

Jan. 13, 1953

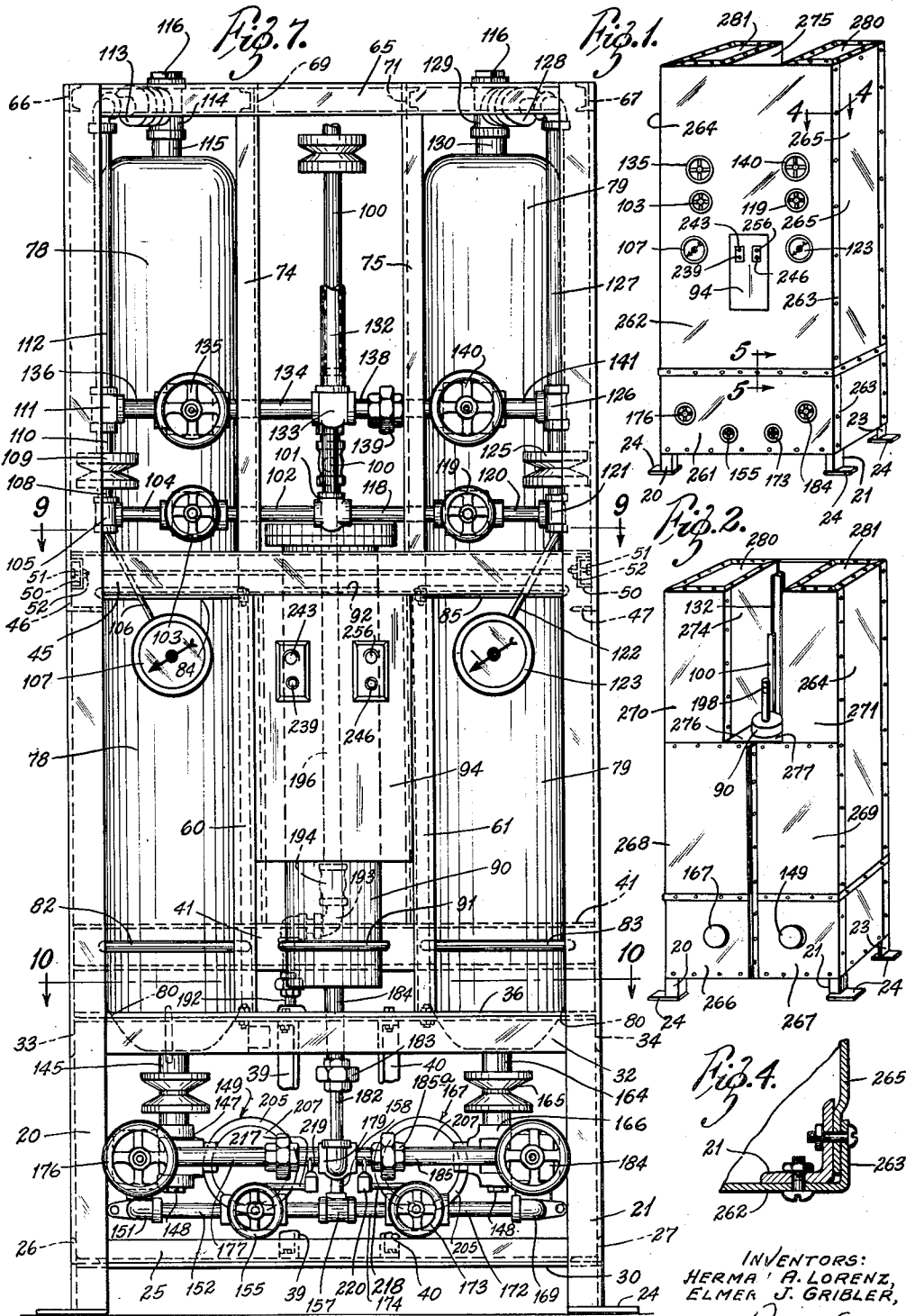
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2,625,237

APPARATUS FOR DRYING GASES

Filed Jan. 11, 1947

4 Sheets-Sheet 1



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Fig. 6.

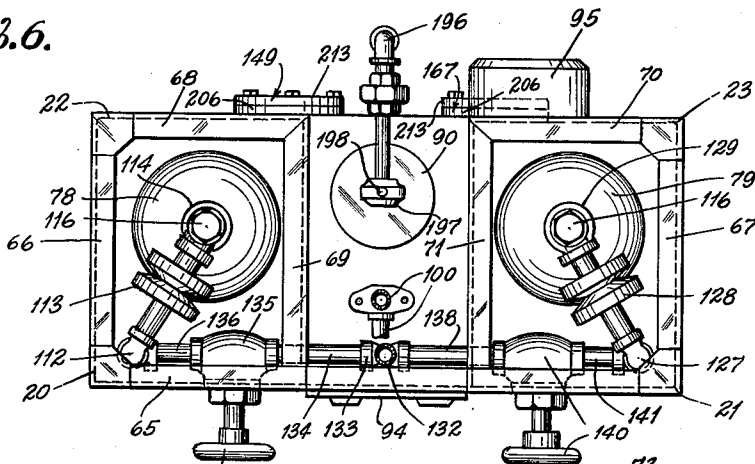


Fig. 9.

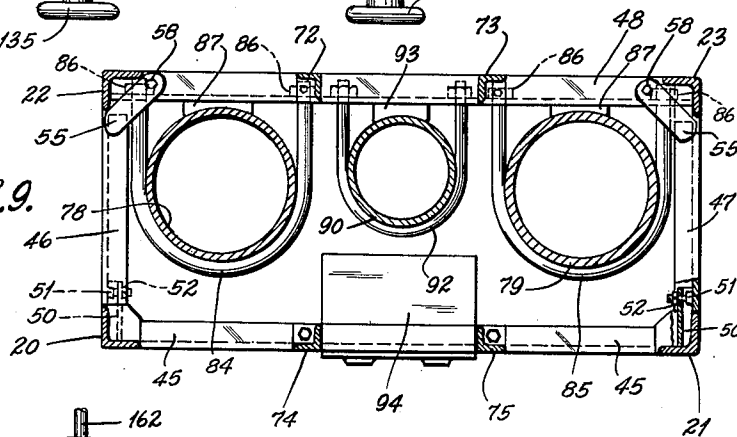
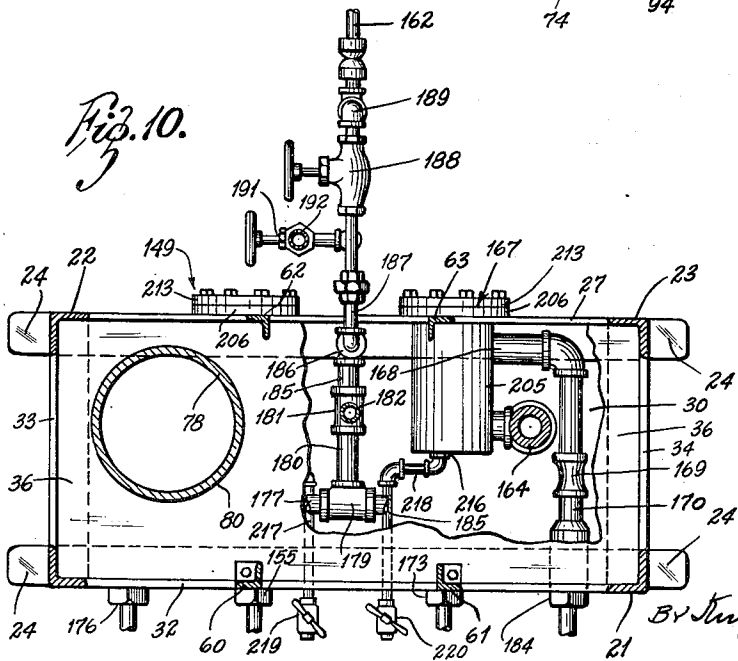


Fig. 10.



