Sept. 10, 1957 C. T. DE GROAT 2,805,689

GAS CHARGING APPARATUS

Filed March 31, 1955 2 Sheets-Sheet 1

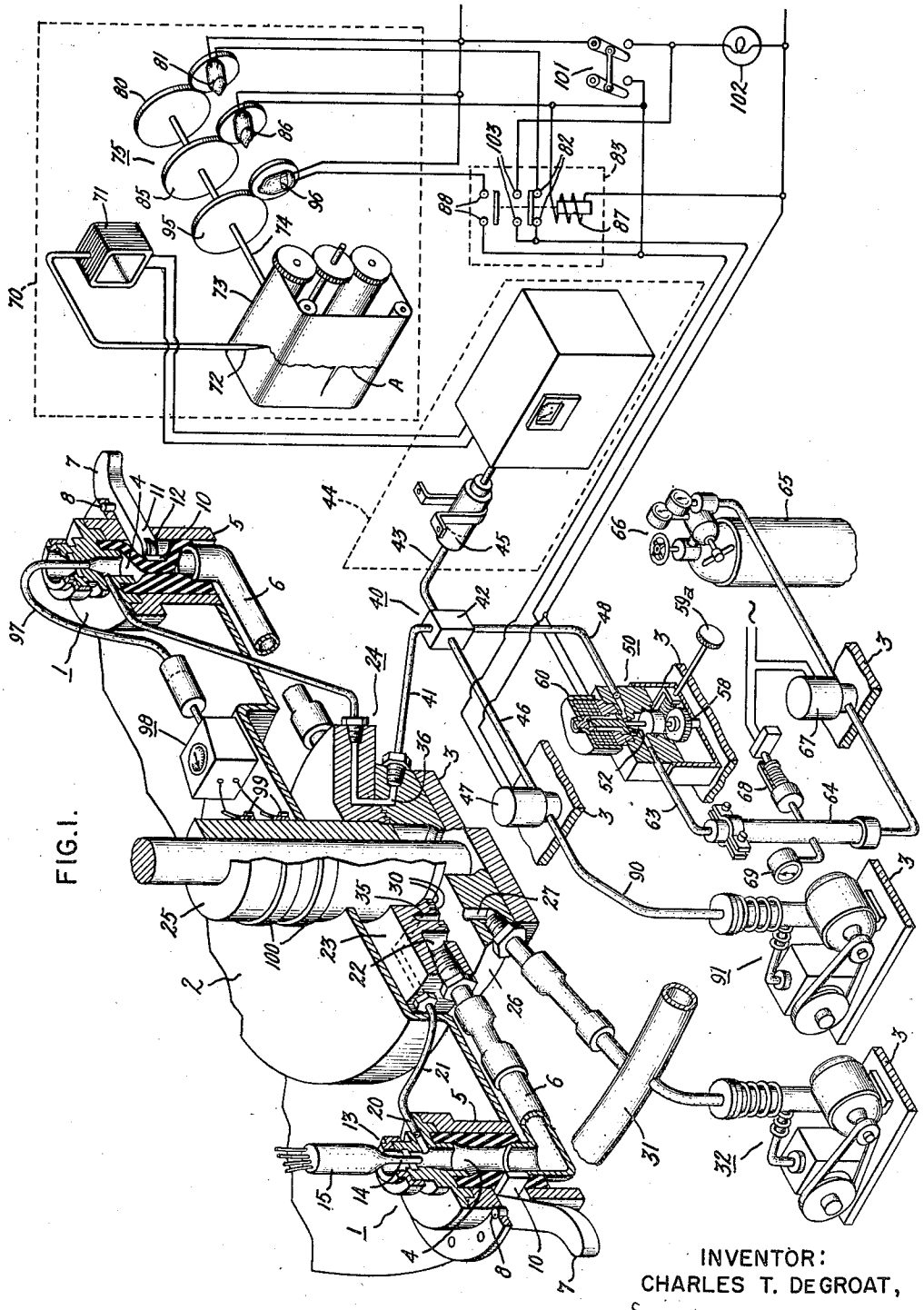


FIG. 1.

