mercury cup positioned at the inner side of the terminal block; thence through the respective mercury cup 178

and terminal block 173 and pick-up brush 176 to the inner positioned pick-up bar 19.

As hereinbefore described, the pick-up bars or tracks 18 and 19 extend from within a short distance within the inlet end of the oven 22 around through the oven and to within a short distance of the discharge end of the bombardment zone, and in order that different voltages may be applied to the filaments as the tubes are moved through the oven and bombardment zone, the outer pick-up ring or track 18 is made up of segments as 18', see Figures 5, 6 and 7. These segments 18' may be made of any desired length and are joined together in insulated spaced relation by means of a tie block 180 composed of suitable insulating material which is secured by any suitable means to the outer insulating ring 15 of the fixed table 12.

The adjacent ends of the segments 18' are arranged in spaced relation when assembled and each of the tie blocks 180 is provided on its inner vertical face with an inwardly extending tongue 180' which extends inwardly between these adjacent ends of the segments 18' to maintain said segments in insulated spaced relation. In order that each of the segments may be supplied with a pre-determined voltage, we have shown a plurality of, in this instance ten, electric conducting wires 181 which are connected with respective pick-up segments 18' as illustrated in Figures 5 and 8. These wires 181 may be maintained in fixed relation with the stationary table 12 in any suitable manner as by a series of brackets 182.

Each bracket 182 has the inner end thereof provided with a terminal 184 which is connected with a respective wire 181 and by a metal strap 185 to a respective segment 18'. The other end of the wires 181 may be connected with any suitable source of potential including a transformer not shown whereby the voltage for each segment 18' may be quickly and easily changed independently of the remaining segments, to produce the proper heating of the filament as the tube is moved through the oven 22. The voltage of the current supplied to the tube filaments depends very largely upon the temperature at which the tubes are designed to operate and the voltage for each segment may be uniform or varied as desired to obtain the maximum efficiency.

The inner pick-up bar 19 may be one continuous member or may be made up of segmental portions similar to the outer bar 18 in which case the segments would be electrically connected together, and in either case, the pick-up bar 19 is provided with one or more ground wires as 186 for electrically connecting said bar with a circular return bar 186' secured to the brackets 10 and which in turn, is electrically connected with the transformer in any well-known manner to complete the circuit through the filaments.

Cooling system

In order that the tube exhaust ports and particularly the mercury cups 178 may be maintained at a relatively cool temperature and to eliminate the escape of mercury fumes which would otherwise be caused by heating, a cooling agent such as water may be supplied to the manifold 143 and to each of the mercury cups in the following manner: An annular vat 187 is mounted adjacent the column 4 upon the inner ends of the manifold supporting arms 147 to rotate with said arms and manifold, as illustrated more particularly in Figures 1, 4, 5, 25 and 26.

The upper portion of the vat 187 is opened for the purpose of receiving water therein from any suitable source as the supply pipe 188 which extends over the top of the oven 22 and may have one end thereof connected with any suitable source of water supply, as a tank or water main not shown, while the other end is provided with a downwardly extending portion adapted to direct the water into the vat 187 as said vat is being rotated by the rotary table 45. In order to prevent the overflow of the water in the vat 187 in case the water is supplied thereto faster than it is being discharged, there is provided a pair of overflow pipes 190 arranged at diametrically opposite sides of the vat and which have their upper ends positioned a short distance below the upper edge of the vat 187 and extend downwardly through said vat with the lower ends thereof extending into an overflow vat 191.

The overflow vat 191 is an annular vat similar to the vat 187 and is secured in any suitable manner to the column 4 intermediate the receiving vat 187 and the rotary table 45, as illustrated more particularly in Figure 4. Any suitable means may be employed for connecting the overflow vat 191 with a drain or source of supply as the outlet pipe 192.

Connected with the lower portion of the inlet vat 187 at diametrically opposite sides thereof and in this instance in the vicinity of the overflow pipes 190, is one end of an outlet conduit 194 which is connected at the other end to the water manifold 143 adjacent one end of one of the segments thereof, as shown more particularly in Figures 25 and 26 for the purpose of supplying water to said manifold. In order that water may circulate from these segments to the remaining segments of the manifold, there has been provided a water connection comprising a U-shaped tubular member 196 which has the ends thereof connected with adjacent ends of the segments for by-passing the water around the closed ends of said segments.

The end of the segment adjacent the segment to which the water inlet is connected is provided with an outlet conduit 197 similar to the inlet conduit and which has the discharge end thereof connected with the respective overflow pipe 190 intermediate the inlet vat 187 and overflow vat 191, as shown in Figs. 25 and 26 so that water entering the inlet pipe as 188 and discharged into the vat 187 will flow from said vat through the manifold inlet conduits 194 and enter at diametrically opposite sides of the water manifold 143. The water then flows through the manifold in the direction of rotation thereof and from one segment to the other through the joining conduits 196 to the opposite side of the manifold where it is discharged through the outlet conduit 197 and overflow pipe 190 to the overflow vat 191 and thence out through the outlet pipe 192 thereby maintaining a fresh supply of cooling liquid to the manifold at all times.