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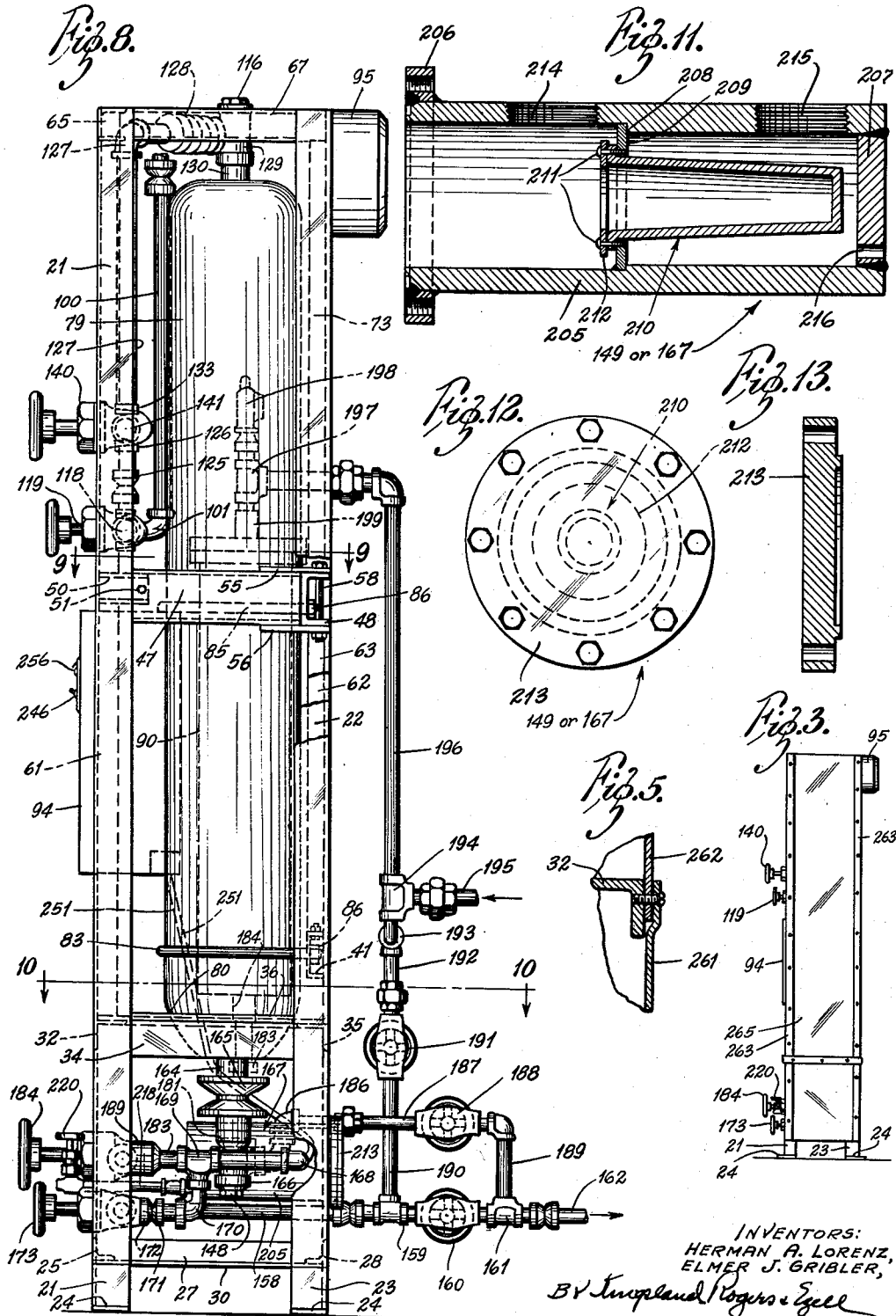
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APPARATUS FOR DRYING GASES

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4 Sheets-Sheet 3



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2,625,237

APPARATUS FOR DRYING GASES

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Fig. 14.
DERIMING

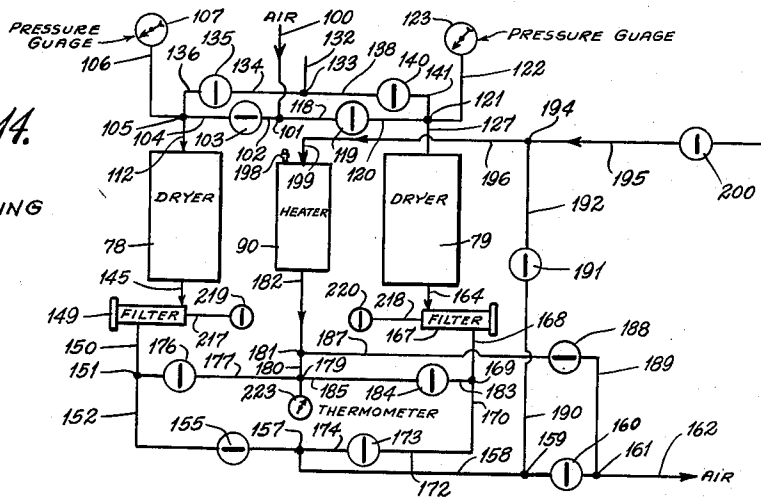


Fig. 15.
REACTIVATION

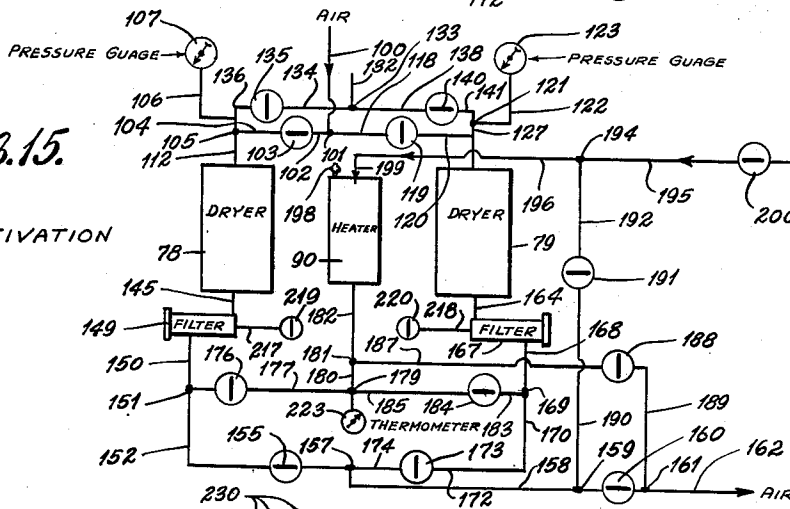
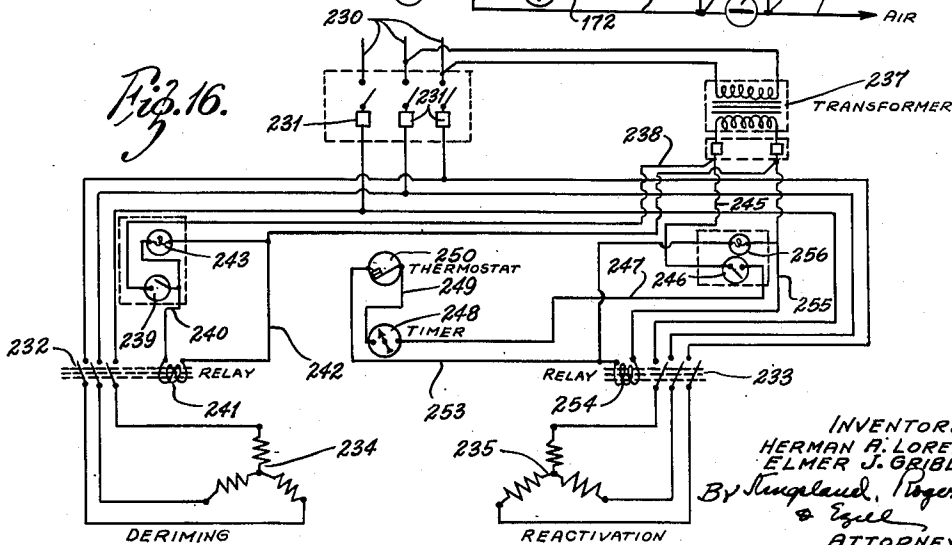


Fig. 16.