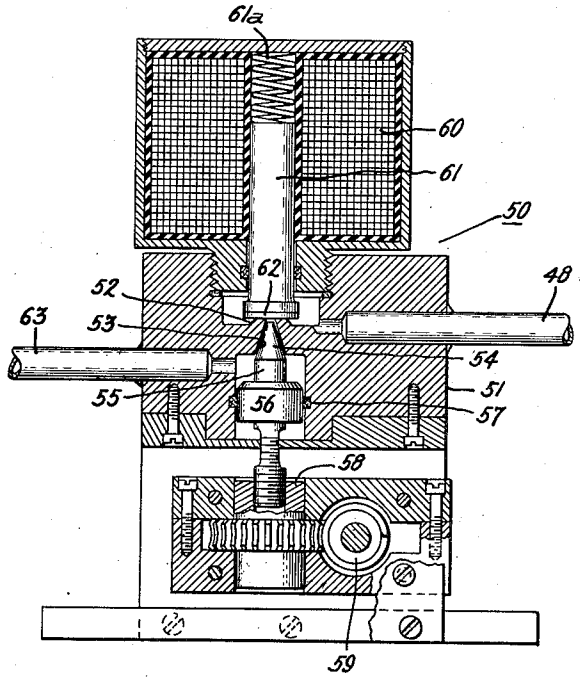
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Sept. 10, 1957 C. T. DE GROAT 2,805,689

GAS CHARGING APPARATUS

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FIG.2.



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2,805,689

GAS CHARGING APPARATUS

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Application March 31, 1955, Serial No. 498,209

17 Claims. (Cl. 141—66)

My invention relates to improved evacuating and gas charging apparatus of a type which is particularly adapted for the manufacture of small volume evacuated devices, such as vacuum tubes, transistors, and the like.

In making gas filled devices or in gas charging or loading devices for treating internal atmospheres, elements or surfaces thereof, considerable difficulty has been generally encountered in providing apparatus for effectively introducing the gas into the devices following evacuation thereof without wasting a volume of gas substantially larger than that actually used. When the gas to be loaded is xenon or some other expensive gas, waste of this kind can prove extremely costly. Additionally, difficulty has been experienced as a result of contamination of the gas in the charging system due to defective or leaking tubes or an unloaded or open tube port on the equipment.

In my United States Patent No. 2,542,636 issued February 20, 1951, and assigned to the same assignee as my present invention, I have disclosed an improved automatic evacuating and gas charging apparatus which has proved completely effective in overcoming both of the above-mentioned difficulties when the devices charged or loaded with gas volumes in the order of ten cc. and larger and the loading or charging is to pressures of 200 microns and higher. Many evacuated devices currently being produced, however, such as those referred to in the art as sub-miniature electronic tubes, transistors, etc. have volumes less than 10 cc. and as little as 1 cc. and are required to be gas filled or charged to pressures as low as approximately 25 to 200 microns. Additionally, these devices are generally produced on high speed equipment such as that known in the industry as the Sealex machine. On such equipment each device dwells in an operating station for only a very short period. This necessitates the provision of equipment or apparatus which will not only gas charge a device quickly but will also purge the system of contamination substantially immediately upon detection of a leak to the atmosphere and will recover substantially immediately thereafter in order to stand ready to gas charge a succeeding device at the desired pressure and thereby avoid spoilage of other devices due to contamination of the system caused by a leak.

Accordingly, the primary object of my invention is to provide a new and improved gas charging system.

Another object of my invention is to provide a new and improved evacuating and gas charging apparatus.

Another object of my invention is to provide a new and improved gas charging apparatus adapted for effectively gas charging devices of volumes down to approximately 1 cc. and at pressures as low as 25 microns.

Another object of my invention is to provide new and improved gas charging apparatus including a charging system adapted for being purged of contamination substantially immediately upon detection of a leak and further adapted for recovering substantially immediately following purging.

Still another object of my invention is to provide gas charging apparatus which is suitable for use in any type

of processing equipment but has all the attributes necessary for use with high speed equipment.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide a controlled gas supply system adapted for having devices to be charged connected in sealed communication therewith. Adjustable control means is provided for replenishing the controlled gas supply from a reservoir upon reduction of the pressure therein below the minimum pressure of a predetermined preset range and until the maximum pressure of the predetermined preset range is attained. Other control means are provided and are effective for substantially immediately closing the controlled gas supply system to the reservoir and evacuating the controlled gas supply system substantially immediately upon a pressure increase above the maximum pressure of the present range and subsequently substantially immediately restoring the controlled gas supply to the predetermined pressure range. A gas pressure gauge including a pressure chamber substantially equal in volume to one of the devices to be charged is adapted for being connected to the controlled gas supply while the adjustable control means is adjusted and until the gauge reads a pressure corresponding to that desired to be obtained in devices to be charged. Additionally, means is provided for purging the controlled supply system and the reservoir.

