April 9, 1946. M. P. WILDER 2,398,340

MANUFACTURE OF VACUUM APPARATUS

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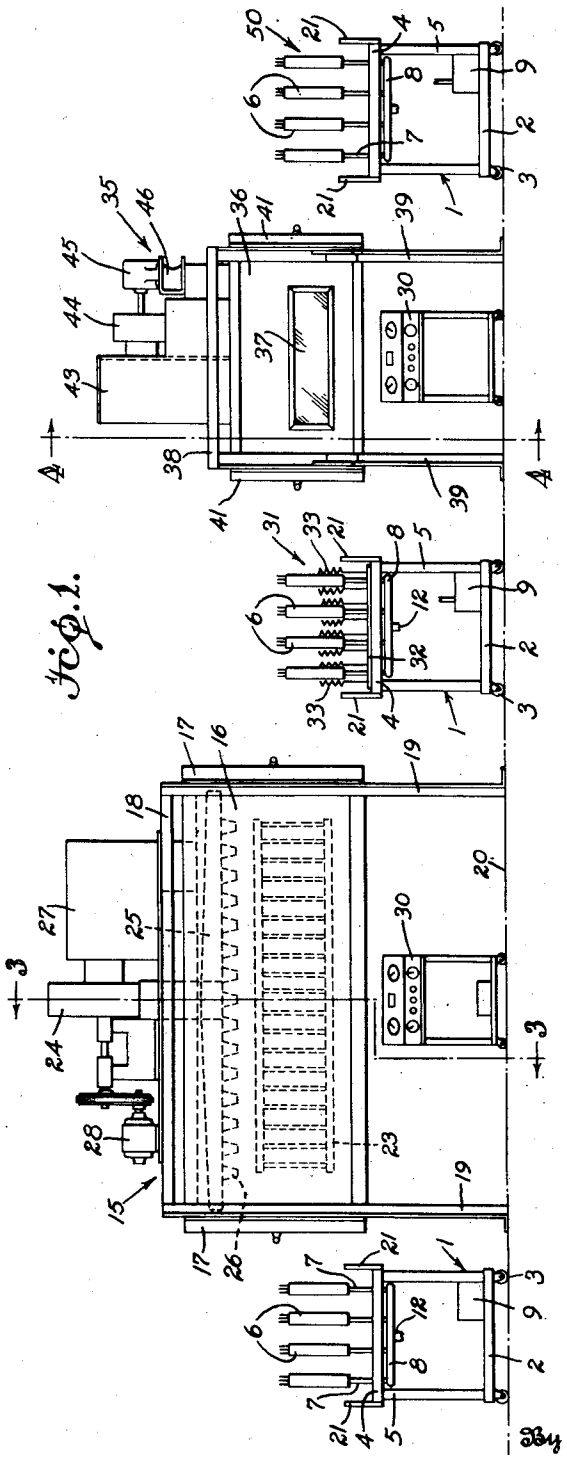


Fig. 1.