In order that cooling liquid may be also supplied to each of the terminal blocks and mercury cups contained therein, each of the terminal blocks in the terminal support 171 adjacent the inlet conduits 194 is connected with the interior of the manifold by means of a flexible conduit 198 and a tube 199, said tube extending through a suitable opening provided in the rear end wall of the terminal support 171 and having the inner end thereof screw-threaded or otherwise mounted in an opening provided in the vertical wall of the respective terminal block 173 in communication

with the chamber 174, as shown more clearly in Figures 25 and 26.

The opposite side of said chamber is provided with a similar tube 200 connected therewith and which extends outwardly through an opening in the forward end of the terminal support 171 and is connected by a suitable flexible tube or hose 201 to a similar tube 200 connected with the next adjacent terminal support 171 and which, in turn, is in communication with the respective chamber 174 provided in said circuit.

Each of the terminal supports and the terminal blocks 173 provided therein are connected in like manner with the next succeeding terminal support and block throughout the respective half portions of the water manifold with the last-positioned terminal support connected with the interior of the respective manifold segment by outlet conduits 202 similar to the inlet conduits 198 and which communicate with the interior of said segment near the outlet conduit 197 of said segment. It is now evident that the water entering the water manifold 143 at diametrically opposite sides thereof, will not only pass through said manifold but will also be forced up through the inlet conduits 198 due to the pressure provided in the inlet vat 191 and through each of the terminal block chambers 174 and about the mercury cups contained therein and thereby maintaining the mercury in said cups at a sufficiently cool degree of temperature to prevent the escape of any mercury fumes which might otherwise be discharged.

Bombardment carriage

The carriage as 204 is utilized to support the bombardment coils 205 and is positioned, as hereinbefore mentioned, adjacent the exit end of the oven 22, see Figure 1. The carriage 204, as illustrated in Figures 28 to 33 inclusive, consists of a pair of side bars 206 arranged in radial spaced relation one at either side of the slot 27 provided in the stationary table 12. These bars are slightly curved longitudinally to conform with the curvature of said slot and are joined together by a plurality of, in this instance two, U-shaped end cross bars 207 and four intermediate U-shaped cross bars 208, all of which are arranged in spaced relation longitudinally of the side bars 206.

The two end cross bars 207 are made, as shown, to extend a short distance below the side rails 206 and have rotatably mounted on the lower ends of each leg thereof, a pair of grooved rollers 209 arranged in vertical spaced relation for receiving a track rail 210 therebetween. There are two of these track rails 210 arranged concentrically with the stationary table slot 27 one at either side thereof and they are maintained in sufficient spaced relation from the upper surface of the table 12 by supporting brackets 211 secured in any suitable manner to the table 12 to permit the free movement of the carriage over said table.

A coil-supporting plate 212 composed of insulating material is positioned longitudinally of the carriage 204 over the transverse portion of the cross bars 207 and 208 to which the plate is secured by screws 213 or by other suitable means. This plate 212 is for the purpose of supporting a plurality of, in this instance five, pairs of bombarding and flashing coils 205 arranged in transverse spaced relation longitudinally of the carriage 204. These coils are each composed of copper tubing or the like coiled in a flat spiral with the outer ends 214 thereof extending upwardly through a respective slot 215 formed in

the vertical edge of the coil-supporting plate 212 and then bent at substantially right angles to extend substantially half way over the plate 212 where it is coupled with the corresponding end of the companion coil by a union 216 to form a continuous passage for a cooling liquid such as water, from one coil 205 to the other coil of the corresponding pair.

The other end 217 of each coil is bent to extend outwardly from the interior of the coil and may be connected as is the case with the inner positioned coils of the first, third and fifth pair of coils by a flexible tubing as 218 to a suitable source of fluid supply such as a pipe 219 connected with a cooling tank and force pump, not shown, supplying distilled water, see Figure 1, so that cooling fluid as distilled water may be supplied to the coils. Others of these centrally located coil ends 217, as those of the inner positioned coils of the second and fourth pair and of the outer coil of the fifth pair, are connected by a flexible tubing 220 to a respective return pipe 221 which are adapted to convey the fluid from the coils to the cooling tanks as indicated in Figures 1 and 25. The remaining ends 217 of these coils, that is, the centrally located ends of the coils of the first and second, and the third and fourth pairs, are connected by tubes 222, see Figures 1 and 32, so that water entering the water supply pipe 188 may pass through the pipe or conduit 219 and flexible tubes 218 to the center of the innermost coils 205 of the first, third and fifth pairs of coils and will then circulate through said coils, and in the case of the first and third pairs, will pass to the outer positioned coils of said pairs and thence through the tubing 222 to the second and fourth pairs of coils respectively and thence out through the outlet tubing 220 and conduit 221 to the cooling tank, and the water entering the fifth pair of coils will pass through said coils and be returned by the respective tubing 220 and conduit 221 to said cooling tank for maintaining said coils in a relatively cool degree of temperature during the bombardment operation.

