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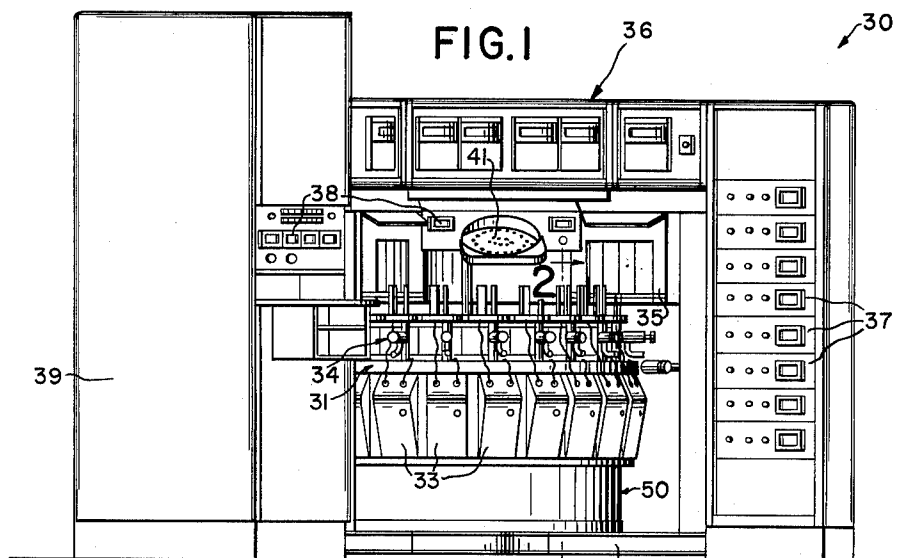
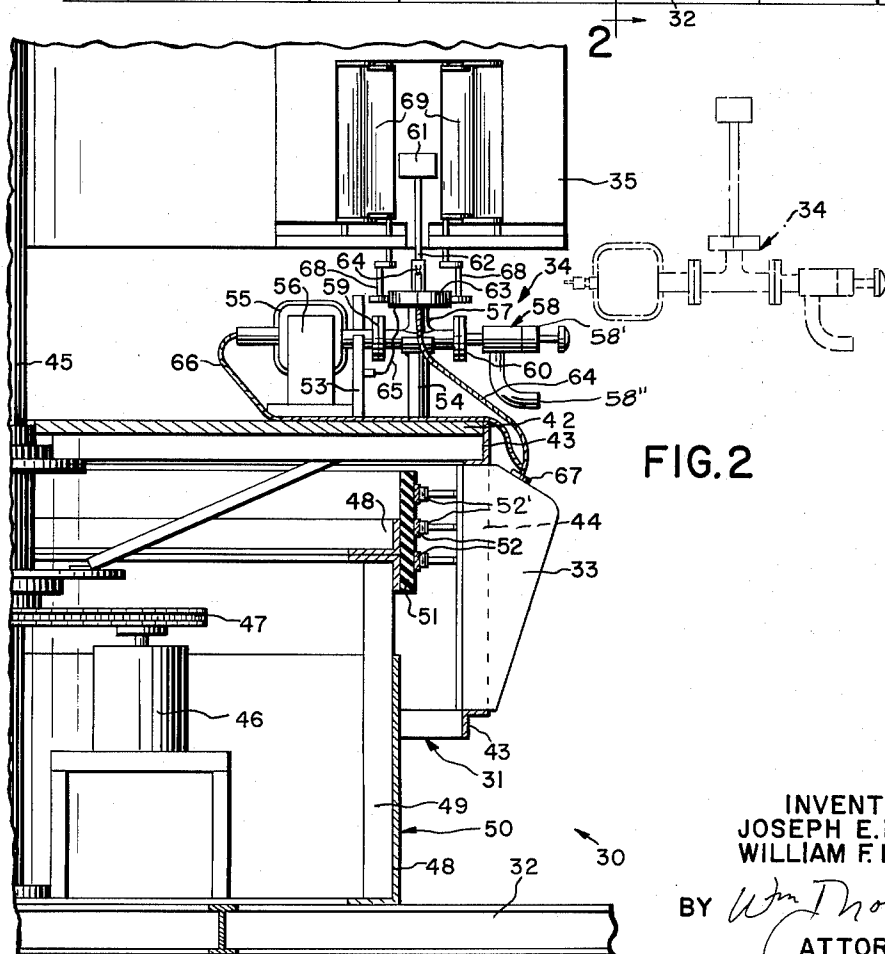
J. E. BYRNE ETAL