For a better understanding of my invention reference may be had to the accompanying drawing in which:

Fig. 1 is a schematic illustration of my invention; and

Fig. 2 is an enlarged sectional view of the adjustable control valve in my system.

Referring now to Fig. 1 of the drawing, I have shown my invention embodied in an automatic exhaust and gas charging machine of the type generally known in the industry as a Sealex machine and adapted for producing electric discharge devices. The machine includes a plurality of identical exhaust heads generally designated 1 and supported on a moveable support or turret 2 which is rotatably mounted on a stationary support or machine frame 3. In a practical machine embodying my invention, sixteen exhaust heads 1 are provided at equally spaced points around the turret 2. Only two of the heads are shown in the drawing to simplify the illustration and description.

It will be appreciated that the moveable turret is moved intermittently by a suitable indexing system (not shown), thereby to position the exhaust heads successively at a plurality of operation stations located spacedly about the machine. It will be further appreciated that in very high speed equipment the turret may move continuously instead of indexed. Each of the heads 1 includes an exhaust chamber 4. The bottom side of the chamber 4 is adapted for being closed by a valve 5. The valve 5 may be any suitable valve such as a pinch-off valve formed of rubber or any similar material. The valve 5 is connected to one end of an exhaust line 6 and is adapted for being operated by a cam 7 pivotally mounted in the head at 8 for controlling communication between the exhaust chamber 4 and the line 6. Provided for cooperating with the cam 7 is a clamp 10 pivotally mounted in the head at 11. The cam 7 carries at the inner end thereof a roller 12 which engages the outer surface of the clamp 10. This surface is so formed that in one rotative position of the cam 7 the roller 12 actuates the clamp 10 inwardly against the rubber valve for thereby closing the chamber 4 to the line 6. In another rotative position of the cam 7 the natural resilience of the valve 5 prevents the clamp 10 from clos-

ing the valve and thus communication is afforded between the chamber 4 and the line 6.

The heads 1 each further include a compression head generally designated 13 and adapted for being operated to grip and maintain or hold the exhaust tubulation 14 of an electronic tube or device 15 to be exhausted and gas charged in sealed communication with the chamber 4. It will be seen that while I have shown an electronic tube 15 held in the exhaust head any device to be exhausted and gas charged and provided with a suitable tubulation may be held in place in communication with the exhaust chamber by the compression head 13. It will be seen further that my invention is not limited to the processing of tubulated devices. For example, it may be used in the processing of evacuated devices in bell-jar arrangements. Additionally, each of the heads 1 includes a gas charging port 20 to which is suitably connected a line 21 which extends toward the center of the machine. This arrangement and the purpose thereof will be brought out in detail hereinafter.

From the heads 1 the lines 6 extend toward the center of the machine and are each connected to one of a plurality of inlet ports 22 (only one of which is shown) formed in suitably spaced relation in a rotatable portion 23 of a rotary valve generally designated 24. The rotatable portion 23 is mounted about and suitably secured to a central hub 25 formed on the turret 3 and rotatably mounted on a central vertical pivot post of the frame 3. A stationary portion 26 of the valve 24 is suitably secured to the stationary frame 3. Additionally, the stationary portion 26 of the valve is formed to include a plurality of outlet ports 27 (only one of which is shown) corresponding in number and spacing to the inlet ports 22 in the rotatable portion of the valve. The rotary valve is further constructed to include a plurality of suitable oil glands 30 on both the inner and outer sides of the ports 22 and 27, thereby to render the valve vacuum-tight.

The operation of the just-described rotary valve is such that in each of the indexed positions of the turret 2, one of the inlet ports 22 in the rotary portion 23 of the valve is in communication with one of the outlet ports 27 in the stationary portion 26 of the valve for permitting fluid passage therethrough. Between indexed positions, the ports 22 and 27 are all out of alignment or register and communication and fluid passage across the valve is prevented.

At several of the operating stations at which the heads are indexed the devices 15 are adapted for being exhausted or evacuated. To accomplish this and in advance of the exhaust stations stationary camming means (not shown) on the machine frame 3 is effective for engaging and actuating the cam 7 of each head 1 as it moves therepast, thereby to open the valve 5 in the head. Additionally, at these stations the corresponding outlet ports 27 of the rotary valve 24 are suitably connected, as by an arrangement of a manifold and line generally designated 31, to vacuum pumping means such as that generally designated 32 and suitably mounted on the stationary frame 3 of the machine. Thus, the devices 15 carried in the heads 1 are adapted for being exhausted at one or more of the various indexing or operating stations of the machine.