Each of these pairs of coils 205' is maintained in uniform spaced relation on the carriage by a pair of split brackets 224 which are composed of insulating material and are arranged one at either side of the respective union 216 and are bolted or otherwise secured to the upper face of the coil-supporting plate 212, as illustrated in Figures 28, 30 and 31.

The pairs of coils 205' are spaced apart, in this instance, a distance equal to the circumferential spacing of the tube sockets 140 so that as the tubes are being moved forwardly from the oven 22, each pair of coils will be brought into operative alignment with a respective tube whereby the metallic elements of the tube will be heated by a powerful high frequency current induced by said coils, and for this purpose, the coils may be connected in any well-known manner to a suitable source of potential not shown.

The coils 205 of each pair are spaced apart, see Figures 30 and 31, a distance which will permit the free movement of the tubes therebetween and at the same time, produce the maximum degree of efficiency; that is, each pair of coils 205' is arranged at a given relation to the tubes for effecting the maximum degree of treatment of a specific element in the tube and for this purpose, the coils are arranged in three groups. The first group comprises the first pair of tubes 205'; the second group consists of the second and

third pair of coils and the third group is composed of the fourth and fifth pairs of coils.

The first group of coils is arranged to bring the center of the coils 205 and, therefore, the center of the flux in the plane of the cup of the vacuum tube to de-gas said cup by heating the same. The second group of coils is somewhat elevated above the first group to bring the center of flux in the plane of the plates of the tubes to heat and de-gas said plates and the third group of coils is arranged at the same level as the first group for the purpose of again heating the cups of the tubes to such a degree as to cause the flashing of the contents thereof.

In order that the value of the current supplied to each group of coils may be altered or controlled independently of the other groups of coils for obtaining the desired degree of temperature of the tube elements effected thereby the coil groups may be connected in circuit with an adjustable bombarder of any well-known make not herein necessary to illustrate. As an example, the current supplied to the first group of coils may have a value of 150 amperes which will heat the cup sufficiently to drive out the occluded gases but not to such a high degree of temperature as to flash the cup.

The second group of coils may be subjected to a current of 100 amperes which will produce a heat by induction sufficient to de-gas the plates, while the current supplied to the third group of coils will flash the cup at 125 amperes.

In order that the cups may remain in operative relation with each group of coils, a sufficient length of time to obtain the desired result, each pair of coils is caused to travel a certain distance with the tubes, in this instance, substantially equal to the distance between two tube sockets 143 and then move rearwardly to the direction of rotation of the tubes into operative relation with the next and succeeding tube, and for this purpose, there is secured to the upper surface of the tube-supporting manifold 143 substantially midway between the adjacent tube sockets 140, a drive bar 226 which has one end thereof 226' up-turned to engage a detent 227 pivotally connected at 228 to a supporting bracket 229 secured by screws 230 to the outer side rail 206 of the carriage 204 intermediate the ends thereof.

The detent 227 extends forwardly from the pivot 228 and is yieldingly maintained in the normal down position against a limiting stop or pin 229' by a spring member 230 which is secured at one end to an offset portion of the bracket 229, as illustrated more clearly in Figure 34.

The forward end 227' of the detent 227 is tapered downwardly and rearwardly for the purpose of engaging a trip bar 231 secured to the top of the stationary table 12 ahead of the detent-supporting bracket 229 and having the inner end thereof in a plane above the drive bar 226 so as to permit the free passage of said drive bar beneath the trip bar. The rear vertical edge as 231' of the inner end of the trip bar 231 is beveled, as indicated in Figure 35, and positioned in the path of movement of the beveled edge 227' of the detent 227 so that as the carriage 204 is being moved forwardly by the engagement of one of the drive bars 226 and detent 227, the detent will be disengaged from the respective drive bar as the cam portion 227' thereof rides upon the beveled portion 231' of the trip bar 231 which will permit the carriage 204 to be returned to the starting position by any suitable means as, for instance, a weight 232 slidably mounted in

a guide tube 233 which may be secured in any suitable manner to the floor or support for the apparatus and which is connected by a flexible cable 234, link 235 and bracket 236 to the carriage 204.

The bracket 236 is shown, in this instance, as being connected to the outer side rail 206 of the carriage near the rear end thereof, and the flexible cable 234 is shown as passing over a suitable guide pulley 237 which is rotatably mounted in a supporting bracket 238 secured to the stationary table 12, said cable passing downwardly through a suitable aperture 240 provided in the adjacent portion of the stationary table 12.

The carriage 204 is normally maintained in the rear-most position against the action of the weight 232 by means of a limiting stop 241 secured to each track rail 210 near the rear ends thereof and which is adapted to be engaged by the respective lugs of the rear end cross bar 207, as illustrated in Figure 32. In order to cushion the rearward movement of the carriage 204 when coming in contact with the stop 241, a suitable flexible buffer member 242 composed of yielding material such as rubber, may be positioned in the weight guide tube 233 at the bottom thereof in the path of movement of the weight 232 as it approaches its lowermost position.