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ROTARY EXHAUST APPARATUS

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2 Sheets-Sheet 1



INVENTORS
JOSEPH E. BYRNE
WILLIAM F. LUCK

BY *Wm F. Nolan*
ATTORNEY

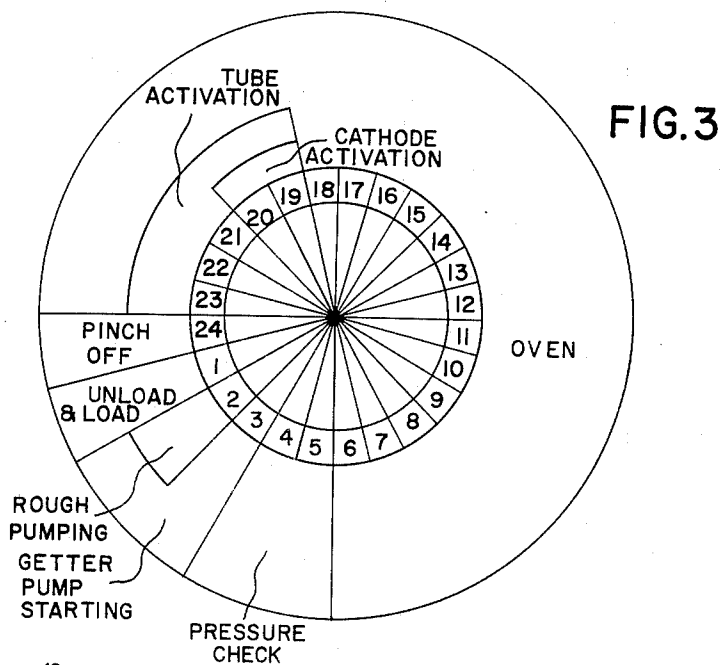
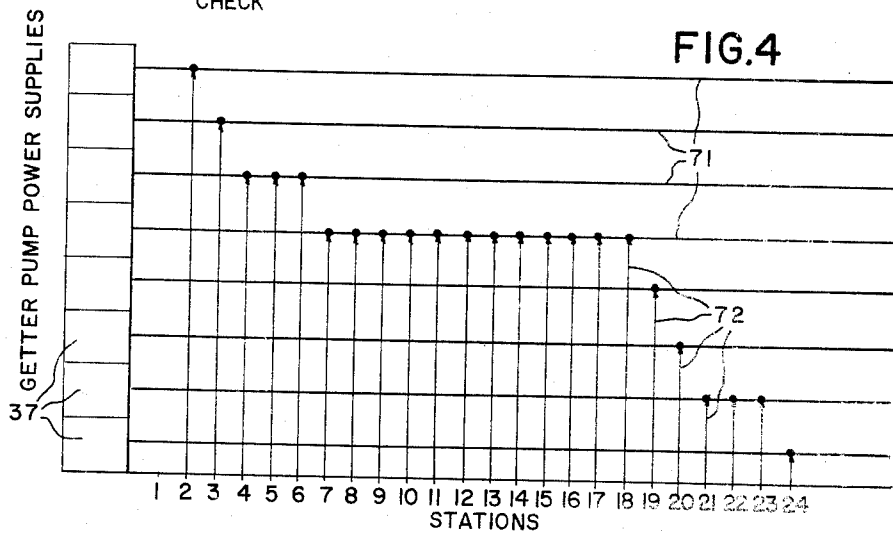
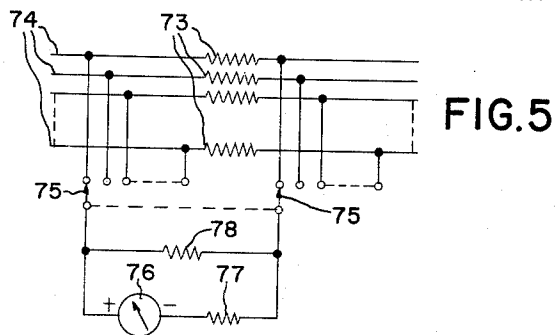
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INVENTORS
JOSEPH E. BYRNE
WILLIAM F. LUCK
BY *Wm. J. Nolan*
ATTORNEY

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ROTARY EXHAUST APPARATUS

Joseph E. Byrne, Los Altos, and William F. Luck, Mountain View, Calif., assignors to Varian Associates, Palo Alto, Calif., a corporation of California
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7 Claims. (Cl. 316—30)

This invention relates to apparatus for manufacturing hollow articles which are to be evacuated and sealed under high vacuum.