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2,625,237

APPARATUS FOR DRYING GASES

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Application January 11, 1947, Serial No. 721,508

19 Claims. (Cl. 183—4.7)

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The present invention relates to an apparatus for drying and heating gases. Particularly, it relates to an apparatus for drying air, and particularly for drying air or other gas in oxygen generating systems. It likewise incorporates means for reactivating the drying elements and means for heating air for use in deriving oxygen columns or other appropriate uses.

It is an object of the invention to provide a single apparatus that can supply a continuous flow of dry air despite the fact that the drying elements become saturated. More particularly, it is an object to provide a plurality of drying elements with immediately available connections by which certain of the elements may be used for drying while other elements are being used for reactivation of the drying material, which connections may be readily reversed so that while one set of drying elements is supplying dry air the other set may be being reactivated. A particular object is to provide an apparatus that can produce dried gas for delivery from one element, and selectively divert a part thereof for reactivation of another element.

In this connection, a further object of the invention is to provide an apparatus for drying air or other primary gas, with alternately operable reactivating means incorporating a heater to receive a reactivating gas, such as nitrogen, or a part of the primary gas, heating the same, and discharging it into another drying element for reactivation thereof while the one is delivering a flow of dry gas. A further object is to provide an apparatus of this kind wherein automatic time, temperature and pressure control of the gas heating means is provided.

A further object is to provide in such an apparatus connections by which heated gas may be supplied in the air outlet line for use in deriving an oxygen column or other appropriate use. A further object is to provide a system wherein part of the heated gas may be diverted through another tank to reactivate the same.

Another object is to provide a structure for an apparatus of this kind wherein operating parts are readily replaceable.

Further objects will appear from the description to follow. In the drawings:

Fig. 1 is a front perspective of the apparatus;

Fig. 2 is a back perspective thereof;

Fig. 3 is a side view;

Fig. 4 is a section on the line 4—4 of Fig. 1, showing the interfit of the outer sheeting;

Fig. 5 is a section on the line 5—5 of Fig. 1, showing the interfit of sheeting;

Fig. 6 is a plan view of the apparatus with the sheeting removed;

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Fig. 7 is a front elevation with the sheeting and insulation removed;

Fig. 8 is a side elevation taken from the right of Figs. 1 and 7;

Fig. 9 is a horizontal section taken on the line 9—9 of Figs. 7 and 8;

Fig. 10 is a horizontal section taken on the line 10—10 of Figs. 7 and 8;

Fig. 11 is a vertical section through one of the filter elements;

Fig. 12 is an end view of the filter element taken from the left of Fig. 6;

Fig. 13 is a section view of a head for one of the filters;

Fig. 14 is an airflow diagram for the delivery of dried, heated air or other gas to an outlet, such as an air supply line for an oxygen column;

Fig. 15 is an airflow diagram for the delivery of dried air to an outlet, from one treating tank, and for the simultaneous reactivation of the drying material of the other tank by the delivery therethrough of heated dry nitrogen; and

Fig. 16 is a wiring diagram of the mechanism.

The principal structural parts of the apparatus are shown in Figs. 6 through 13. In the views, the outside sheeting that forms an enclosure for the entire framework, and the insulation therein, are not shown.

The apparatus is mounted in a frame that includes four vertical corner columns 20, 21, 22 and 23 that are formed of angle irons. These four columns extend to the floor and preferably have feet 24 at their bottoms.

Near the bottom, the four columns are joined by angle beams 25, 26, 27 and 28. These parts are welded together. Mounted below the four angle beams mentioned is a partition plate 30. These various parts, as are the others unless otherwise described, are preferably welded together.

Spaced above the parts thus described are another set of transverse angle beams 32, 33, 34 and 35. Across the top of these angles, there is another partition 36. The rear transverse beams 28 and 35 are connected by vertical beams 39 and 40. These vertical beams are preferably bolted in place so as to be removable to give access to the parts within the frame.

Across the two back columns 22 and 23 slightly above the partition 36, a channel beam 41 is attached. A channel beam 45 extends across between the two front columns 20 and 21 above the foregoing. At the side, the columns 20 and 22 are connected by a somewhat wider channel beam 46.

A similar wider channel beam 47 joins the columns 21 and 23. At the rear, a wide channel beam 48 extends between the columns 22 and 23.

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The front and rear beams 45 and 48 are welded in place in the framework. The two beams 46 and 47 are removably held to the columns 20 and 21 in the following manner: There is a small out-turned channel piece 50 that is welded to each of the columns 20 and 21. The web sides of the transverse channels 46 and 47 have screws 51 welded thereto and sized to project inwardly through suitable openings in the channels 50 so that they may receive nuts 52 that secure the ends of the beams 46 and 47 to the framework. The result is that the forward ends of the two channel beams 46 and 47 are removably securely held to the columns 20 and 21.

As shown in the broken-away part of Fig. 8 and in Fig. 9, upper and lower attachment plates 55 and 56 are welded to the upper and lower flanges of each of the channel beams 46 and 47. These pairs of attachment plates engage across the upper and lower flanges of the back channel beam 43 at its respective ends, and are bolted thereto by removable bolts 53. By this arrangement, the two side beams 46 and 47 may be removed and replaced at will.

The front beam 45 rests upon the upper ends of the two inner column beams 60 and 61. These two beams extend down to the front beam 32 and rest upon the top thereof with the partition 36 intervening. These columns may be bolted at their respective ends.

At the rear, the beam 48 is supported on two column beams 62 and 63 that extend downwardly to the channel beam 41 extending across the back of the frame. The beams 62 and 63 may be bolted at their upper and lower ends.

At the top of the machine, the front columns 20 and 21 are connected by a channel beam 65. There are side channel beams 66 and 67 likewise at the top between the columns 20 and 22, and the columns 21 and 23, respectively. At the back, there is a channel beam 68 extending inwardly from the corner column 22 and joined to a front and rear channel 69. A similar channel 70 extends in from the corner column 23 and is joined to a front and rear channel 71.

The intersecting corners of the beam sets just described are supported by inner rear columns 72 and 73. These columns extend downwardly, and are bolted to the back channel 48 at their bottoms, and at their tops are attached as by welding to the intersecting channel beams 68 and 69, and 70 and 71. Additionally there are two inner upper columns 74 and 75 that extend from the beam 45 to the beam 65, at the junctions between that beam 65 and the beams 69 and 71.

The foregoing forms a frame in which the operating parts are supported. Certain elements of the frame are removable. It will be understood that this frame is covered with removable sheet metal covering which adds to its strength, and, in some cases, aids in the support of operating parts. This sheeting will be described hereafter. Insulation is packed around the operating parts.

There are two tanks 78 and 79 supported in the frame. Each tank has a converging bottom that partially fits through a properly sized opening in the partition 36, typified by the opening shown approximately by the reference number 80 in Fig. 10. These openings thus engage the lower parts of the tanks and give vertical support to them.

A short distance above the partition 36, each tank is strapped to the framework. These lower straps are shown at 82 and 83. They extend back

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and are attached to the back channel section 41, as shown in Fig. 8. This form of attachment is the same as will be described more fully in connection with the upper straps.