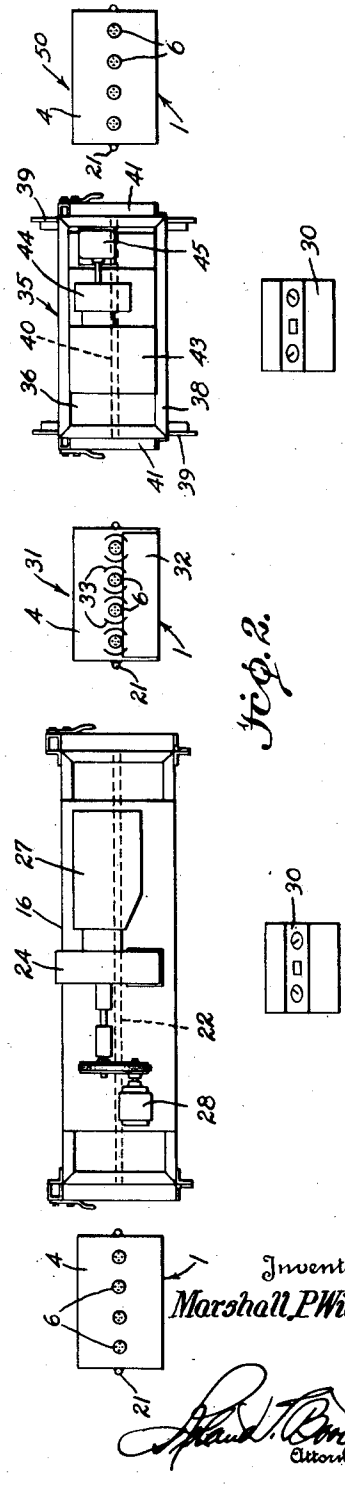


Fig. 2.

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Fig. 3.

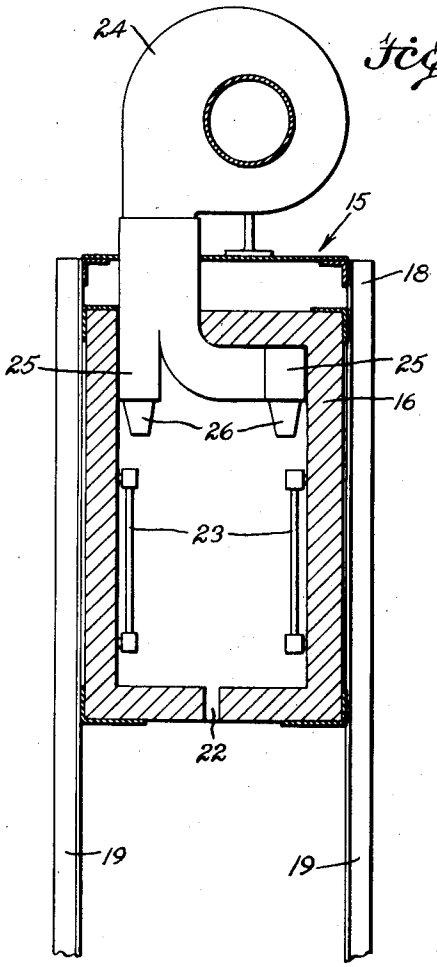
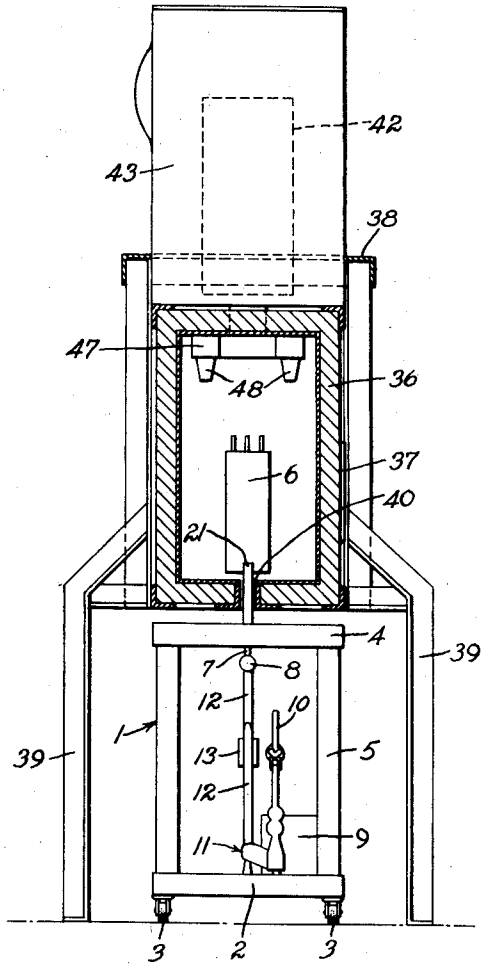


Fig. 4.