After being positioned at the various operating stations whereat exhaustion occurs each head 1 moves to a tip-off station (not shown) whereat the tubulation 14 of the tube or device 15 held in the head is suitably sealed off. By means not shown and in advance of the tip-off station, the cam 7 is rotated or actuated for closing the head valve 5.

My invention, as applied to the machine illustrated and above-described is adapted for gas filling or charging each tube or device 15 just before tip-off and after the valve 5 is closed, and preferably on-the-fly between the station immediately preceding the tip-off station and the tip-off station. I find it preferable to charge the tube on-the-fly before tip-off inasmuch as this allows the gas greater time to enter the tube before the tip-off operation commences than if the gas charging or injection occurred at the tip-off station but before the tip-off operation. But, of course, if speed of machine operation is not an important factor charging may occur at the tip-off station. To accomplish this I connect each of the above-described lines 21 to one of a plurality of gas ports 35 formed in the rotatable portion 23 of the rotary valve 24 and disposed radially inwardly of the corresponding exhaust inlet ports 22. Provided for cooperating with the ports 35 is a single port 36 formed in the stationary portion 26 of the rotary valve between the two outlet ports 27 corresponding to the tip-off station and the station immediately preceding the tip-off station. Thus, just before each head 1 moves into the tip-off station and after the pinch-off valve 5 is closed communication is provided to the exhaust chamber 4 of the head through the line 21 and across the valve arrangement comprising the corresponding port 35 in the rotatable portion of the rotary valve and the single port 36 in the stationary portion of the valve.

Port 36 is connected to a controlled gas supply system generally designated 40 and comprising a line 41 connected to a terminal block 42, a line 43 connected to a pressure sensitive device or control 44, a pressure chamber 45 in the device 44, a line 46 connected to a normally closed solenoid controlled vacuum valve 47, and a line 48 connected to the outlet side of an adjustable control valve generally designated 50.

As perhaps better seen in Fig. 2, the adjustable control valve 50 comprises a housing 51 suitably mounted on the frame 3 and formed to include an upstanding or raised valve seat 52. The valve seat 52 includes a substantially frusto-conical internal surface 53; and provided for cooperating with the surface 53 is a frusto-conical portion 54 of a valve pin or needle 55. The surfaces 53 and 54 are lapped and in the closed position of the needle the upper end thereof is as perfectly even with the upper edge of the valve seat 52 as possible. Formed on the pin 55 is an enlarged portion 56 further formed to provide a suitable sealing surface for cooperating with an O-ring seal 57 for avoiding leakage across the valve pin. The lower end of the valve pin 55 is fixedly secured in the center of a worm wheel 58 suitably rotatably mounted in the lower side of the housing 50. Meshing with the worm wheel 58 is a worm 59. Fitted in one end of the worm and extending through the housing wall is a stem carrying a knurled knob 59*a*. With this arrangement very fine adjustments may be made to the position of the valve pin in the valve seat thereby to control with a high degree of accuracy any gas supplied through the valve 50 and into the controlled gas supply system 40.

Also included in the valve 50 is an "on"-"off" arrangement including a coil 60, a magnetic plunger 61 and a coil spring 61*a* normally biasing the plunger 61 toward the valve seat 52. The lower end of the plunger 61 is fitted with a resilient cap 62 adapted for moving into and out of engagement with the valve seat 52 for closing the valve under the influence of the spring 61*a* when the coil 60 is deenergized and for being raised from the valve seat and opening the valve when the coil is energized.

Connected to the inlet side of the valve 50 by means of a line 63 is a gas reservoir 64 adapted for being supplied with a suitable gas such as xenon from a tank thereof 65. The gas is supplied from the tank to the reservoir through a pressure regulator 66 and a solenoid controlled valve 67 which is mounted on the frame 3 and controlled by a bellow operated switch 68. The switch 68 is usually set at approximately 1200 millimeters or just slightly above atmospheric pressure as indicated on a dial type pressure gauge 69 connected to a reservoir 64.

The pressure of the gas admitted into the system 40 through the valve 50 determines the operation of the above-mentioned pressure sensitive control 44. The control 44 may be of any suitable type, for detecting pressure changes and providing suitable proportional electrical

signals. For example, when xenon or other heavy gases are used an ionization type gauge such as an Alphatron Vacuum Gauge of the type designated 510 and manufactured by the National Research Company of Boston, Massachusetts, may be used. If lighter gases, such as hydrogen or helium are used, the device or control **44** may comprise a thermo-conductivity gauge of the thermocouple or Pirani types and which are well-known in the art. Additionally, the control **44** is adapted for operating in unison with a pressure recorder or recording controller generally designated **70** and which may be of the type designated "Type 153 Electronik Recorder" manufactured by the Brown Instruments Division of the Minneapolis-Honeywell Regulator Company of Philadelphia, Pennsylvania.