Adjacent the back channel beam 48, the tanks are additionally strapped by straps 84 and 85. These straps, like the straps 82 and 83, are in the form of U-bolts having their ends threaded. These ends pass through openings in the back channel 48 to which they are attached by nuts 86. Spacer blocks 87 are interposed between the backs of the tanks and the back channel beams 41 and 48. By this arrangement, the straps 82, 83, 84 and 85 securely but removably attach the tanks into the frame.

Between the two tanks 78 and 79, there is an electric heater means 90. It comprises a tank or container with heating coils in it. This heater is strapped removably to the beams 41 and 48 by straps 91 and 92 that are similar to the straps for the tanks. A spacing block 93 is employed between the tank and each of the two cross beams, so that the heating chamber may be securely held and clamped to the framework.

A switch box 94 is mounted between the beams 60 and 61 just below the front channel beam 45, and in front of the heater 90. A safety switch 95 is mounted on the beam 70 at the top and back of the frame.

The piping connections may be best understood by a primary reference to Fig. 15. In this Fig. 15, the two driers are indicated at 78 and 79 and the heater at 90.

There is an air or other primary gas inlet leading into the top of the apparatus indicated at 100. It is adapted for connection to an air pump or the like. It leads to a T 101 from which a left hand branch 102 leads to a manual valve 103 that is connected to a T 105. A pressure gauge line 106 leads from the T 105 to a pressure gauge 107. The T 105 is likewise connected by a line 112 into the top of the drier tank 78. There is an additional branch from the first-mentioned T 101 comprising a pipe 113 that leads through a manual valve 119. The other side of this manual valve is connected by a pipe 120 to a T 121. From this T, a pressure gauge line 122 leads to a pressure gauge 123. The T 121 is likewise connected by a pipe 127 into the top of the other drier tank 79.

Also at the top of the tanks, there is a pipe 132 that, in the particular use of this apparatus, consists of a secondary or reactivating gas outlet. This pipe is connected to a T 133. From this T, a left hand branch 134 leads to a hand valve 135. This hand valve is connected by a pipe 136 to the line 112 that extends into the top of the drier 78. A right hand branch from the T 133 leads through a pipe 138 to a hand valve 140 that is connected by a pipe 141 to the pipe 127 leading into the top of the drier 79.

The bottom connections from the two drier tanks 78 and 79 are as follows: From the bottom of the drier 78, there leads an outlet 145. This extends into one end of a filter 149. The outlet of this filter is shown at 150, it leading to a T 151. From this T, a line 152 leads into a hand valve 155 that, in turn, is connected to a T 157. From the T 157, a pipe 158 leads to another T 159, from which a connection leads to a hand valve 160. The other side of the hand valve 160 is connected to a T 161, from which an air outlet line 162 extends. This line is adapted to be connected into a liquid oxygen column or like consuming device.

The other drier 79 has an outlet 164 that leads to a filter 167 like the previously mentioned filter. The outlet of this filter leads at 168 to a T 169, from which a line 170 leads to a hand valve 173. The other side of this hand valve is connected to the T 157, so that the foregoing piping leads to the air outlet.

The T 151 leading from the left hand filter 149 is connected to a hand valve 176. This, in turn, is connected by a pipe 177 to a T 179. This T is connected by a pipe 180 to another T 181, from which a line 182 leads into the bottom of the heater 90.

The T 169 below the right hand filter 167 is connected by a line 183 to a hand valve 184, from which a pipe 185 leads to the T 179, so that this drier may alternately be connected into the bottom of the heater.

The T 181 below the heater 90 has a pipe 187 leading from it to a hand valve 188. This hand valve is connected by a pipe 189 to the T 161 in the air outlet line.

On the side of the valve 160 opposite the T 161, there is a pipe 190 leading from the T 159. The pipe 190 is connected to a hand valve 191, the other side of which is connected by a pipe 192 into a T 194. This T is connected by a pipe 196 into a pipe 199 leading into the top of the heater. The T 194 is likewise connected to a reactivating gas inlet line 195 that is controlled by a hand valve 200. Conventionally, this hand valve 200 will be found at the nitrogen outlet of the column.

The actual structural disposition of these piping connections is shown in Figs. 1 through 8. The primary gas inlet connection 100 leads from a union that is adapted to be connected to a supply of gas under pressure. In the operation to be described, this supply will consist of an air pump. The line 100 extends to the T 101. From it, as shown in Fig. 7, the left pipe 102 leads to the hand valve 103. A pipe 104 leads from the valve 103 to the T 105. The pressure gauge line 106 leads from this T to the pressure gauge 107. Upwardly from the T 105, a connection 108 leads to a union 109, thence by a connection 110 to a T 111. Upwardly from this T, the line 112 extends through a union 113 to a T 114, from which a pipe 115 leads into the top of the tank 78. The T 114 has a filler plug 116 removably inserted in its top. The unions 109 and 113 enable the threaded connections at the other points to be made.

Returning to the inlet line 100, at its T 101, the right hand line 118 leads to the hand valve 119, from whence the pipe 120 connects to the T 121. From this T, the pressure gauge line 122 leads to the pressure gauge 123. Above the T 121, there are connections through a union 125 to a T 126. From this T, the inlet pipe 127 leads upwardly through a union 128 to a T 129 and a connection 130 into the tank 79. A filler plug 116 is located in the top of the T 129.

The nitrogen or secondary gas outlet 132 leads from the T 133. From the T 133, the left hand line 134 leads to the hand valve 135, from which the pipe 136 connects into the T 111 of the line 112 leading into the tank 78. From the right side of the T 133, the pipe 138 leads into a union 139 that is connected to the hand valve 140, the other side of which is connected by the pipe 141 into the T 126 and thence into the inlet line 127 of the tank 79. The union enables the various threaded connections to be made.

While the reference numbers derived from the

diagrams of Figs. 14 and 15 are applied on Figs. 7 and 8 to the connections below the tank 78, a clearer showing of the structural arrangement is obtained by considering the piping below the tank 79, as these constructions are parallel.

The outlet 164 from the tank 79 leads through a union 165 that is connected into a T 166, having a clean-out plug on its lower side. This T 166 is connected directly into the filter 167. The outlet 168 of this filter leads to a T 169 (Figs. 7, 8, 10). From this T, the line 170 extends downwardly through a union 171 and through a pipe 172 to the hand valve 173 that is connected by the pipe 174 into the T 157.

The T 169 leading from the outlet side of the filter 167 is connected by the pipe 183 to the hand valve 184. This valve is connected by the pipe 185 through a union 185a to the T 179. This T has the pipe 180 connecting through the T 181, from which the vertical pipe 182 leads, through a union 183 into the pipe 184 entering the bottom of the heater 90.

The T 181 beneath the heater has an outlet pipe connected through a double elbow arrangement 186 to the pipe 187 leading through a union to the hand valve 188. The outlet of the hand valve 188 is connected by the pipe 189 to the T 161.

The T 159 behind the frame is connected by the pipe 190 to the hand valve 191. The hand valve 191 is connected through a union, by the pipe 192, through a double elbow 193, to the T 194. The secondary gas inlet 195, controlled by the hand valve 200, leads to this T 194. The pipe 196 rises from this T 194, and is connected to a T 197 that has a relief valve 198 on one side and the pipe 199 leading into the top of the heater at the other side.

In the foregoing, reference has been made to the two filters 149 and 167. These are of identical construction, shown in Figs. 11-13. Each comprises a body 205, preferably of cylindrical seamless metal tubing, into which a flange 206 is formed or welded. An end closure 207 may be welded into place. The inner diameter of the open end is enlarged, and provides a shoulder 208, to which an anchor ring 209 is welded.

A filter element 210, preferably of frusto-conical shape, with a flange at the open end thereof, fits into the casing body 205. The element 210 is made of a suitable compressed material forming a rigid permeable filter. It is removably clamped in place by screws 211 through a clamping retainer ring 212, the filter element flange, and the anchor ring. The shape of the element 210 makes it readily removable and replaceable.