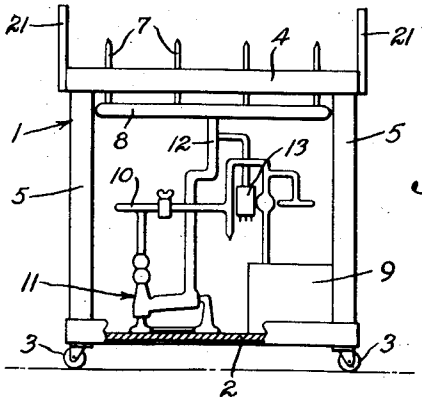


Fig. 5.

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MANUFACTURE OF VACUUM APPARATUS

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Application July 11, 1944, Serial No. 544,429

3 Claims. (Cl. 316—26)

This invention relates to a method and apparatus for the manufacture of vacuum tubes, particularly those used for electron emission of all kinds, including X-ray.

The invention is directed to a method and apparatus that provides for eliminating the disadvantages experienced in prior methods and apparatus and provides for more efficient processing of vacuum tubes, provides for a larger output of processed tubes compared with previous methods and apparatus, eliminates the necessity for having operators who are efficient in several different skills and provides for employing operators with more limited skill.

The invention further comprehends the provision of apparatus that is arranged and constructed for more convenient operation, apparatus arranged at a plurality of stations, having other portions of the apparatus arranged so that it may be moved from one station to another for facilitating the treatment of vacuum tubes through several different steps or stages in a more efficient manner for saving time, obtaining greater production and reducing the cost of processing vacuum tubes. For example, the invention provides a dolly carrying a pumping system including a fore pump, a diffusion pump, a manifold and tubulations connected together and having the tubes secured to the tubulations for conveying the tubes while being evacuated from one station to another for baking, high frequency and electrical treatments.

In the drawings:

Fig. 1 is a side elevation showing the new apparatus for practicing the new method of making vacuum tubes.

Fig. 2 is a plan view of the apparatus shown in Fig. 1.

Fig. 3 is a vertical cross-section taken on line 3—3 of Fig. 1 showing substantially diagrammatically the arrangement for heating and circulating the heat in one of the baking ovens.

Fig. 4 is a vertical transverse cross-section taken on line 4—4 of Fig. 1 through another oven illustrating the arrangement for heating and circulating the heat therein.

Fig. 5 is an enlarged side elevation with the portions broken away showing the pump dolly and illustrating some of the details of construction and arrangement thereof.

All of the views in the drawings show the apparatus in substantially diagrammatic form, many of the controls and electric circuits for the various heating and circulating elements being omitted for convenience in illustration.

The apparatus for practicing the new method has a carriage or pump dolly provided with a base 2 mounted on casters 3 and having a top 4 supported on the base by means of corner posts or legs 5.

In the manufacture of vacuum tubes it is customary to first provide a glass container or envelope and a stem. The various electron emission and control elements are usually mounted on the stem in their assembled relation with suitable circuit connection arranged through the stem so that the tube may be included in the desired electric circuit. Some elements of some of these tubes are constructed and mounted in the envelope and some are combined with the envelope in the construction thereof. The stem is usually assembled in the glass envelope after the various elements have been assembled. The stem and envelope are secured together by a glass-blowing operation while the stem is usually provided with a glass tube through which the air and other gases in the tube may be evacuated in completing the processing of the tube.

The tubes are indicated diagrammatically by the numeral 6 and have the tubular extensions thereon connected in the first operation according to the invention by a glass-blowing operation to the tubulations on pump dolly 1, as indicated at 7. Tubulations 7 are connected to manifold 8 mounted in a suitable manner on the under side of top 4 of the pump dolly.

The dolly carries a pumping system of conventional form used in evacuating the tubes connected with the tubulations. A motor driven fore pump diagrammatically indicated at 9 is mounted on base 2 of the dolly. Fore pump 9 may be constructed in any manner well known in the art and is adapted to provide a means for rapidly producing a fair vacuum within the tubes on the dolly. Fore pump 9 is connected by tubulation 10 to the discharge end of diffusion pump 11. The inlet end of diffusion pump 11 is connected to manifold 8 by tubulation 12. An ionization gauge is indicated diagrammatically at 13 connected with tubulation 12 adjacent its connection with manifold 8.