The recorder or recording controller **70** is adapted for receiving electric signals of varying magnitudes from the pressure control **44**. In the controller **70** these signals operate an electromotive device **71** which actuates a marker **72** adapted for cooperating with a scroll **73** arranged to move in coordination with the operation of the machine. Also included in the controller **70** is a shaft **74** carrying a plurality of control disks **75** and adapted for rotating and counter-rotating in accordance with the movement of the marker **72**. In a manner which will be described in detail hereinafter, the pressure in the system **40** is normally caused to fluctuate between the high and low values of a predetermined preset pressure range. This causes the marker **72** to scribe a substantially symmetrical mark designated "A" on the scroll and the shaft **74** and the plurality of control disks **75** to assume positions substantially the same as those shown in Fig. 1. When the pressure in the system exceeds the upper value of the preset range, the marker moves to the right of "A" and the shaft and disks are caused to rotate clockwise from the positions of Fig. 1. When the pressure falls below the lower level of the predetermined range the marker **72** moves to the left of "A" and the shaft and disks are caused to rotate counterclockwise from the positions of Fig. 1.

The disks **75** comprise three independent controlling disks. The first disk designated **80** operates a mercury switch **81** and is positioned on the shaft **74** for opening the mercury switch when the pressure in the system **40** stands above the lower level of the predetermined range. When the pressure in the system **40** falls below the lower level of the predetermined pressure range the control **44** varies the magnitude of the signal of the recorder **70** which causes the shaft **74** to rotate counterclockwise and the disk **80** thereon to actuate and close the mercury switch **81**. This results in completion of a circuit through a normally closed pair of contacts **82** in a relay **83**. This circuit when completed energizes the coil **60** in the control valve **50** for raising the plunger **61** against the bias of the spring **61***a* and thereby admitting gas into the system **40** from the reservoir **64**.

When the system **40** attains the upper level of the predetermined pressure range, the control **44** again varies the signal to the recorder **70** which counter rotates the shaft **75** causing the disk **80** to open the mercury switch **81** and thereby deenergize the coil **60** for enabling the spring **61***a* to move the plunger **61** toward the valve seat **52** and close the valve **50**. This is the operation of the system under normal operating conditions. That is, as the gas port **35** of the rotary valve associated with each exhaust head **1** flies or moves past the stationary port **36** a quantity of the gas in the controlled supply system **40** is admitted through the corresponding line **21** and exhaust chamber **4** into the device **15** held in the head. In accordance with the volume of the devices being charged the pressure in the system **40** is reduced by substantially equal increments. Ultimately, this pressure is reduced to the pressure where the disk **80** is again effective for closing the mercury switch **81** and thereby opening the valve **50** for admitting more gas from the reservoir into the system **40** for again raising or restoring the controlled pressure to the upper level of the predetermined range.

It will be seen that through adjustments to the valve **50** I am able to determine with extreme accuracy the amount of gas admissible into the system **40** when the valve **50** is opened. Additionally, by presetting the pressure control **44** and presetting the position of the disk **80** on the shaft **74** I am able normally to maintain the pressure in the system **40** within a preset predetermined pressure range. For example, when it is desired to charge devices of a volume of approximately 1 cc. to a pressure of approximately 25 microns the valve **50** may be adjusted and the control **44** and the disk **80** may be preset for closing the valve **50** when the pressure in the system **40** stands at approximately 500 microns, which would represent the upper level of the normal range, and opening the valve **50** when the pressure stands at the lower level of the range which may be 5% below the upper level. The pressure in the system **40** will drop to the lower level of the predetermined range after a predetermined plurality of the devices **15** have been moved into and out of communication with the system and thereby charged with gas to the prescribed pressure.

Now in the event of a leak into the system **40** from the atmosphere, as might be effected by a leaking device **15** in one of the heads **1**, it is desirable to detect such a leak, close the valve **50** to avoid waste of gas, purge the controlled gas supply system **40** and restore the pressure in the controlled gas supply system **40** to the preset pressure range all before the port **35** corresponding to the next succeeding head moves into register with the stationary port **36**, thereby to avoid spoilage of the device of the next succeeding head. To accomplish this I have provided a second control disk **85** on the recorder shaft **75**. The disk **85** is adapted for closing a normally open mercury switch **86** when the pressure control **44** senses a pressure increase in the system above the upper level of the normal or predetermined preset pressure range, as would be effected by a leak or open head. The switch **86** when closed energizes the coil **87** of the relay **83** whereby the normally closed contacts **82** are opened for deenergizing the coil **60** in the event the latter is energized and assuring that the plunger **61** is in its lower position for closing the valve **50**.