Many diverse apparatus have been constructed for evacuating and sealing hollow articles but for the most part such apparatus has suffered the disadvantages of being highly complex and hence difficult to service and maintain in continuous service, of necessitating shut down of the entire apparatus upon failure of any of the component elements, and of requiring a large amount of supervision of the various apparatus components in order to insure proper operation thereof. These disadvantages have been particularly present in evacuating apparatus of the rotating type primarily because of the vacuum systems which have been used thereon. Prior rotating exhaust apparatus have utilized open vacuum systems which include a high pressure part to which gas is exhausted from a low pressure part. These open vacuum systems, mostly of the diffusion pump type, require a large number of vacuum components in addition to a vacuum pump. For example, an open vacuum system utilizing a diffusion pump requires an associated backing pump, a suitable valve and conduit assembly arranged so that the backing pump can act first as a roughing pump in direct connection with a vacuum system and then as a backing pump for the diffusion pump when the diffusion pump is connected to the vacuum system, a suitable cold trap positioned in the vacuum system between a mechanical backing pump and the high vacuum diffusion pump, and etc. The necessary use of these additional vacuum components in open vacuum systems has greatly complicated the structure and required supervision and maintenance of rotating exhaust apparatus.

Another problem associated with an open vacuum system is that any failure in the pumping apparatus because of power, or mechanical failure will result in the low pressure part of the vacuum system being subjected to a rapid increase in pressure upon the discontinuation of pumping action because of gas leakage from the high pressure part of the system. This problem also becomes a factor when it is desired to remove a particular open vacuum system and attached article being evacuated from a rotary exhaust machine because in so doing the article being evacuated will be subjected to a possible undesirable increase in pressure. The prior solution to this problem was the inclusion in the vacuum system of a relatively complex safety valve structure which would automatically seal off the cavity being evacuated upon a failure of the pumping apparatus.

Still another complexity in rotary exhaust machines is created by the desirability in certain machines of knowing the pressure which exists in each particular vacuum system mounted on the rotary machine. The knowledge of existing pressures in particular vacuum systems is helpful to machine operators in determining whether the various phases of the evacuation process are proceeding properly and also in determining when and where malfunctions are occurring in the vacuum pumping apparatus. In previous rotating exhaust machines utilizing open vacuum systems this pressure information was normally obtained by utilizing a separate pressure gage located in each of the separate vacuum systems mounted on the rotating apparatus, which added considerably to the complexity and required supervision of these machines.

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It is therefore the object of this invention to provide novel and greatly improved apparatus for processing hollow articles which are to be evacuated and sealed during the processing cycle.

Another object of the present invention is to provide improved rotary exhaust apparatus having a minimum of component parts thereby making it relatively inexpensive to construct and maintain.

Another object of the present invention is to provide improved rotary exhaust apparatus which is adapted for ease of repair of its parts subject to mechanical failure without seriously interrupting the operation of the rotating apparatus.

Another object of the present invention is to provide rotary exhaust apparatus in which supervision and trouble shooting difficulties are reduced to a minimum.

One feature of the present invention is the use of a plurality of individually removable completely closed high vacuum systems on a rotary exhaust machine.

Another feature of the present invention is the utilization in the above rotary exhaust machine of electrical getter ion pumps in each of the closed high vacuum systems to thereby greatly reduce the number of required vacuum components required on the machine.

Another feature of the present invention is the use in an exhaust apparatus requiring a plurality of vacuum systems including electrical getter ion pumps of a novel circuit and meter arrangement which provides selective and separate pressure indications for each of the plurality of vacuum systems.

Another feature of the present invention is the use in a vacuum apparatus having a plurality of electrical getter ion pumps of a novel switch and circuit arrangement which reduce the number of power supplies required to service the plurality of getter ion pumps.