The relation of the carriage stop 241, detent 227, drive bars 226 and the trip bar 231 are such that when a tube emerging from the oven 22 comes into operative alignment with the first pair of coils 205' positioned at the rear of the carriage 204, the carriage 204 will be moved forwardly by the engagement of the detent 227 and one of the drive bars 226 maintaining the coils and tube in operative relation until the carriage and coils have been moved forwardly substantially the distance between two tubes, whereupon the detent 227 will be engaged by the trip bar 231 which will release the carriage 204, and permit it to be returned to the starting position by the action of the weight 232 and as the drive bars 226 are provided one for each tube, this movement of the carriage and coils will be repeated for each tube emerging from the oven 22.

Seal-off mechanism

As each tube passes from the bombardment zone, it is next operated upon by the seal-off torch which automatically seals the tube and disconnects it from the evacuating pump. The seal-off torch, in this instance as illustrated in Figures 36 to 42 inclusive, consists of a pair of gas jets or burners 245 mounted in opposed relation at the forward end of a U-shaped supporting frame 246. This frame consists of a pair of burner-supporting blocks 247 secured to the forward ends respectively of a pair of horizontally disposed rock arms 248 pivotally mounted intermediate their ends upon a shouldered screw 249 secured to the forward ends of the carriage side bars 206 which are extended forwardly beyond the forward end cross bar 207 for this purpose.

The rear ends of the rock arms 248 are provided with weights 250 for counterbalancing the forward end of the torch frame to permit the ready pivoting movement of the frame about the pivots 249 for a purpose presently described.

The burner-supporting blocks 247, in this instance, are each provided with a bore 251 in communication with the respective burner 245. These bores 251 are also connected with each other by means of an inverted U-shaped tubular yoke 252 which has its ends secured in respective blocks

247 and which is of sufficient height and width to permit the free passage therethrough of any vacuum tube for which the machine is designed.

The fuel, as a mixture of gas and air, may be supplied to the burners 245 in any suitable manner as by a flexible conduit 253 which has one end thereof connected to a corrugated hose connection 254 which, in turn, is connected with one of the blocks 247 in communication with the respective bore 251. The other end of the conduit 253 may be connected, as shown more particularly in Figure 1, with a pipe or conduit 255 which is connected with the air inlet pipe 39 and also through the medium of a second conduit 256 and pipe 35 with the gas supply conduit 36.

It is now evident that the mixture of gas and air entering through the conduit 253 into the bore 251 connected therewith will pass outwardly through the respective burner 245 connected with said bore and also be conducted by the yoke 252 to the other burner 245, and in order that the supply of fuel may be uniform to each of the burners, the bore to which the supply conduit 253 is connected, may be provided with a valve for controlling the supply of fuel to the burner connected therewith which, in this instance, consists of the screw 257 screw-threaded in said bore so as to be brought into more or less closing relation with the port as 258 leading from the bore to said burner as shown more particularly in Figure 37.

Any suitable means may be employed for igniting the gas escaping from the burners 245 and which, in this instance, consists of an electrode 259 connected at one end by a screw 260 in insulated relation with the frame 246 and which has the other end thereof positioned in slightly spaced relation with the outlet end of one of the burners 245 which constitutes the other electrode and which may be electrically connected together with the electrode 259 with an induction coil as 261, Figures 1 and 36, which may as shown, be provided with a suitable switch 262 which when moved to close the circuit, will cause current to pass through the electrode 259 and jump across the spark gap between said electrode and the adjacent portion of the burner 245 constituting the other electrode thereby igniting the gas escaping from said burner. In order that the flame produced at the burners 245 may not injure the vacuum tube during the seal-off operation, there is provided a pair of shield plates 264 which are arranged in a horizontal plane transversely of the frame 246 over the burners 245 with their outer ends secured to the respective burner supporting blocks 247, and their inner ends terminating in spaced relation substantially midway between said blocks, the inner ends of these plates 264 being spaced apart a distance slightly greater than the diameter of the seal-off tube as X of the vacuum tubes Y being evacuated. The rear edge of the inner ends of each shield plate 265 is extended rearwardly and downwardly to form respective guides 264' for engaging the lead-in wires of the tubes and lifting them out of the respective mercury cups and onto the shield plates prior to the sealing off of the tube X.

The shield plates 264 are also utilized to position the vacuum tube at a predetermined position relative to the burners 245 during the seal-off operation so that the seal-off tube X will be severed in close proximity with the bottom portion of the tube Y. In order to accomplish this result, the frame 246 is rocked about the pivots 249 to bring the shield plates 246 below the base of the tube as

said plates engage the tube at the rearmost position of the frame 246 and, therefore, a corresponding position of the bombardment carriage 204 with which said frame is connected.

pin 266 along said cam surface 270 during the forward movement of the carriage 204 by means of a weight 279 which is secured to the opposite end of the pin 278 as shown more clearly in Figures 40 and 41, the upward movement of the rock arm 277 being limited by the engagement thereof with the rear edge of the guide plate 276, as shown in Figure 39.