The filter casing 205 is closed by a removable head plate 213, adapted to receive screws (Fig. 12) engageable in the flange 206, with a suitable gasket interposed.

The filter casing has an inlet opening 214 for connection with either inlet line from the tanks, and an outlet opening 215 for connection with the lines to the hand valves. The designations of inlet and outlet are for convenience, as the filters are subjected to reverse flow. It has an end opening 216 for receiving blow-out lines 217 or 218 that lead to hand valves 219 and 220, respectively (Figs. 7, 8). These filters are disposed so that their heads 213 are accessible from the back of the apparatus, and the filters can be serviced at any time.

There is a thermometer 223 connected into the T 179 to indicate temperatures of the gas coming from the heater.

The wiring of the apparatus is indicated in

Fig. 16. There are there shown three-phase power lines 230. These power lines run through main fuses 231 and thence are connected to two parallel three-phase relay switches 232 and 233. From these switches, the lines run, respectively, through heaters 234 and 235 that are Y-connected. The two heaters 234 and 235 are located within the heater 90, which consists of a hollow container through which gas may flow, over the heater coils to become heated. It will be seen that the two heaters 234 and 235 are separately connected, each to be operated when its relay switch 232 or 233, as the case may be, is closed.

Across two of the power lines, there is connected the primary of a transformer 237. The secondary of this transformer has a first lead 238 extending to a switch 239. The other side of this switch is connected to a line 240 that leads through the coil 241 of the relay, which coil actuates the switch 232 in the high power line. The other side of the relay coil 241 is connected by a line 242 that extends back to the other side of the secondary. An indicating lamp 243 is connected across the lines 240 and 242 so that it is in parallel with the relay coil 241.

There is another lead 245 extending from the left side of the transformer to a switch 246. The other side of this switch is connected by a line 247 to a timing switch 248. The other side of this switch is connected by a line 249 to a thermostat 250. This thermostat is located to respond to temperature of the gas coming from the heater. Its connecting line appears at 251 (Fig. 8). The other side of the thermostat is connected by a line 253 through a relay coil 254 that operates the relay switches 233. The other side of the relay coil 254 is connected by a line 255 back to the secondary. An indicating lamp 256 is connected across the lines 253 and 255, so as to be in parallel with the relay coil 254.

The preferable form of paneling for this apparatus is shown in Figs. 1-5.

There are lower and upper front panels 261 and 262. These panels are overlapped at their junction, as shown in Fig. 5, so they can be screwed jointly to the beam 32, with a smooth surface afforded by the offset of the edge of the lower panel. They are both provided with lateral flanges 263, appearing in Fig. 4. These flanges 263 overlap offset edges of two side panels 264 and 265. There are six back panels, 266, 267, 268, 269, 270 and 271. The panels 266 and 268 enclose the back of the lower piping compartment between the partitions 30 and 36. The back panels 268 and 269 enclose the middle of the back, up to the top of the channel 43. The panels 270 and 271 enclose the backs of the top parts wherein the tanks 78 and 79 extend.

There are inner vertical panels 274 and 275, that have extensions 276 and 277 extending across to interflanges bolted together just below the top of the heater 90, they being cut away for receiving the heater top. Top panels 280 and 281 enclose the tops of these parts.

The various panels are cut away to receive the valves, switch box, gauge dials, filter heads, and extended piping. The panels are secured together and to the frame so as to hold the insulation securely, but all are removable.

Assembly

The various working parts are assembled into the frame. All of them are removable.

The tanks 78 and 79 are inserted with the two cross beams 46 and 47 removed. They rest

upon the partition 36, and are given full support when the U-bolts are fastened. The beams 46 and 47 are then replaced. The height of the tanks relatively to the space between the partition 36 and the top cross beams 66 and 67 permits the foregoing.

The heater may be installed and removed from the top, above the panel extensions 276 and 277, and secured by its U-bolts. Support is aided by the piping connections.

The upper piping is installed in the manner that is apparent. Unions are used to enable connections to be made where alignment of screwed fittings would be difficult. The valves are individually removable for servicing.

The lower piping is largely welded or otherwise permanent, except for the unions. Each filter assembly is removable with its connections as a unit. Thus the union 165 below the tank 79, the union 171, and the union 185a may be released, and the filter 167, together with the indicated pipes, T's and the valve 184, removed, for necessary servicing. In similar fashion, the central pipe network below the heater may be removed as a unit by releasing the unions 183, 170, 185a and the union in the pipe 187. The two lower valves 155 and 175 may be removed by release of the union 171 and its counterpart, and of the pipes 156 and 174.

The foregoing not only facilitates servicing, but affords less possibility of leakage. The outer panels are divided to enable the particular parts requiring service to be removed without disassembling the entire structure. It is particularly to be noted that the lower piping compartment is partitioned off, so that it may be completely serviced without disturbing the upper assembly. The entire casing is packed with insulation.

Operation

While this apparatus is capable of a number of uses, it is designed for the particular use in connection with the supplying of dried air or dried heated air to an oxygen producing column, or with the drying of gas in oxygen systems. Consequently, it may be interposed into a line between the supply pump of air and the oxygen column. The drier tanks 78 and 79 are filled with some drying agent, such as activated alumina, which is subject to deactivation after a period of use. This alumina may be reactivated by being subjected to a stream of gas, such as the nitrogen take-off from the liquid oxygen column that is heated, or a bleed-off of air dried in the tank supplying the same. As is evident already, the reactivating gas flow is preferably counter to the flow of the air through the drying tanks.

A further use of this device is in connection with the deriming of the oxygen column or production of heated, dry gas for other uses. Deriming is accomplished by directing dried heated air through the column. Its use will be first described as applied to the delivery of dried air to a liquid oxygen column.

For the primary operation of supplying dried air for the production of liquid oxygen in the column, the apparatus is designed so that one of the two drying tanks is always available for the supplying of the dried air. This is accomplished by the piping hook-up or network, by the connections of which the tank not in use to supply the dried air is connected for reactivation by nitrogen from the column.

Such operation is diagrammatically shown in Fig. 15.

When the apparatus is started with no pressure in the main air line 100, the air valves 103, 155 and 160, and the nitrogen valves 200, 184 and 140 are all open. The air valves 119, 173, 191 and 188, and the nitrogen valves 176 and 135 are closed. When the air compressor is started, the air will then flow from the compressor through the supply line 100, to the T 101, thence through the valve 103 and by way of the inlet 112 to the top of the drier 78. This flow of air is obstructed from the other drier by the closed valve 119. It is also prevented from running into the nitrogen outlet line by the closed valve 135. From the bottom of the drier, the air passes out the outlet 145 and into the filter 149. From this filter, it flows out the line 150 and down through the open valve 155, thence to the T 157, and, by the line 158, through the valve 160 to the air outlet 162.

This discharge from the drier A, consisting of dried air, is prevented from leaving the foregoing discharge course by the closed valves 176, 173, 188 and 191.

Assuming at this time that the drier tank 79 has been deactivated, a supply of dry nitrogen is passed backward through it. This nitrogen enters past the valve 200 in the nitrogen inlet line 195. It passes thence through the line 196, being cut off from the outlet by the closed valve 191. It then flows into the top of the heater 90 by way of the inlet 199 thereinto. In this heater, it flows across the heating elements, as will be described, becoming heated, and thence out through the outlet pipe 182 to the T 179. It is prevented from bypassing through the line 187 connected into the outlet 182 by the closed valve 188. From the T 179, it is also prevented from passing to the other drier tank 78 because of the closed valve 176. It does flow through the open valve 184 and thence to the T 169. It cannot flow to the outlet line from the T 169 because of the closed valve 173. It, therefore, flows through the filter 167 backward, and thence into the discharge outlet 164 of the drier 79. It passes through this drier in the form of heated, very dry gas, so that it may take up the moisture from the alumina therein. It flows out the top inlet 127 of the tank 79. It is prevented by the closed valve 119 from running into the air inlet, so that it must flow through the open valve 140 to the nitrogen outlet 132.