Other and further features of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

FIG. 1 is a front elevation view of a rotary exhausting apparatus which constitutes one embodiment of the present invention and which is particularly adapted for processing vacuum tubes,

FIG. 2 is an enlarged fragmentary cross section taken along the lines 2—2 of FIG. 1,

FIG. 3 is a diagrammatic representation of a typical vacuum tube processing cycle embodying the apparatus shown in FIG. 1,

FIG. 4 is a schematic representation of the power supply circuits employed for the pumping apparatus shown in FIG. 1,

FIG. 5 is a schematic representation of circuitry for providing pressure indications for the vacuum systems shown in FIG. 1.

Referring now to FIGS. 1 and 3 there are shown processing stations 1—24 on a vacuum tube processing machine 30 having a squirrel cage type turntable 31 rotatably mounted on a stationary support structure 32. Twenty-four individual control boxes 33 and associated vacuum systems 34 are mounted at 15° intervals along the periphery of the turntable 31. A semicircular electrical oven assembly 35 having the same radius of curvature as does the turntable 31 is mounted above and concentric thereto. The console unit 36 frames the turntable member 31 and includes a plurality of vacuum pump power supplies 37, a plurality of electrical measurement meters 38, and a housing 39 for additional electrical apparatus used by the processing machine 30. Also mounted in the console 36 is an alarm system having a plurality of signal lights 41 which light in response to faults in the operation of the processing machine 30.

The turntable 31, as shown more clearly in FIG. 2, in-

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cludes a flat circular top 42 mounted on a pair of circular concentric and spaced apart angle irons 43 which are separated around their peripheries by a plurality of transverse bars 44. The turntable 31 is mounted on a drive shaft 45 which is supported by the stationary support 32. The motor 46 drives the shaft 45 through the intermediary of a chain and sprocket assembly 47 thereby causing rotation of the turntable 31. An inner frame 50 composed of a pair of concentric circular angle irons 48 separated by a plurality of bracing bars 49 is mounted inside the squirrel cage turntable 31 on the stationary support 32. An insulator board 51 having a plurality of commutator switching contacts 52 is mounted opposite each of the control boxes 33 around the periphery of the inner frame 50.

The commutator contacts 52 are connected by electrical leads (not shown) to the vacuum pump power supplies 37, electrical apparatus within the housing 39, electrical measurement meters 38 and etc.

The vacuum systems 34 are removably mounted on the Y-shaped supports 53, 54 around the outer surface of the turntable top 42. Each of the vacuum systems 34 includes an electrical getter ion pump 55 which is straddled by the spaced apart pole pieces of a permanent magnet 56 permanently mounted on the turntable top 42, a three appendaged hollow exhaust tube 57, and a roughing tubulation and vacuum valve assembly 58. Two horizontal appendages of the exhaust tube 57 are connected to the electrical getter ion pump 55 and a valve assembly 58 including high vacuum valve 58' and exhaust or roughing conduit 58'' by the mating flange assemblies 59, 60. The vertical appendage of the exhaust tube 57 supports and connects to a vacuum tube 61 providing a gas communication path therefor. Also mounted on the vertical appendage is a slotted hollow tube 62 which extends upwardly from a disc-like combination heat sink and cam assembly 63 and encloses the electrical leads 64 connected to the vacuum tube 61. A ground wire 65 is connected between Y-shaped support 53 and the combination heat sink and cam member 63 maintaining the entire exposed portion of the vacuum system 34 at ground potential. The electrical wires 64 and a high voltage lead 66 connected to the electrical getter ion pump anode electrode pass through suitable fittings 67 into the control box 33 where they are connected to the commutating contacts 52 by a plurality of sliding contacts 52'.

The vacuum system 34 is a completely closed system since the getter ion pump will exhibit a pumping action without the requirement for apparatus to exhaust pumped gases from the low pressure part of the vacuum system to some other area which is at a higher pressure. This is because of the getter ion pump's well known ability to entrap pumped gas molecules through a gettering process. Thus the pumping action in the vacuum system 34 will continue while the high vacuum system is completely and continually sealed off from areas outside the high vacuum system. Such a closed vacuum system adds greatly to the simplicity of the rotating exhaust machine in that it eliminates the necessity for a continuously operating backing pump, cold vacuum traps positioned between backing pump and the high vacuum system, pump failure automatic valve apparatus positioned between the high vacuum pump and apparatus being evacuated, and etc. The complete vacuum system is therefore an extremely compact and relatively lightweight unit requiring a minimum of installation space. The compact structure and closed system operation of the vacuum system 34 also allow it and its associated electron tube to be removed from the turntable 31 as a composite unit without any appreciable loss in vacuum within the system. The removal of this composite unit is as shown in the phantom view of FIG. 2. This ease of removability without loss of vacuum is a very important feature at times when failures occur in the pumping apparatus. An operator is able to remove a defective pump and asso-

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ciated vacuum tube from the turntable 31 and replace it with an operable standby vacuum system without a stoppage of the processing apparatus and without a possible harmful rise of pressure within the removed vacuum tube.