It will now be clearly understood that during the rearward movement of the carriage 204, that the guide pin 266 in traveling over the cam pawl 273 and guide plate 276 will raise the rear end of the frame 276 and be guided across the cam face 270 to the upper surface of the extension 265' by the rock arm 277 which will be moved to the lowermost position in engagement with the cam face 270 against the action of the weight 278 by the guide pin 266, and as soon as the guide pin 266 has passed beyond the rock arm 277 and onto the upper surface of the extension 265', that the rock arm 277 will again be returned to its uppermost position by the action of the weight 278 thereby permitting the free passage of the pin 266 along the cam surface 270 of the guide block 265 when the carriage 204 is again being moved in the forward direction.

Operation

Considering now, that the apparatus is in operation, that is, that the oven 22 is being maintained at the desired degree of temperature by the flames issuing from the burners 32, electric current at the proper voltage and amperage is being supplied to the pick-up tracks 18 and 19 and to the bombardment coils 205 and that the electric current is being supplied to the bus-bars 85 for supplying current to the pump motors 64 and that the rotary table and the pump units and tube exhaust ports connected therewith are being rotated by the action of the motor 59 and also that a cooling fluid as water is being supplied through the inlet pipe 188 to the water manifold 143 and, therefore, to the tube exhaust ports 140 for maintaining the mercury cups at a normally low degree of temperature and that water is being supplied to the bombardment coils 205. Vacuum tubes as Y which have previously been assembled and in condition for evacuation, are then mounted in each of the tube exhaust ports 140 by inserting the seal-off tube as X in the respective inner passage 155 of the exhaust port tube 152 as the tube exhaust ports are moving between the bombardment carriage 204 and the inlet end of the furnace 22.

Each of the vacuum pumps 65 connected with the tube exhaust ports which are located at the loading station between the bombardment carriage 204 and inlet end of the furnace 22 will be in an inoperative condition due to the opening of the circuit supplying the motors for said pumps by the operation of the throw-out trip member 126, and as soon as the exhaust ports have been loaded and the contactor 95 for controlling the circuit to the respective motors has been closed by the action of the automatic starting switch 108, the pumps 65 actuated by these motors will be set into operation and thereby begin the drawing of the air from the tubes just previous to the tubes entering the furnace 22.

As soon as the tubes enter the furnace 22, the glass portion thereof will be subjected to the heat in the furnace which will begin the freeing of the glass of the occluded gases contained therein. Shortly after the tubes have entered the furnace, the filaments therein will be heated by

In order to automatically accomplish this result, there has been provided a guide block 265 which is secured to the upper surface of the stationary table 12 at the inner side of the carriage 204 near the forward end thereof, as shown more particularly in Figures 36, 38 and 39 and in operative relation with a guide pin 266 secured to the rear end of an extension lever 267 which has the forward end thereof pivotally mounted on the adjacent stud 249 for the seal-off frame 246, the extension lever 267 being maintained in the plane of the adjacent rock arm 248 of the frame 246 and against upward movement by a limiting pin 268 which is secured to said extension lever intermediate the ends thereof and adapted to travel in a slot 269 provided in the lower edge of the rear end of the adjacent rock arm 248.

The rear end of the seal-off frame 246 is normally maintained in the uppermost position when the carriage 204 is in its normal rearmost position by the guide pin 266 resting upon the upper surface of a vertical extension 265' formed at the rear end of the guide block 265. As the carriage 204 and the frame 246 are moved forwardly by the action of one of the drive bars 226 upon the detent 227 in a manner hereinbefore described, the guide pin 266 will ride downwardly over a beveled cam face 270 formed at the forward vertical edge of the extension 265' and thence along a flat surface 271 over the top of the major portion of the guide block 265, as illustrated more clearly in Figures 38 and 39, thereby permitting the forward end of the seal-off frame 246 to be yieldingly moved by the weights 250 from the lowermost position to the uppermost position, as indicated by full lines and dotted lines respectively in Figure 38, as the carriage 204 approaches its extreme forward position. This upward movement of the forward end of the frame 246 will bring the shield plates 264 in contact with the bottom portion of the vacuum tube Y which will cause the seal-off tube X to be severed adjacent the underface of said shield plates and in close proximity to the bottom of the tube.

As the carriage is being returned to its original rearmost position by the action of the weight 232 in a manner previously described, the forward end of the frame 246 will again be brought into its lowermost position by the guide pin 266 traveling upwardly over a cam pawl 273 which has one end thereof normally resting on the surface 271 of the guide block 265 and the other or rearwardly positioned end pivotally mounted in an elevated plane upon a screw or pin 274 secured to a bracket 275 connected with or made integral with the guide block 265, as shown in Figures 39 and 41.

The upper surface of the rear end of the cam pawl 273 is, as shown, in the plane of a guide plate 276 formed integral with the bracket 275 and which, in turn, is in the plane of the upper surface of the extension 265' of the block 265.