The diffusion pump may be any of the well-known types of construction now used in the art, such as the molecular disc type as diagrammatically illustrated in the drawings. Such a diffusion pump includes an evaporating vessel heated by an electric coil for a low vapor pressure fluid that is vaporized by the heat and projected through a jet nozzle and subsequently condensed and returned to the evaporating vessel. The con-

struction, operation and design of molecular diffusion pumps are well known in the art, particularly where they are constructed for condensing of the vapor by air cooling. It is well known that when such a pump is employed in series with a fore pump as disclosed herein, that the system is capable of producing a high vacuum of the order of 5×10—7 mm. of mercury.

The ionization gauge is constructed and operated in a manner well known in the art and further description thereof is not believed to be necessary. Suitable sockets and electrical connections are provided on dolly 1 so that the electric motor of the fore pump, the ionization gauge and the heating elements of diffusion pump 11 may be connected with a source of current supply by a suitable flexible cable. These electrical connections and the plugs on the dolly are not illustrated in the drawings because they are merely the usual conventional means well-known in the art. It will be understood that the flexible cable connection between the dolly and the source of current supply will be provided with a sufficient length so that the dolly can be plugged in and moved into the various stations at which the tubes are processed in accordance with the method of this invention.

The first operation in processing vacuum tubes by the present invention will be the sealing of the tubes on the tubulations 7 of the pump dolly. This is done by a glass blowing operation of well-known character. The dolly may then be moved on its casters after starting the fore and diffusion pumps to the first baking station indicated by the numeral 15. The first baking station has an oven 16 of suitable construction, of rectangular form in cross-section, and open at opposite ends as illustrated in Fig. 3. Suitable oven doors 17 close the open ends of the oven and are hingedly mounted on oven frame 18 also carrying the oven. Frame 18 includes legs 19 arranged in spaced relation for supporting the oven and doors in spaced relation above floor 20 a sufficient distance so that the pump dolly may be moved under the oven during processing of tubes thereon between the legs on opposite sides of the frame.

The upper surface of top 4 of pump dolly 1 can be moved under the bottom surface of the oven between legs 19 with guide pins 21 engaged in and extending through slot 22 formed in longitudinally extending relation through the central portion of the bottom of the oven from end to end, as shown in Fig. 3. Guide pins 21 on pump dolly 1 have a larger transverse dimension than tubulations 7 so that in movement of the pump dolly under the oven from one end to the other tubes 6 thereon will project into the oven above the bottom for treatment while the pump dolly is moved underneath the oven and guide pins 21 prevent contact between tubulations 7 and the portions of the oven at opposite sides of slot 22.

Electric heating units are mounted on the side walls in the oven as indicated diagrammatically at 23. These electric heating units are of conventional form well-known in the art, are connected with a suitable source of current supply with conventional type wiring, fuse and switch construction, not shown, while suitable temperature control means of conventional form, not shown, is provided for automatically maintaining the desired temperature in the oven. In order to maintain substantially uniform heat within the oven, heat circulating means is provided including a suitable conventional blower 24 having the outlet connected with a pair of conduits 25 extending longitudinally along opposite upper side portions inside the oven with a plurality of outlet nozzles 26 directed downwardly, as shown in Figs. 1 and 3. An intake manifold 27 is connected with the intake portion of blower 24 and has communication with the upper portion of the oven interior at one end, as shown in Fig. 1. An electric motor 28 is mounted on the oven frame 18 adjacent blower 24 and is connected for driving the blower so as to maintain continuous circulation of hot air in the oven to maintain a substantially uniform temperature throughout the interior of the oven. Motor 28 is electrically connected with a suitable source of supply through a control switch and fuse system of conventional form, not shown.