Operation of this embodiment of the present invention will be more readily understood by referring to the schematic processing cycle shown in FIG. 3 which shows the twenty-four different stations which each individual vacuum system and associated vacuum tube will sequentially occupy during the processing cycle. The operator begins the cycle by mounting a tube to be processed on the vacuum system located at station 1 and attaching processing voltage leads 64 to the tube from the corresponding control box 33. The turntable 31 then indexes in response to a suitable pretimed index control system (not shown) placing this particular tube and vacuum system at station 2. The operator then attaches a suitable roughing pump to the conduit 58'' and proceeds to rough pump the vacuum system. After a time sufficient for the roughing pump to reduce the pressure in the vacuum system to a level which will allow starting of the electrical getter ion pump, operating voltage is either manually or automatically applied to the pump. The operator then closes the valve 58' and isolates the roughing pump from the vacuum system. This particular vacuum system and associated tube will then sequentially index through stations 3, 4 and 5 during which time the electrical getter ion pump is reducing the pressure in the attached tube. The operator makes vacuum checks at stations 4 and 5 to establish that a proper vacuum has been obtained before the tube enters the oven 35. As the vacuum system indexes from station 5 to station 6 the combination heat sink and cam assembly 63 engages mechanical linkages 68 to automatically open the hinged oven doors 69 allowing entry of the tube into the oven. The tube then remains in the oven as the entire apparatus indexes through stations 6-18 during which time the tube is being evacuated and baked. Cathode activation of the tube takes place at stations 19 and 20 and other scheduled tube activation voltages are applied at stations 21-23. The tube leaves the oven as it indexes from station 23 to station 24 where a suitable apparatus automatically pinches the tube off from its vacuum system. After indexing again to station 1 the finished tube is removed by the operator who replaces it with another tube to be processed. The above cycle is carried out by each of the 24 separate vacuum systems mounted on the rotary machine so that twenty-four different tubes are simultaneously being processed.

FIG. 4 shows a schematic representation of the power supply circuits employed for the machine 30 which allows operation of the plurality of pumps 55 by a lesser number of the getter ion pump power supplies 37 used in the present invention. Each of eight separate power supplies 37 have an output lead 71 which connects to a female socket in a suitable patch panel board (not shown). One terminal of a voltage lead 72 is connected to a commutator bar 52 at each of the twenty-four stations located around the processing machine. The other terminals of the voltage leads 72 are connected to male plugs adapted to communicate with the female sockets positioned in the patch panel board. This arrangement allows an operator to preselect the most efficient power supply relationship between the power supplies 37 and the individual getter ion pumps 55 for any given processing cycle. For example, the particular connections shown in FIG. 4 will produce the most efficient use of the getter ion pump power supplies 37 when used in the processing cycle described above. Each of the voltage leads 72 from stations 2 and 3 are solely connected to a separate power supply since at these particular stations the getter ion pump will be in a starting condition at which time the pump will draw a very heavy starting current of, for example, approximately 150 milliamperes. The voltage leads from

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stations 4, 5 and 6 are all connected to a single power supply since the lower pressure of the vacuum systems at these stations will result in a reduced pump current of, for example, 10–30 milliamperes, making it possible for a single power supply to simultaneously service three separate getter ion pumps. The voltage leads from stations 7–18 are all connected to another individual pump supply since the internal pressure of the pumps at these stations will be very low causing individual pumps to draw a current of, for example, only 1 milliamperes. This allows a single power supply to simultaneously service the twelve separate getter ion pumps. Each of the voltage leads 72 from stations 19 and 20 will be solely connected to individual power supplies because the cathode activation which takes place at these stations results in large bursts of gas within the vacuum system thereby causing an increase in pump current to, for example, 150 milliamperes. The voltage leads from stations 21, 22 and 23 are all connected to a single power supply since the system pressure at these stations is again reduced causing a similar decrease in pump current. The voltage lead from station 24 is solely connected to an individual power supply so that an extremely accurate pump current reading may be obtained before tube pinch off takes place. This current reading will give very accurate information regarding the pressure within the tube before pinch off. Thus, the station location of an individual getter ion pump will determine what proportion of the total current supplied by the power supply to which it is connected that the individual pump will draw. This allows the use of only eight pump power supplies, each having only the maximum power requirements necessary for operating a single getter ion pump, to adequately service twenty-three simultaneously operating getter ion pumps which results in a great saving of space and expense requirements for the rotary processing machine.