A rock arm as 277 is secured at one end to a shaft 278 which is pivotally mounted in the bracket 275 at the rear of the guide plate 276. The rock arm 277 extends rearwardly from the pivot 278 with the rear end thereof adapted to engage the upper portion of the cam surface 270 and is normally maintained in spaced relation thereto for permitting the passage of the guide

the pick-up brushes 176 connected with each tube exhaust port coming in contact with the pick-up track 18 and 19 respectively which will free the coating of the filament of the gases contained therein which will then be drawn from the vacuum tube as rapidly as they are discharged by the action of the vacuum pumps. This freeing the glass of the tube and the filament of the occluded gases will continue during the passing of the tubes through the oven 22.

As the tubes pass from the exit end of the furnace 22, the heating of the glass portion will, of course, be discontinued while the heating of the filament will continue until after the end of the bombardment zone. The tubes leaving the furnace 22 will then be brought into operative alignment with the first group of coils consisting of the first pair 205' of coils connected with the carriage 204, and as the tube and carriage 204 are moved forwardly in unison, the cup of the tube will be heated by induced currents set up by these coils which will free the occluded gases contained therein.

As the first tube and carriage reach the end of movement of said carriage, the carriage will be automatically released from the respective drive bar 226 by the engagement of the detent 227 with the trip bar 231 and be returned to its normal rear position by the action of the weight 232 in the manner hereinbefore described, whereupon the first tube will then be in operative alignment with the second pair of coils connected with the carriage 204, and the second tube coming from the furnace 22 will be in operative alignment with the first pair of coils 205'. The second pair of coils 205' being positioned in the plane of the plate of the tube, said plate will be heated by induced currents set up by the second pair of coils, and the gases discharged therefrom will be immediately withdrawn from the vacuum tube by the respective pump.

As the coils and tubes again approach the limit of the forward movement of the carriage 204, the carriage will then be released and returned to the rearward position with the first and second coils in engagement with the second and third tubes coming from the furnace 22, while the third pair of coils 205' will be in operative alignment with the first tube coming from the furnace. As the third pair of coils 205' are in the same plane as the second pair of coils, the plate of the tube will remain subjected to the high frequency flux for the purpose of continuing the heating and driving out of the gases previously absorbed thereby.

As the coils and tubes again approach the limit of the forward movement, the carriage 204 will be released and each of the tubes will again be brought into operative relation with each succeeding pair of coils 205' which will bring the first tube coming from the furnace into operative relation with the fourth pair of coils which, in this instance, are positioned in the plane of the first pair of coils; that is, that of the getter cup of the tube. After the carriage has again reached the limit of its forward movement and then returned to the rearward position, the first tube will then be subjected to the last or fifth pair of coils which being in the plane of the fourth pair of coils will continue the bombardment and heating by induction of the getter cup to such an extent as to cause the flashing of the contents thereof.

It is thus seen that the tubes, as they pass

from the furnace 22, are each successively brought into operative engagement with each pair of bombardment coils 205' and the metallic parts thereof are subjected to high frequency currents induced by the coils 205' which heats said metallic parts and frees them of the occluded gases which are immediately evacuated from the tube, and as the tubes are successively brought into operative relation with the third and fourth pairs of coils, the contents of the getter cup such as magnesium or, as preferably used in this instance, barium, is flashed for the well-known purpose of absorbing any gases remaining in the vacuum tube.

Each of the tubes leaving the bombardment zone will then be successively engaged by the seal-off mechanism as the carriage 204 assumes the extreme rearward position; that is, as the carriage approaches the rearmost position, the guide members 264' will pass between the lead-in wires of the respective tube Y as the shield plates 264 are being brought beneath the tube and the burners 245 will be brought into operative relation with seal-off tube X. As the carriage and tube travel in unison towards the extreme forward position of the carriage, the forward end of the seal-off frame 246 will be lifted by the action of the weights 250 as said frame is freed by the guide pin 266 passing from the extension 265' of the guide block 265 to the lower surface 271 thereof. This upward movement of the forward end of the seal-off frame 246 will cause the lead-in wires for the tube to be lifted by the shield plates 264 from the respective mercury cups out of the path of the flame emitted by the burners 245, and at the same time, bring the shield plates into contact with the bottom of the tube Y which, in turn, will subject the seal-off tube X to the flame and sever it adjacent the bottom end of the tube.

Just after the severing of the seal-off tubes, the operation of the respective pumps will be discontinued due to the opening of the circuit for the motors operating said pumps by the respective cut-out switches 106 coming into operative engagement with the automatic throw-out trip member 126.

As the tube Y is released by the severing of the seal-off tube X, the tube may then be removed from the machine after which the portion of the seal-off tube X remaining in the exhaust port may be removed from said exhaust port and the exhaust port be again re-loaded with a fresh tube.

It is now evident that the tubes may be continuously and successively moved from the loading position to the seal-off position which eliminates the time otherwise consumed in intermittently moved evacuated mechanism in the starting and stopping thereof during the vertical movements of the bombardment coils; that the mechanism thereof is comparatively simple in that no Geneva movements or other mechanism for producing intermittent movements is employed, and although there has been shown and described the preferred embodiment of this invention, it is not wished to be limited to the exact construction shown, as various changes in the construction both in the form and relation of the parts thereof may readily be made without departing from the spirit of this invention as set forth in the appended claims.