Additionally, energization of the coil **87** results in the closing of a pair of normally open contacts **88** which is effective for energizing the above-mentioned normally closed vacuum control solenoid valve **47** for thereby opening the valve **47**. The outlet side of the valve **47** is connected by a suitable line **90** to a constantly operating vacuum pump generally designated **91** and suitably mounted on a portion of the machine frame **3**. The pump **91** is of such capacity as to evacuate and thereby purge the system **40** of contamination completely substantially immediately or well within the time required for movement of an exhaust head **1** from one operating position to the immediately next succeeding position.

This evacuation of the system **40** results in a corresponding movement of the shaft **75** in the controller **70**. Provided on the shaft **75** to take advantage of this movement is a third controlling disk **95**. The disk **95** operates a mercury switch **96** which is normally closed above a preset minimum pressure below the predetermined range and corresponding to a satisfactorily low purging pressure.

The circuit completed by the switch **96** maintains the coil **87** energized and thus maintains the vacuum valve **47** open after the pressure in the system is reduced to the point where the switch **86** is normally opened and until the pressure is reduced by the pump **91** to the preset minimum value at which the switch **96** will open. Opening of the switch **96** deenergizes the coil **87** whereby the contacts **88** are opened and the contacts **82** are closed. At

this stage of the operation, inasmuch as the pressure in the system **40** will be below the predetermined preset pressure range, the disk **80** will be effective for closing the switch **81** and thereby resulting in a circuit being completed through the normally closed contacts **82** and the coil **60** in the control **50** thereby to open the valve **50** and permit the pressure in the system **40** to return to the normal preset maximum pressure. Thus, my system is adapted for avoiding contamination of the next succeeding device **15** moved into communication with the system **40** following a leaking device or open head.

When devices of predetermined volume are to be processed by the machine and gas charged, I set up the machine by inserting a tube **97** in one of the heads **1** instead of the tubulation of a device to be charged. The tube **97** is connected to a pressure gauge generally designated **98** and suitably secured to the turret **2**. By means of a pair of brushes **99** resiliently contacting a pair of commutator rings **100** mounted on the rotatable hub **25** of the turret and connected to a suitable power source, the gauge **98** is provided with required power for operation. The gauge **98** may be of any suitable type. For example, when xenon or other heavy gases are used the gauge may be of this ionization type similar to that manufactured by the National Research Company of Boston and designated ACXB–1 Alphatron-Miniature cylinder. If lighter gases, such as helium or hydrogen, are being used, the gauge may be of the thermo-conductivity type, such as a thermocouple gauge or Pirani tube. This arrangement is constructed so that the pressure chamber **99** of the gauge **98** and the tube **97** provide a volume substantially equal to that of the device to be gas charged. This enables one to adjust the control valve **50** by turning the knob **59***a* until the gauge **98** reads the pressure at which it is desired that the devices **15** be gas charged at the particular operating speed of the machine. With this accomplished the control gas supply system **40** will stand at the maximum pressure of the desired or preset normal pressure range. While it is possible to set up the machine in this manner and then remove the tube **97** from the exhaust head in order that this head may be used for processing a device **15**, it is often found desirable to leave the tube **97** in the head and thereby have a constant check on the pressure to which the devices are being charged. Additionally, gauges of different chamber volumes corresponding to the volumes of different sized devices to be charged may be provided. Thus, in accordance with the volume of the devices to be processed on the machine the proper gauge arrangement may be used in setting up the machine.

After a shut-down of the machine of any length of time, the system including the reservoir **64** is likely to be contaminated. Thus, in initially setting up the machine for operation an operator will open the power line to the switch **68** for deenergizing and thereby closing the reservoir control valve **67** to avoid waste of gas and then turn the knob **59***a* to move the needle in the valve **50** to its lowest position and close a key type switch **101**. With the switch **101** closed a lamp **102** will light indicating that purging is taking place and the relay coil **87** will be energized for closing a pair of contacts **103** and the contacts **88** and opening the contacts **82**. This will cause energization of both the control valve **50** and the vacuum valve **47** for opening the system **40** and the reservoir **64** to the constantly operating vacuum pump **91** whereby the system **40** and the reservoir **64** are purged. Then the operator will open the switch **101**, and then energize and thereby open the valve **67**. This will enable the valve **47** to close and the vacuum pressure control **44** to sense a pressure lower than the minimum predetermined pressure below the preset pressure range. In turn, this will allow the system to recover and be supplied with gas up to the predetermined range in the above-described manner. Thereafter, the knob **59***a* may be turned to obtain a fine adjustment of the gas admitted through the valve **50** when it is energized and opened and the system will stand ready to charge the first device moved into communication with the system to the desired pressure.