In carrying out the invention, the oven is usually heated to the desired temperature before the baking operation at the baking station 15 is started. The baking station has the temperature in the oven maintained substantially uniform during the processing of vacuum tubes in accordance with the method used in carrying out this invention. When a plurality of tubes have been attached to a pump dolly as shown at the left-hand side of Fig. 1 by the glass-blowing operation and the pump operated to provide the desired vacuum within the tubes to commence the processing operation of the present invention, the dolly is moved from the position shown at the left-hand side of Fig. 1 under the oven, through first opening door 17 at the left-hand side of the oven, and engaging guide pins 21 in slot 22 in the bottom of the oven. When the pump dolly with the tubes mounted thereon is fully engaged within the oven, the left-hand door 17 is closed and the processing at the baking station is begun.

An electrical processing control unit 30 is mounted on a suitable stand having casters so that the unit is readily movable over floor 20. The unit 30 is illustrated diagrammatically in Figs. 1 and 2 and has an electric cable connection with pump dolly 1 of conventional form so that the desired electrical connections can be made with all of the apparatus on the pump dolly including the tubes, the ionization gauge, etc., for effectively controlling and processing the tubes during their treatment at the various stations in carrying out the method provided by this invention.

The oven, at baking station 15, may be of sufficient length to take two or more dollies in aligned relation so that the tubes on the dollies may be treated simultaneously and in a progressive manner for continuous processing of tubes particularly where the baking operation requires more time than processing operations at other stations. The tubes are heated for a substantial period of time in oven 16 in order to evolve or remove the occluded gases from the interior surfaces of the glass, metal and other parts. The tubes are constantly pumped to evacuate them during the heating operation in oven 16 in order to aid in the removal of the occluded gases from the various parts of the tube. The duration of the baking treatment in station 15 and the temperature at which the baking is carried on may be varied with different types of tubes in obtaining desired results.

When the heating and baking of the tubes is completed at station 15, right-hand door 17 as shown in Fig. 1, is opened and the dolly adjacent thereto is removed from under the oven and moved to the treatment station indicated at 31 in Fig. 1. After pump dolly 1 is removed from the oven the right-hand door is closed so that

the temperature in the oven at station 15 will be maintained at the desired heat for continuing the treatment of tubes or other pump dollies in the oven.

When the dolly is positioned at station 31 as shown in Figs. 1 and 2, the tubes are then treated with high frequency current. A slide panel 32 carries a plurality of high frequency coils 33 formed in half sections so that they may be engaged about tubes 6 by sliding the slide panel into position on top of top 4 as illustrated in Fig. 1 at station 31. The sections of each high frequency coil are spaced apart a sufficient distance to provide for the engagement of the sections about each tube 6. When the high frequency coils are in the position shown in Figs. 1 and 2, they will have a processing control unit 30 connected therewith to control the operation of the high frequency coils in processing the tubes. The high frequency coils provide for heating the metal parts within the tubes such as the electrodes, stems, etc. The process is carried on according to the type and size of tubes for a period of time that may approximate in length that of the baking operation at station 15, although the length of time for this high frequency treatment may be varied to suit the type of tube being treated.

When the electrical treatment at station 31 has been completed the tubes are then given further electrical treatment while the tubes are heated in an oven. This treatment involves the supplying of current to the filaments and high voltage to the anodes and different voltages to other electrodes so that the anodes are bombarded by electron streams for evolving or eliminating gases in the material. This treatment is carried on at station 35, indicated in Figs. 1 and 2.

Station 35 has an oven 36 somewhat smaller than oven 16 arranged with a transparent window 37 so that the electrical treatment of the tubes within the oven can be observed. Oven 36 is mounted on a framework 38 with the bottom mounted in spaced relation above the floor 20 at such a distance that a pump dolly 1 can be moved under the oven with the top face of top 4 in contiguous relation to the bottom of the oven. Frame 38 includes a leg structure 39 arranged to provide spaced legs so that pump dollies can be moved between the legs underneath oven 36. Oven 36 is provided with a longitudinal slot 40 extending from end to end thereof while the open ends of oven 36 are closed by hinged doors 41. Hinged doors 41 provide for the convenient insertion and removal of the tubes in oven 36 by moving the pump dollies underneath the oven with guide pins 21 engaged in slots 40. A pump dolly 1 is moved into oven 36 at station 35 from the left-hand side, as shown in Fig. 1, the left-hand door being opened for this purpose and after the dolly is moved under the oven with the tubes in the oven, door 41 is closed.