We claim:

1. In a machine for evacuating radio tubes, heating means for the elements of the tubes con-

sisting of groups of high frequency coils arranged with the coils of each group at opposite sides of the path of movement of the vacuum tubes and with the coils of each group positioned so that a respective element of the tube will pass through the center of flux of said coils, means for continuously moving the tubes through said groups of coils, and means for intermittently moving the coils in unison with said tubes.

2. A machine for evacuating radio tubes comprising a fixed table having an oven, high frequency coils and a seal-off mechanism connected therewith in circumferential spaced relation, a carrier comprising tube-receiving exhaust ports, said exhaust ports having mercury cups for receiving the lead wires for the tube electrodes, means for supplying an electric current to said mercury cups, means for continuously rotating the carrier to bring the tubes connected with said exhaust ports into successive operative relation with said oven, coils and seal-off mechanism, and means for maintaining said mercury cups at a relatively cool degree of temperature.

3. A machine for evacuating radio tubes comprising a fixed table having an oven, high frequency coils and seal-off mechanism mounted thereon in circumferential sequential relation, said seal-off mechanism and oven being maintained in spaced relation to provide a tube loading station, a carrier comprising tube-receiving exhaust ports, means for continuously rotating the carrier to bring the tubes connected with said exhaust ports into successive operative relation with said oven, coils and seal-off mechanism, pump units for evacuating gas or air from the tubes comprising a vacuum pump connected with a tube exhaust port and a motor for operating said pump, means removably securing each unit to the carrier to rotate therewith, and means for automatically controlling the operation of the pumps at the loading station.

4. In a machine for evacuating radio tubes, a plurality of tube exhaust ports, high frequency coils arranged in planes at opposite sides of said exhaust ports, means for causing relative movement of the coils and exhaust ports, separate means for intermittently moving the coils and exhaust ports in unison whereby the tubes in said exhaust ports will be successively heated by current induced by said coils.

5. In a machine for evacuating radio tubes, a continuously movable carrier having a plurality of tube exhaust ports, a fixed table, high frequency coils arranged in spaced relation and movably mounted on said table in planes at opposite sides of said exhaust ports, means for intermittently moving said coils in unison with said carrier for successively subjecting the tubes maintained in said exhaust ports to a constant degree of inductive heating from said coils over a predetermined time interval.

6. In a machine for evacuating radio tubes, a carrier having a plurality of tube exhaust ports, a fixed table, a carriage mounted for movement on said table, high frequency coils arranged in spaced relation on said carriage in planes at opposite sides of said exhaust ports, means for continuously moving said carrier to bring the tubes maintained in said exhaust ports in successive operative relation with said coils, and means associated with the carrier for intermittently moving the carriage in unison therewith when said coils and tubes are in operative relation.

7. In a machine for evacuating radio tubes, a carrier having a plurality of tube exhaust ports,

a fixed table, a carriage mounted for movement on said table, high frequency coils arranged in spaced relation on said carriage in planes at opposite sides of said exhaust ports, means for continuously moving said carrier to bring the tubes maintained in said exhaust ports in successive operative relation with said coils, means associated with the carrier for intermittently moving the carriage in unison therewith when said coils and tubes are in operative relation, and means for returning the carriage to an initial position at the end of each intermittent movement.

8. In a machine for evacuating radio tubes, a carrier having a plurality of uniformly spaced exhaust ports, each exhaust port being adapted to receive therein the seal-off tube of the vacuum tube and having terminals connected with the lead-in wires of said vacuum tube, means for severing the seal-off tubes comprising a burner, means for continuously moving said carrier to bring the tubes into successive operative relation with said burner, means for automatically bringing the burner adjacent the bottom of the vacuum tube when said burner and seal-off tubes are in operative relation, and means for disconnecting the lead-in wires from the terminals and maintaining said wires out of contact with the flame from said burner.

9. In a machine for evacuating radio tubes, a carrier having a plurality of uniformly spaced exhaust ports, each exhaust port adapted to receive therein the seal-off tube of a vacuum tube, means for severing said seal-off tube comprising a burner, means for continuously moving said carrier to bring the tubes into successive operative relation with said burner, and means for intermittently moving the burner in unison with said tubes.

10. In a machine for evacuating radio tubes, a carrier having a plurality of uniformly spaced exhaust ports, each exhaust port adapted to receive therein the seal-off tube of a vacuum tube, means for severing said seal-off tube comprising a burner, means for continuously moving said carrier to bring the tubes into successive operative relation with said burner, means for intermittently moving the burner in unison with said tubes, and separate means for returning the burner to the initial position at the end of each intermittent movement.

11. In a machine for evacuating radio tubes, a carrier having a plurality of uniformly spaced exhaust ports, each exhaust port adapted to receive therein the seal-off tube of a vacuum tube, means for severing said seal-off tube comprising a burner, means for continuously moving said carrier to bring the tubes into successive operative relation with said burner, and means for automatically bringing the burner adjacent the bottom of the vacuum tube when said burner and seal-off tubes are in operative relation.