It will be seen that while I have disclosed my invention as applied to fully automatic tube processing equipment, my invention is equally adaptable to bench systems or the like wherein my invention may be operated manually or semi-automatically.

Additionally, while I have shown and described a specific embodiment of my invention, I do not desire my invention to be limited to the particular form shown and described and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

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

1. In gas charging apparatus, a gas supply system adapted for being connected to a device, thereby to charge said device, means normally maintaining the gas pressure in said system within a predetermined range, and pressure-controlled means operative for evacuating said system in response to any abnormal increase in pressure above said predetermined range.

2. In gas charging apparatus, a gas supply system adapted for being connected to a device, thereby to charge said device, means normally maintaining the gas pressure in said system within a predetermined range, pressure-controlled means operative for evacuating said system in response to any abnormal increase in pressure above said predetermined range, and means restoring said pressure in said system to said predetermined range upon evacuation of said system to a predetermined pressure below said range.

3. In gas charging apparatus, a gas supply system, means admitting gas to said system until the pressure therein attains the upper level of a predetermined range in which a device connected to said system is chargeable only to a predetermined desired final pressure, means for successively connecting devices to said system, thereby to charge said devices, and means effective when pressure in said system stands at the lower level of said predetermined range for restoring said pressure to said upper level.

4. In gas charging apparatus, a gas supply system, means admitting gas to said system until the pressure therein attains the upper level of a predetermined range, means for successively connecting devices to said system, thereby to charge said devices, pressure-response means effective when pressure in said system stands at the lower level of said predetermined range for restoring said pressure to said upper level, and means for evacuating said system in response to an increase in pressure above said upper level of said range.

5. In gas charging apparatus, a gas supply system, means admitting gas to said system until the pressure therein attains the upper level of a predetermined range, means for successively connecting devices to said system thereby to charge said devices, and means effective when pressure in said system stands at the lower level of said predetermined range for restoring said pressure to said upper level, means for evacuating said system in response to an increase in pressure above said upper level of said range, and means for terminating said evacuation and restoring said pressure in said system to said upper level of said range when said pressure in said system stands at a predetermined minimum pressure below said range.

6. In evacuating and gas charging apparatus, a gas supply system, means for successively exhausting a device and connecting said device to said supply system, thereby to charge said device, pressure-responsive means normally operative for maintaining the gas pressure in said system at a predetermined range, and pressure-controlled means

for evacuating said system in response to any abnormal increase in pressure above said predetermined range.

7. In evacuating and gas charging apparatus, a gas supply system, means for successively exhausting a device and connecting said device to said gas supply system, thereby to charge said device, means for maintaining the gas pressure in said system within a predetermined range, means for evacuating said system in response to any increase in pressure above said predetermined range, and means restoring said pressure in said system to said predetermined range upon evacuation of said system to a predetermined level below said range.

8. In gas charging apparatus, a gas supply system adapted for having devices to be charged connected thereinto, a gas reservoir, a control valve responsive to pressure conditions in said system for admitting gas into said system from said reservoir, means normally operating said control valve for maintaining the pressure in said gas supply system within a predetermined operating range, vacuum pumping means, and means closing said control valve and connecting said system and vacuum pumping means in response to any abnormal increase in pressure in said system above said operating range.

9. In gas charging apparatus, a gas supply system adapted for having devices to be charged connected thereinto, a gas reservoir, a control valve for admitting gas into said system from said reservoir, means automatically operating said control valve for maintaining the pressure in said system within a predetermined operating range, vacuum pumping means, means automatically closing said control valve and connecting said system and vacuum pumping means in response to any increase in pressure in said system above said operating range, and means automatically disconnecting said system and pumping means and opening said control valve for restoring said pressure to said predetermined operating range upon a decrease in pressure in said system to a predetermined pressure below said operating range.