The foregoing air and nitrogen flow is continued until the alumina in the tank 78 becomes loaded with moisture drawn from the air. Then the valving is reversed, so that the air flows from the air inlet 100 to the drier 79, the filter 167 and to the outlet 162; and so that the nitrogen flows through the heater and therefrom backward through the drier 79 and ultimately out the nitrogen outlet 132.

If there is pressure in the air supply line 100 at the time the driers are placed in service, it is necessary to start out with the air line valves all closed. In particular, this will mean that the valves 103, 119, 176, 184, 155, 173, 191, 188 and 160 are closed. The first operation is to crack the valve 103 and allow the air to flow slowly past this valve into the drier 78. When the drier has built up the main line pressure, as indicated on the pressure gauge 107, the valve 103 is opened wide. Then the valves 155 and 160 are opened slowly to put this drier 78 into service. The nitrogen supply valve 200 is open, the valves 184 and 140 are open, and the nitrogen supply will

then flow through the heater and backwardly through the drier 79 to reactivate the alumina therein.

In reversing the operation to shift from drying air in the drier 78 to drying it in the drier 79, which may take place after approximately eight hours of drying service from the drier 78, the valves 184 and 140 are closed tight. The valve 173 is cracked, so that high pressure air slowly flows backward through the filter 167 and into the tank 79, building the pressure therein slowly until it attains line pressure, as shown by the pressure gauge 123. Then the valve 119 is opened, so that air passes through both driers. Thereafter, the valves 103 and 155 are closed. This leaves the drier 79 in service, supplying dried air to the air outlet 162 and the column.

Thereafter the valve 219, which is the blow-off valve for the filter 149, is open momentarily, so that the air under pressure in the tank 78 blows out any dust entrapped in the filter. The valve 219 is then closed. The valve 135 is then cracked, allowing the remainder of the air under pressure in the tank 78 to blow out through the outlet line 132 and slowly relieve the pressure in the tank 78. When all of the pressure is out of the tank 78, the valves 135 and 176 are open wide, so that nitrogen flows from the heater through the drier 78 and out the outlet 132. Thereafter, the drier 78 will be reactivated, while the drier 79 supplies dry air to the air outlet. It will be noted that all of the great pressure changes in the filter tanks are made slowly so that the alumina will not become powdered.

The foregoing air and nitrogen flow is under the further control of the electrical system shown in Fig. 11. The heating elements of the heater 90 are put in circuit by operation of their switches. At the start of any reactivation of either drier, the timing switch 248 is turned to a chosen point, such as a point that indicates a four-hour operation. Such timing switches are conventional in the art and usually involve the turning of a handle over a dial to the indication desired. Then the toggle switch 246 is closed. When this is done, the heater 235 will be put in circuit as the closure of the two switches 248 and 246 closes the secondary circuit through the relay coil 254, and this coil closes its switches 233 to put the heater 235 in the primary high-powered lines. It will also be observed that the lamp 256 will be energized to indicate the operation of this circuit. It will also be observed that this circuit passes through the thermostat 250, which is an indicator of the temperature of the nitrogen being heated. Preferably, this thermostat is set to open when the nitrogen temperature reaches 475° F., as indicated on the thermometer 223 connected into the T 179. This thermostat may have a suitable differential, and, for example, may reclose when the gas temperature drops to 450° F.

The temperature of the nitrogen will be a function of the amount of flow. The valve 200 should be adjusted to maintain a temperature in the nitrogen of between 425° and 450° F. If the flow is too small, the temperature will rise, and, when it reaches 475°, will cause the thermostat 250 to open and shut off the circuit to the heater 235. When the temperature then drops to 450°, the circuit will reclose and start the heater again. If too much nitrogen is passed through the heater, it will not be sufficiently warm to reactivate the bed of alumina. Hence, the valve 200 should be properly regulated to maintain the temperature

within the range noted, as indicated by the thermometer.

After the preset four hours of heating, the timer switch 248 automatically opens and cuts off the heater 235. The nitrogen, however, is allowed to continue flowing in order to cool the alumina to atmospheric temperature. This cooling time may be another four hours, so that the total cycle is eight hours in a typical case. At the end of the eight hours, the flow circuits are reversed in the manner already described.

Another operation that is possible as a result of the piping network is to bleed off a part of the gas dried from one column, to reactivate the other. A particular value of this is that it may be used where the drier is in a pure gas line, such as an oxygen gas line, because, when a tank is reactivated by the conditioned gas, rather than by a different gas, it does not require purging after reactivation of the reactivating gas before the conditioned gas may be passed through it.

If air is being dried through the tank 78, and the flow path of this air is as indicated in Fig. 15, the valve 200 may be closed. The valve 191 may be opened to admit a small part (such as 5% in certain installations) of the dried air to flow from the discharge pipe 158 to the pipe 196 leading into the heater. This dried air is heated, and flows thence backward through the filter 167 and the tank 79 to reactivate the medium therein. Thence it flows through the outlet 132. If the drier is in an oxygen gas line from the column, the moistened oxygen from the line 132 may be forced into suitable tanks for storage, or otherwise used.

The deriming operation is one that illustrates the connection of the heater 90 in series with one of the driers, so that the dried air supplied is also heated. The use of deriming is one that this apparatus is particularly adapted to because it is an operation in the column that normally is supplied with dried cool air.

Assuming the oxygen column to be in proper condition to be derimed, the nitrogen valve 200 is closed, the valves 135, 140 and 119 are closed at the top of the apparatus, and the lower valves 176, 184, 173 and 160 are closed. The remaining valves are open so that the system appears as in Fig. 14. This produces an air flow that enters the air inlet 100, passes thence through the valve 103 into the top of the drier 78 (assuming that it is this drier that is to be used in this operation. Of course, the other drier could be used, as is evident). The air flow from the drier 78 passes through the filter 149 and thence past the valve 155 and the line 158 to the T 159. It is obstructed from the outlet by the closed valve 160, but is permitted to flow upwardly through the line 190 past the now open valve 191. It flows thence into the heater 90. From the heater 90, it flows through the line 182 to the T 181. As both of the valves 176 and 184 are closed, it must flow out the line 187 and past the now open valve 188 to discharge into the air outlet 162.

In this operation, the electrical parts are operated as follows:

Both of the two toggle switches 239 and 246 are closed. The closure of the toggle switch 239 closes the secondary circuit to the relay coil 241, which thereupon closes the switches 232 and puts the deriming heater 234 in circuit to be energized. After the column has been partially warmed up by air heated from this somewhat smaller deriming heater 234, the timer switch

248 is turned clockwise all the way. This will close the secondary circuit of the relay coil 254, which will operate its switches 233 to put the reactivation heater 235 in circuit. Thereafter, the air from the compressor will be given the total output of both heaters and deriming will be greatly speeded up. When it is complete, the toggle switches 239 and 246 can be opened.

In this operation, the pressure must be maintained at not over 250 p. s. i. The safety valve on the heater 90 is set for 300 p. s. i. and protects the heater.

During this deriming operation, the other tank 79 may be reactivated. To do this, the valve 184 is cracked to pass a small part of the dry, hot air flowing from the heater. The valve 140 is also cracked, or opened. This small quantity flows upward through the filter 167 and the tank 79, reactivating the drying medium. Thence it flows pass the valve 140 and into the discharge line 132.