The oven is heated electrically by suitable heating elements indicated generally in Fig. 4 at 42, suspended in a heater casing 43 mounted on framework 38 above the oven and having the lower end of the heater casing provided with a passage communicating with the upper portion of the oven. The upper left-hand portion of heater casing 43, as shown in Fig. 1, is connected with the intake of blower 44 driven by an electric motor 45 mounted on bracket structure 46 carried by framework 38. The outlet of blower 44 is connected with a manifold 47 in the upper interior portion of oven 36. Manifold 47 has sections arranged at opposite side portions of the oven in longitudinally extending relation and is formed with a plurality of downwardly projecting discharge nozzes 48. Hot air for heating the oven to the desired temperature which is usually less than that of the oven at station 15 is circulated through the oven by blower 44 driven by motor 45 to maintain the heat in the oven uniform for uniformly heating all parts of the tubes being processed to the desired temperature. While the tubes are being heated in the oven at station 35 they are connected to an electrical processing control unit 30, one of which is shown at station 35 for controlling the heating of the filaments and voltage on the several electrodes in order to control the bombardment of the electrodes by the electron streams within the tube for driving out the gases in the electrodes. This operation is carried on for a desired length of time as well-known in the art, the operator being able to watch the tubes through window 37 in controlling the processing thereof.

If X-ray tubes are to be treated at station 35 it is usually preferable to provide a lead shield for the oven. It may also be desirable to enclose the space below the oven between the legs 39 with a suitable casing arranged with lead shields to protect the operator from the X-rays during the processing of the tubes. This will provide a complete enclosure for the oven and the frame 38 extending from the floor up to the top of the frame while the doors 41 will be extended to the floor in order to control the openings at the ends of the oven and the space below to provide for the movement of the dollies from the left-hand end of the oven at station 35 into the casing and then after the treatment is completed to move the dollies out from the right-hand end. This casing enclosing the whole frame is not disclosed in the drawings but from the disclosure in the drawings it will be readily understood by one skilled in the art how this casing for protecting an operator against X-rays may be readily provided. The window 37 will be formed of lead glass so as to protect the operator observing the condition of treatment of X-ray tubes.

Depending on the type of tube being produced, it may be desirable to give the tubes further treatment after they are removed from the oven at station 35. For this purpose the dolly mounting the tubes is moved to the station indicated at 50 in Figs. 1 and 2 where an electrical processing control unit 30 may be connected thereto and further electrical processing carried on to complete the treatment of the tubes. When this treatment is completed at station 50, a glass-blowing operation is then carried on to seal off tubulations 7 for removing the tubes from the dolly in completely treated form so they may be finally tested and subsequently prepared for commercial use. One of the treatments carried on at station 50 for example, may be special filament in addition to the sealing off operation on tubulations 7.

With the apparatus described above the treatment of vacuum tubes can be carried on in which the baking, high frequency heating and electrical treatment consume about the same length of time so that a series of dollies with the tubes mounted thereon may be successively moved from one station to the other in the successive treatments. In this way the baking and electrical treatment of the tubes may be carried on continuously for continuous production of tubes as rapidly as the treatment can be completed. Several dollies may be placed under over 16 so that

when the treatment at station 15 requires more time than treatments at the other stations, the baking operation may be carried on simultaneously on a greater number of tubes in order to provide for continuous treatment of a limited number of tubes at all of the stations to maintain a desired quantity of production and operate the apparatus at full capacity in production.

By placing the pumping units on the pump dolly 1, the pumping operation can be carried on in advance of the baking treatment at station 15 for the desired length of time in order that the tubes may be processed in an efficient manner. The present process and apparatus provides an advantageous method of treating vacuum tubes for increasing efficiency and lowering cost in production because very little time is lost in the baking treatment of the tubes as compared with previous methods. The ovens at both stations 15 and 35 may be readily maintained at a substantially constant temperature for carrying on the baking operations at different temperatures and the dollies with the tubes thereon may be quickly and conveniently inserted and removed from each of the ovens for this treatment without material loss of heat. At no stage in the processing of tubes according to the present invention is it necessary to allow the ovens to cool down in order to carry on part of the treatment of the tubes. This gains a particular advantage in the operation of the present process and apparatus in the manufacture of tubes, saving heating costs, time and labor.