10. In gas charging apparatus, a gas supply system adapted for having devices to be charged connected thereinto, a gas pressure gauge including a pressure chamber having a fixed volume substantially the same as the volume of one of said devices to be connected into said system, a gas reservoir, a control valve for admitting gas into said system from said reservoir, means automatically operating said control valve for maintaining the pressure in said system within a predetermined operating range, and adjusting means for varying said operating range in accordance with the pressure desired to be obtained in said devices and as indicated by said pressure gauge.

11. In gas charging apparatus, a gas supply system adapted for being connected to an evacuated device thereby to charge said device, pressure-responsive means operative for normally maintaining the gas pressure in said system within a predetermined operating range, and evacuating means of substantially greater capacity than said system effective in response to any increase in pressure above said predetermined operating range for substantially immediately evacuating said system.

12. In gas charging apparatus, a gas supply system adapted for being connected to an evacuated device thereby to charge said device, means for normally maintaining the gas pressure in said system within a predetermined operating range in which a device connected to said system is initially chargeable only to a desired final pressure, and a constantly operating vacuum pump of substantially greater capacity than said system effective in response to any increase in pressure above said predetermined pressure for substantially immediately evacuating said system.

13. In gas charging apparatus, a gas supply system adapted for having devices to be charged connected thereinto, a gas reservoir, a control valve for admitting gas into said system from said reservoir, pressure-responsive means normally operating said control valve for maintaining the pressure in said system within a predetermined operating pressure range, a constantly operating vacuum pump of substantially greater capacity than said system, a normally closed vacuum valve controlling a connection between said pump and system, and pressure-responsive means closing said control valve and opening said vacuum valve in response to any abnormal increase in pressure in said system above said operating range whereby said vacuum pump is effective for substantially immediately evacuating said system.

14. In gas charging apparatus, a gas supply system adapted for having devices to be charged connected thereinto, a gas reservoir, a control valve for admitting gas into said system, means automatically operating said control valve for normally maintaining the pressure in said system within a predetermined operating range, a constantly operating vacuum pump of substantially greater capacity than said system, a normally closed vacuum valve controlling a connection between said pump and system, means automatically closing said control valve and opening said vacuum valve in response to any increase in pressure on said system above said operating range whereby said vacuum pump is effective for substantially immediately evacuating said system, and means automatically closing said vacuum valve and opening said control valve for restoring said pressure to said predetermined operating range upon a decerase in pressure in said system to a predetermined pressure below said operating range.

15. In gas charging apparatus, a gas supply system, for having devices to be charged connected therein, a gas reservoir, means for supplying gas to said reservoir, a control valve for admitting gas into said system from said reservoir, means automatically operating said control valve for normally maintaining the pressure in said system within a predetermined operating range, a constantly operating vacuum pump of substantially greater capacity than said system, a normally closed vacuum valve controlling a connection between said pump and system, means automatically closing said control valve and opening said vacuum valve in response to any increase in pressure on said system above said operating range whereby said vacuum pump is effective for substantially immediately evacuating said system, and manually operable means for disconnecting said reservoir and said means for supplying gas thereto and for opening both said vacuum and control valves, thereby to purge said system and reservoir.

16. In evacuating and gas charging apparatus, an exhaust system, a gas supply system, means for successively connecting devices into said exhaust and gas supply systems for evacuating and gas charging said devices, a gas reservoir, a control valve for admitting gas into said gas supply system from said reservoir, pressure-responsive means normally operating said control valve for maintaining the pressure in said gas supply system within a predetermined operating range, a constantly operating vacuum pump of substantially greater capacity than said gas supply system, a normally closed vacuum valve controlling a single connection between said pump and said gas supply system, and means for closing said control valve and opening said vacuum valve in response to any abnormal increase in pressure in said gas supply system above said operating range, whereby said vacuum pump is effective for substantially immediately evacuating said gas supply system.

17. In evacuating and gas charging apparatus, an exhaust system, a gas supply system, means for successively connecting devices into said exhaust and gas supply systems for evacuating and gas-charging said devices, a gas reservoir, a control valve for admitting gas into said gas supply system from said reservoir, means automatically operating said control valve for normally maintaining the pressure within said gas supply system within a

predetermined operating range, a constantly operating vacuum pump of substantially greater capacity than said gas supply system, a normally closed vacuum valve controlling a connection between said pump and gas supply system, and means automatically closing said control valve and opening said vacuum valve in response to any increase in pressure in said gas supply system above said operating range, whereby said vacuum pump is effective for substantially immediately evacuating said gas supply system, and means automatically closing said vacuum valve and opening said control valve for restoring said pressure in said gas supply system to said predetermined

operating range upon a decrease of pressure therein to a predetermined pressure below said operating range.

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