After some period of use, such as about a year, the pores of the activated alumina may become plugged with oil and other impurities, and the drying qualities impaired to such an extent that replacement is required. To do this, the panels are removed from the lower part of the frame and the insulation is withdrawn. The two drain plugs 148 at the bottom of the two T's 147 and 166, with their filter screens (not shown), are removed, and the alumina in the two tanks is permitted to run out. Thereafter the filter screens and plugs are replaced, sealed into place, the insulation and panels are replaced. Then the filter screens and filling plugs 115 at the top of the two tanks are removed, and new alumina is placed in the cylinders to fill them. It will be observed that the lateral connections of the inlet and outlet lines into the unions leading to the tanks, and the axial disposition of the plugs enable the foregoing operations to be made without the flow of the drying medium into these lines during charging and draining.

At regular intervals, such as once a month, the main filters should be checked. The heads 213 of these filters are removed, the screws 211 that hold the filter cones in place are removed, the cone is withdrawn, scraped carefully and washed, such as with carbon tetrachloride. Thereafter, the cones are dried with air and replaced.

It will be seen that an apparatus has been provided which can supply a continuous flow of dried air. It does this by supplying the air selectively through one drier, while reactivating the other drier. It also may be used to supply heated air where such is desired. It provides a high degree of automatic control of its operations. It is relatively compact, so that all of the foregoing functions may be obtained from a single apparatus with a minimum of bulk and complication.

What is claimed is:

1. In an apparatus for drying and heating gas, a pair of tanks for containing an adsorbent treating medium subject to deactivation, a main gas inlet for delivering an untreated gas to the apparatus, a valved connection from the inlet to the first end of each tank for selectively directing the untreated gas to either of said tanks, a secondary outlet for discharging a spent reactivating gas from the apparatus, a valved connection from the secondary outlet to the first end of each tank for selectively discharging a spent reactivating gas from either of said tanks into said secondary outlet, a main gas discharge line for delivering a treated gas from the apparatus, a valved con-

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nection from the second end of each tank to the discharge line for selectively delivering a treated gas from either of said tanks to said discharge line, a heater for conditioning a treated gas to reactivating condition, an inlet to the first end of the heater for delivering an unconditioned treated gas thereto, a valved connection between the second end of the heater and the second end of each tank for selectively delivering a reactivating gas to either of said tanks, and a valved connection between the main gas discharge line and the heater inlet for selectively delivering a treated gas to the heater, whereby a portion of the treated gas from said discharge line may be bypassed through the heater.

2. In an apparatus for drying gases, a first tank, a second tank, an inlet and an outlet to each, each tank being adapted to contain an adsorbent material subject to deactivation, a primary gas supply connection, a primary gas discharge connection, a first set of valved conduits between the primary supply connection and the inlet to each tank and a second set of valved conduits between the primary gas discharge connection and the outlet of each tank whereby the primary gas may be selectively directed through one tank and cut off from the other, a reactivating gas supply connection, a reactivating gas discharge connection, a third set of valved conduits between the reactivating gas supply connection and one of the aforementioned sets of valved conduits and interposed into the latter between the respective valves thereof and the tanks and a fourth set of valved conduits between the reactivating gas discharge connection and the other of the two first mentioned sets of valved conduits and interposed into said other of the two first mentioned sets of valved conduits between the respective valves thereof and the tanks whereby reactivating gas may be directed through the other tank while the one is receiving primary gas, heating means for the reactivating gas interposed into the reactivating gas supply connection ahead of said third set of valved conduits, and selectively operable means, including a valve in the primary gas discharge connection, a valved conduit from said latter connection ahead of said valve therein and leading into the heater, and a valved conduit leading from the heater and connected into the primary gas discharge connection behind said valve therein, for directing some of the primary gas through said heating means in the absence of reactivating gas flow therethrough.

3. In an apparatus for drying and heating gases, a tank, a first conduit for introduction of primary gas into the tank, a first valve in said first conduit for selective employment thereof, a second conduit for discharge of primary gas from the tank, a second valve in said second conduit for selective employment thereof for discharge of primary gas, a third conduit for introduction of a second gas into the tank, said third conduit being connected into the tank in parallel with said second conduit, a third valve in said third conduit for selective employment thereof for introduction of a second gas, a fourth conduit for discharge of the second gas from the tank, said fourth conduit being connected into the tank in parallel with said first conduit, a fourth valve in said fourth conduit for selective employment thereof, and a flow-through heater, one side of the heater having a valved connection with said second conduit ahead of said second valve, the other side of the heater having a valved connec-

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tion with said second conduit behind said second valve, the heater being also interposed into said third conduit ahead of said third valve for selectively heating said second gas prior to its introduction into the tank.

4. In an apparatus for drying and heating gases, a tank for containing an adsorbent, conduit means having selectively operable valves for selectively passing a first gas through the tank, other conduit means having selectively operable valves for selectively passing a second gas through the tank, and a heater disposed in said other conduit means, said conduit means aforementioned including selectively operable connections for selectively passing a first gas through the heater after passage through the tank and including also connections for selectively passing a second gas through the heater prior to passage through the tank.

5. In an apparatus for drying and heating gases, a tank having two openings thereinto, means for connecting the tank into a first gas flow line, valves in the inlet and outlet sides of the connecting means, second means for connecting the tank into a second gas flow line, valves in the inlet and outlet sides of the second connecting means, a flow-through heater, and selectively operable means for selectively introducing the heater either into the outlet side of the first gas flow line or the inlet side of the second gas flow line.

6. In an apparatus for drying and heating gases, a tank for containing an adsorbent, conduit means having selectively operable valves for selectively passing a first gas through the tank, other conduit means having selectively operable valves for selectively passing a second gas through the tank in a direction counter to said passage of the first gas through the tank, and a heater disposed in said other conduit means, said conduit means aforementioned including selectively operable connections for selectively passing a first gas through the heater after passage through the tank and including also connections for selectively passing a second gas through the heater prior to passage through the tank.

7. In an apparatus for drying and heating gases, a first and a second gas drying tank, each having an inlet and an outlet, a first gas inlet branching to both tank inlets and having a valve for each branch, a second gas outlet branching from both tank inlets and having a valve for each branch, a first gas outlet branching from both tank outlets and having a valve in each branch, a second gas inlet branching to both tank outlets and having a valve in each branch, a heater in the second gas inlet disposed ahead of the branches thereof, a supplemental valve in the first gas outlet, a valved connection between the first gas outlet ahead of the supplemental valve and the second gas inlet ahead of the heater, and an additional valved connection between the second gas inlet behind the heater and the first gas outlet behind the supplemental valve.

8. A gas drying and heating apparatus including two gas drying tanks and a heater, conduit means for passing a first gas through either tank, said conduit means having valve means whereby said first gas may be passed through one of said tanks and cut off from the other, said valve means being reversible whereby said first gas may be passed through the other of said tanks and cut off from the one, other conduit means for passing a second gas through the heater and either tank, said other conduit means having valve

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means similar to the previously mentioned valve means whereby said second gas may be passed from the heater through either one of said tanks and cut off from the other, selectively operable means whereby said first gas may be passed through either tank and the heater, said heater having electric heating coils therein, means for selectively operating said coils to produce one heating capacity for the first gas, and means for operating the coils to produce a different heating capacity for the second gas.

9. In an apparatus for drying and heating gases, a frame, a pair of gas drying tanks on the frame, a heater on the frame, a first gas inlet pipe having a first gas inlet branch into each tank, a first gas inlet valve in each branch, said valves being supported on the frame, a second gas outlet pipe having a second gas outlet branch into each of said first gas inlet branches between the valves therein and the tanks, a valve in each of said second gas outlet branches, said first gas inlet branches being removably connected into the tops of the respective tanks, a first gas outlet branch from each tank removably connected therewith, a filter in each of said first gas outlet branches, said filters being separately mounted on the frame, a second gas inlet pipe into the heater, a second gas outlet pipe from the heater having a second gas inlet branch into each filter, a second gas inlet valve in each of said latter branches, a first gas outlet valve in each of said first gas outlet branches behind the respective filters therein, and a first gas outlet pipe connected to both of said first gas outlet branches behind said first gas outlet valves therein.