The apparatus provided by this invention also utilize operators that have considerably less skill than have been heretofore required in the art. For example, the sealing on and sealing off operations of the tubes done by a glass-blowing operation, may be done by an operator skilled in these particular operations while another operator will carry on the baking treatment at the station 15. These operators will only be required to have sufficient skill to perform one of these operations instead of both, so that operators may be trained for each different operation. Still another operator will be utilized for carrying on the high frequency treatment of the tubes at station 31. It is only necessary that the operator be skilled in the high frequency treatment of the tubes at the station 31 and likewise another operator skilled in the operations carried on in processing tubes at the station 35 will be more efficient and will be able to carry on the operation on successive tubes with greater uniformity so that the tubes produced by the present invention will be more uniform in their operating efficiency than when they are produced by methods heretofore used in which different operators would completely process different groups of tubes and due to the varying skill of the operators the tubes would vary to a substantial extent.

In addition operators may be secured that are particularly adept for operating the processing of the tube at one station as distinguished from another and the talents of the operator thereby used to better advantage in obtaining greater efficiency in manufacturing more efficient tubes.

This invention therefore provides for the more rapid training of operators in the different operations so that more highly skilled operators can be trained for carrying on the sealing on of the tubes, the baking, high frequency treatment, etc. in a much more efficient manner than has heretofore been possible.

The invention also provides for the continuous processing of tubes through the various stations with the maintenance of uniform conditions of operation in all of the stations and by this method more efficient and uniform processing of vacuum tubes is obtained in which the tubes produced will also be more uniform.

The invention claimed is:

1. Apparatus for manufacturing vacuum tubes comprising a carriage having a flat top portion, a plurality of tubulations extending through said top portion in aligned spaced relation for mounting a vacuum tube on each tubulation for processing, a slide panel detachably and slidably mounted on said top portion, a plurality of coils, one for each tubulation and tube thereon mounted on said slide panel, each coil being formed in sections mounted in spaced complementary relation to receive a tube and tubulation between the sections in sliding said slide panel on said top portion for engaging said coils about tubes on said tubulations, and means on said carriage and for connection with said coils for processing tubes mounted on said tubulations.

2. Apparatus for manufacturing vacuum tubes comprising a frame, an oven body formed of insulating material having a hollow rectangular form in cross-section, open at both ends and formed with a longitudinal slot in the bottom opening through both ends, means attaching said body to said frame for support in spaced relation above a floor, doors closing both open ends of said body, heating units mounted on the inner side walls of said body intermediate the upper and lower edges and extending from end to end thereof, a pair of nozzle conduits, each mounted at one side of the body on the inner face of the top wall adjacent one side wall and extending from end to end thereof, each nozzle conduit having a plurality of nozzles extending downwardly therefrom for directing air in streams downwardly toward the adjacent heating unit, a blower connected for circulating air through said conduits and outwardly from said nozzles, and an air return passage from the interior of said body to said blower, whereby heat may be distributed through said body in a substantially uniform manner for baking vacuum tubes.

3. Apparatus for manufacturing vacuum tubes comprising a frame having supporting legs spaced to provide a passage therethrough along the supporting floor, an oven body mounted in said frame above said floor, said oven body being open at both ends and having a slot in the central bottom wall opening through the ends, doors closing both ends adapted to be opened for moving material into and out of the oven body, means for uniformly heating said oven body, and a carriage movable under said body through said passage having tubulations for carrying vacuum tubes for processing in said oven with said tubulations extending through said slot, and guide pins on said carriage for engagement in said slot and with said body for guiding said carriage through said passage and protecting said tubulations from breakage during moving through said slot.

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