12. A machine for evacuating radio tubes including a tube-loading station, a carrier comprising tube receiving exhaust ports, means for continuously moving said carrier to bring the exhaust ports into and out of registration with said station, vacuum pumps mounted on the carrier to move therewith and connected with exhaust ports, means for operating said pumps, and means for automatically controlling the operation of the pumps at the loading station.

13. A machine for evacuating radio tubes comprising a carrier having tube receiving exhaust ports, mercury cups associated with the exhaust

ports adapted to receive the lead wires from the tube electrodes, means for moving said carrier, and means for supplying an electric current to said mercury cups during the movement of the carrier.

14. A machine for evacuating radio tubes comprising a carrier having tube receiving exhaust ports, mercury cups associated with the exhaust ports adapted to receive the lead wires from the tube electrodes, means for moving said carrier, means for supplying an electric current to said mercury cups during the movement of the carrier, and means for maintaining said mercury cups at a relatively cool degree of temperature.

15. A machine for evacuating radio tubes comprising a tube seal-off mechanism, a carrier having tube-receiving exhaust ports, means for moving said carrier to bring the tubes into successive engagement with the seal-off mechanism, means for supplying electric current to the electrodes of the tubes including contact members releasably engaging lead-in wires of the tube electrodes, and means for disconnecting said lead-in wires from the terminals and maintaining said wires out of contact with the flame from the seal-off mechanism.

16. A machine for evacuating radio tubes comprising a continuously rotating tube carrier having tube elements mounted thereon, means for heating the tube, and means for intermittently rotating the heating means.

17. A machine for evacuating radio tubes comprising a continuously rotating tube carrier having tube elements mounted thereon, means for heating the tube, means for intermittently rotating the heating means a predetermined distance in unison with the carrier, and means for returning the heating means to the initial position.

18. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, high frequency means for heating the elements of said tubes including a plurality of coils on opposite sides of the path of movement of said tubes and arranged in pairs so that the center of flux of said pairs of coils will be directed on different parts of the tube elements, and means for intermittently moving all coils in unison with said carrier.

19. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, a normally stationary means for heating the tubes, and means for intermittently moving the heating means in unison with the carrier.

20. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, a normally stationary high frequency induction means for heating the tube elements, and means for intermittently moving the heating means in unison with the carrier.

21. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, a normally stationary means for heating the tubes, means for intermittently moving the heating means in unison with the carrier, and means for continuously

evacuating said tubes while under the influence of said heating means.

22. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, a normally stationary means for heating the tubes, means for intermittently moving the heating means in unison with the carrier, means for continuously evacuating said tubes while under the influence of said heating means, and means for sealing off said tubes from the atmosphere when evacuated.

23. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, an oven surrounding in part the path of movement of said tubes, inductive means for heating the elements of said tubes apart from said oven, and means for applying variable heating current to the filaments of said tubes while under the influence of said heating means.

24. A machine for evacuating radio tubes comprising a continuously moving carrier adapted to have tubes mounted thereon, an oven surrounding in part the path of movement of said tubes, inductive means for heating the elements of said tubes apart from said oven, means for applying variable heating current to the filaments of said tubes while under the influence of said heating means, means for evacuating said tubes while under the influence of said heating means, and means for sealing off said tubes from the atmosphere when evacuated.

25. A machine for evacuating radio tubes including a tube-loading station, a carrier comprising tube receiving exhaust ports, means for continuously moving said carrier to bring the exhaust ports into and out of registration with said station, vacuum pumps mounted on the carrier to move therewith and connected with said exhaust ports, electric motors for operating said pumps, and means for automatically controlling the operation of said motors at the loading station.

26. A machine for evacuating radio tubes comprising carrier means adapted to have tubes mounted thereon, heating means for said tubes, operating mechanism for continuously moving one of said means, and means for intermittently moving both of said means in unison.

27. A machine for evacuating radio tubes comprising carrier means adapted to have tubes mounted thereon, heating means for said tubes, operating mechanism for continuously moving one of said means, means for intermittently moving both of said means in unison, and means for evacuating said tubes while under the influence of said heating means.

28. A machine for evacuating radio tubes comprising carrier means adapted to have tubes mounted thereon, heating means for said tubes, operating mechanism for continuously moving one of said means, means for intermittently moving both of said means in unison, means for evacuating said tubes while under the influence of said heating means, and means for sealing off said tubes from the atmosphere when evacuated.

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CERTIFICATE OF CORRECTION.

Patent No. 2,006,771.

July 2, 1935.

CHARLES J. KAYKO, ET AL.

It is hereby certified that the title of invention in the above numbered patent was erroneously written and printed in the grant and in the heading to the printed specification as "Electric Tube Evaporating Apparatus" whereas said title should have been written and printed as Electric Tube Evacuating Apparatus, as shown by the records of the case in this office; 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 6th day of August, A. D. 1935.

Leslie Frazer

Acting Commissioner of Patents.

(Seal)