FIG. 5 shows a novel circuit arrangement for providing separate selective pressure indications for each of the twenty-four vacuum systems 34 on a single specially calibrated electrical meter. A resistor 73 is connected in each of the lines 74 supplying current to the individual getter ion pumps 34. A multiposition rotary switch 75 separately connects the series connected current meter 76 and adjustable resistor 77 across any selected one of the resistors 73 in the pump supply lines 74. Thus, the meter 56 will give an indication proportional to the current drawn by any selected one of the individual getter ion pumps 34. Since the current drawn by a getter ion pump is directly proportional to its internal pressure the adjustable resistor 77 may be adjusted and the current meter 76 calibrated so as to provide a separate indication of the pressure within any individual getter ion pump as selected by the selector switch 75. This pressure will be substantially equal to the pressure at any place in the vacuum system. Thus, the circuit shown in FIG. 5 provides internal pressure indications for each of the individual vacuum systems on the rotary exhaust machine on a single meter and without the use of separate pressure gages, amplifiers, and etc.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A rotary exhaust apparatus for evacuating a hollow article including: a stationary support means having operating stations arranged thereon in circumferential sequential relation, a plurality of said stations including stationary electrical contact members; a plurality of power supplies electrically connected to said stationary contact members, for supplying an electric current thereto; a turntable member mounted for movement relative to said

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support means having a plurality of sliding contact members arranged thereon in circumferential spaced relation; a plurality of closed vacuum systems mounted on said turntable for evacuating said hollow article, each of said closed vacuum systems including an article receiving exhaust tubulation and an electrical getter ion vacuum pump connected to said tubulation; means for sequentially electrically connecting each of said electric getter ion pumps to a respective one of said power supplies by means of said sliding contact members; and, means for continuously indexing said turntable member to thereby advance said hollow articles through successive operating stations and said sliding contact members in contact with said stationary contact members whereby electrical current is supplied to said electrical getter ion pumps.

2. The apparatus according to claim 1 wherein the number of power supplies is less than the number of stations to which current is supplied.

3. The apparatus according to claim 1 wherein the current supplied to certain of said stations is different than current supplied to other of said stations.

4. Apparatus according to claim 1 wherein a plurality of magnetic field producing means are mounted on said turntable member, said magnetic field producing means comprising spaced apart poles adapted to straddle each of said electrical getter ion pumps.

5. Apparatus according to claim 1 wherein said turntable member includes a plurality of support members adapted to removably support each of said closed individual vacuum systems.

6. Apparatus according to claim 1 wherein each of said closed vacuum systems includes valve and roughing tubulation means adapted for connection to a roughing pump.

7. A rotary exhaust apparatus for evacuating a hollow article including: a stationary support means having operating stations arranged thereon in circumferential sequential relation, a plurality of said stations including stationary electrical contact members; a plurality of power supplies electrically connected to said stationary contact members, for supplying an electric current thereto; a turntable member mounted for movement relative to said support means having a plurality of sliding contact members arranged thereon in circumferential sequential relation; a plurality of closed vacuum systems mounted on said turntable for evacuating said hollow article, each of said closed vacuum systems including an article receiving exhaust tubulation and an electrical getter ion vacuum pump connected to said tubulation; means for electrically connecting each of said electric getter ion pumps to a respective one of said sliding contact members; means for continuously indexing said turntable members to thereby advance said hollow articles through successive operating stations and said sliding contact members in contact with said stationary contact members whereby electrical current is supplied to said electrical getter ion pumps, selective electrical means for separately indicating the pressure in said plurality of independent vacuum systems; and, said selective electrical means being selectively and separately responsive to the current drawn by said getter ion pumps.

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FRANK E. BAILEY, *Primary Examiner*.

75 ROBERT BEALL, *Examiner*.