10. In an apparatus for drying and heating gases, a frame, a pair of gas drying tanks on the frame, a heater on the frame, a first gas inlet pipe having a first gas inlet branch into each tank, a first gas inlet valve in each branch, said valves being supported on the frame, a second gas outlet pipe having a second gas outlet branch into each of said first gas inlet branches between the valves therein and the tanks, a valve in each of said second gas outlet branches, said first gas inlet branches being removably connected into the tops of the respective tanks, a first gas outlet branch from each tank removably connected therewith, a filter in each of said first gas outlet branches, said filters being separately mounted on the frame and having removable covers and removable filter elements, said covers and elements being removable from outside the frame, a second gas inlet pipe into the heater, a second gas outlet pipe from the heater having a second gas inlet branch into each filter, a second gas inlet valve in each of said latter branches, a first gas outlet valve in each of said first gas outlet branches behind the respective filters therein, and a first gas outlet pipe connected to both of said first gas outlet branches behind said first gas outlet valves therein.

11. In an apparatus for drying and heating gases, a frame, a pair of gas drying tanks on the frame, said frame having an opening in one side for removal of the tanks, a beam across said opening, means removably securing the beam to the frame, means removably securing the tanks to the beam, a heater on the frame, a first gas inlet pipe having a first gas inlet branch into each tank, a first gas inlet valve in each branch, said valves being supported on the frame, a second gas outlet pipe having a second gas outlet branch into each of said first gas inlet branches between the valves therein and the tanks, a valve

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in each of said second gas outlet branches, said first gas inlet branches being removably connected into the tops of the respective tanks, a first gas outlet branch from each tank removably connected therewith, a filter in each of said first gas outlet branches, said filters being separately mounted on the frame, a second gas inlet pipe into the heater, a second gas outlet pipe from the heater having a second gas inlet branch into each filter, a second gas inlet valve in each of said latter branches, a first gas outlet valve in each of said first gas outlet branches behind the respective filters therein, and a first gas outlet pipe connected to both of said first gas outlet branches behind said first gas outlet valves therein.

12. A gas drying apparatus including a frame comprising two columns up one side, spaced supports, means attaching the columns and supports including cross beams across said one side, tanks in the frame, said tanks being insertable between the columns and cross beams, a removable beam between the columns across said one side between the ends of tanks to facilitate by removal thereof the insertion of said tanks in the frame, and means removably attaching the tanks to the beam for securement of said tanks in the frame.

13. In an apparatus for drying gases, a frame, a pair of tanks mounted on the frame with their bottom parts above the bottom of the frame, means on the frame dividing it into vertical sections, said means being adjacent the bottoms of the tanks, an upper section piping system leading into the tops of both tanks, comprising first gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system comprising also second gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, a lower section piping system leading into the bottoms of both tanks, comprising third gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said lower section piping system comprising also fourth gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system being disposed in an upper of said vertical sections, said lower piping system being disposed in a lower of said vertical sections, and means enclosing said upper vertical section separately from said lower vertical section, whereby said lower section piping system may be serviced without disturbing said upper vertical section.

14. In an apparatus for drying gases, a frame, a pair of tanks mounted on the frame with their bottom parts above the bottom of the frame, means on the frame dividing it into vertical sections, said means being adjacent the bottoms of the tanks, an upper section piping system leading into the tops of both tanks, comprising first gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system comprising also second gas piping connections including a common pipe, branches leading to the two tanks, and valve

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means to connect the common pipe with either tank and to cut it off from the other, a lower section piping system leading into the bottoms of both tanks, comprising third gas piping connections, including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said lower section piping system comprising also fourth gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system being disposed in an upper of said vertical sections, said lower piping system being disposed in a lower of said vertical sections, means enclosing said upper vertical section separately from said lower vertical section, whereby said lower section piping system may be serviced without disturbing said upper vertical section, and separately removable means for enclosing said lower vertical section.

15. In an apparatus for drying gases, a frame, a pair of tanks mounted on the frame with their bottom parts above the bottom of the frame, means on the frame dividing it into vertical sections, said means being adjacent the bottoms of the tanks, an upper section piping system leading into the tops of both tanks, comprising first gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system comprising also second gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, a lower section piping system leading into the bottoms of both tanks, comprising third gas piping connections, including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said lower section piping system comprising also fourth gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system being disposed in an upper of said vertical sections, said lower piping system being disposed in a lower of said vertical sections, means enclosing said upper vertical section separately from said lower vertical section, whereby said lower section piping system may be serviced without disturbing said upper vertical section, and insulation within the upper section about the tanks.

16. In an apparatus for drying gases, a frame, a pair of tanks mounted on the frame with their bottom parts above the bottom of the frame, means on the frame dividing it into vertical sections, said means being adjacent the bottoms of the tanks, an upper section piping system leading into the tops of both tanks, comprising first gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system comprising also second gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, a lower section piping system leading into the bottoms of both tanks, comprising third gas piping connections, including a common pipe, branches leading

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to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said lower section piping system comprising also fourth gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system being disposed in an upper of said vertical sections, said lower piping system being disposed in a lower of said vertical sections, means enclosing said upper vertical section separately from said lower vertical section, whereby said lower section piping system may be serviced without disturbing said upper vertical section, and a heater mounted in said upper vertical section, said heater having connections to said lower section piping system.

17. In an apparatus for drying gases, a frame, a pair of tanks mounted on the frame with their bottom parts above the bottom of the frame, releasable holding means for securing the tanks to the frame, means on the frame dividing it into vertical sections, said means being adjacent the bottoms of the tanks, an upper section piping system leading into the tops of both tanks, comprising first gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system comprising also second gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, a lower section piping system leading into the bottoms of both tanks, comprising third gas piping connections, including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said lower section piping system comprising also fourth gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system being disposed in an upper of said vertical sections, said lower piping system being disposed in a lower of said vertical sections, means for disconnecting said lower section piping system from the tanks, and removable means enclosing said upper vertical section separately from said lower vertical section, whereby said lower section piping system may be serviced without disturbing said upper vertical section.

18. In an apparatus for drying gases, a frame, a pair of tanks mounted on the frame with their bottom parts above the bottom of the frame, releasable holding means for securing the tanks to the frame, said holding means including releasable attaching devices between the frame and the respective tanks, said frame including fixed members and cross members releasably attached to said fixed members at points between the ends of the tanks, means on the frame dividing it into vertical sections, said means being adjacent the bottoms of the tanks, an upper section piping system leading into the tops of both tanks, comprising first gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system comprising also second gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with

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either tank and to cut it off from the other, a lower section piping system leading into the bottoms of both tanks, comprising third gas piping connections, including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said lower section piping system comprising also fourth gas piping connections including a common pipe, branches leading to the two tanks, and valve means to connect the common pipe with either tank and to cut it off from the other, said upper section piping system being disposed in an upper of said vertical sections, said lower piping system being disposed in a lower of said vertical sections, means for disconnecting said lower section piping system from the tanks, and removable means enclosing said upper vertical section separately from said lower vertical section, whereby said lower section piping system may be serviced without disturbing said upper vertical section.

19. In an apparatus for drying and heating gas, a pair of tanks adapted to contain a gas treating material subject to deactivation, a valved secondary discharge from the first end of each tank for selectively discharging a spent reactivating gas from either of said tanks, a main gas inlet having valved connections to the first end of each tank for selectively delivering an untreated gas to either of said tanks, a main gas outlet having valved connections with the second end of each tank for selectively delivering a treated gas from either of said tanks, a heater having an inlet connected with the main gas outlet for conditioning at least a portion of said treated gas to reactivating condition, and having an outlet line for

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delivery of a reactivating gas from the heater, a valved connection between the heater outlet and the second end of each tank whereby the reactivating gas from the heater may be selectively directed through one of the tanks.

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