

[54] **CRYOGENIC APPARATUS ASSEMBLY METHOD**
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[63] Continuation of Ser. No. 767,713, Oct. 15, 1968, abandoned.

[52] U.S. Cl. **62/42, 29/423, 165/76, 165/77**

[51] Int. Cl. **F25j 1/00, F25j 5/00, F25j 3/02**

[58] Field of Search **165/78; 62/36, 42, 62/43, 44; 165/76, 77, 78; 29/423**

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[57] **ABSTRACT**

An apparatus for carrying out cryogenic processes wherein the major pieces of equipment, such as fractionating towers, separators, etc., form a central vertical column on which the various pieces of accessory equipment, such as heat exchangers, absorbers, compressors, etc. are both supported and operatively connected.

1 Claim, 7 Drawing Figures

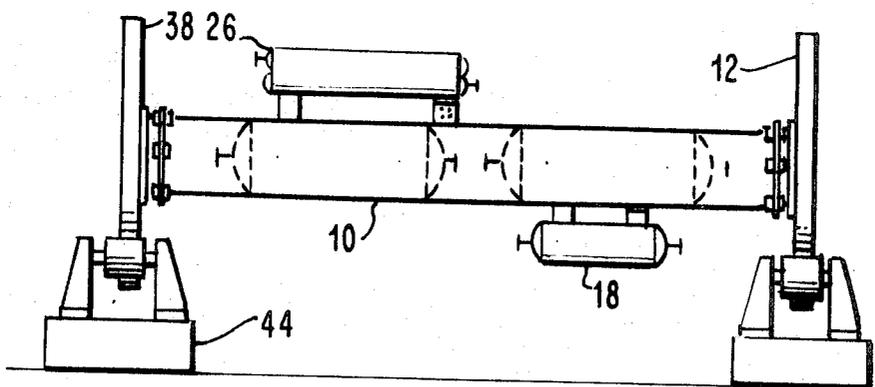


FIG. 1

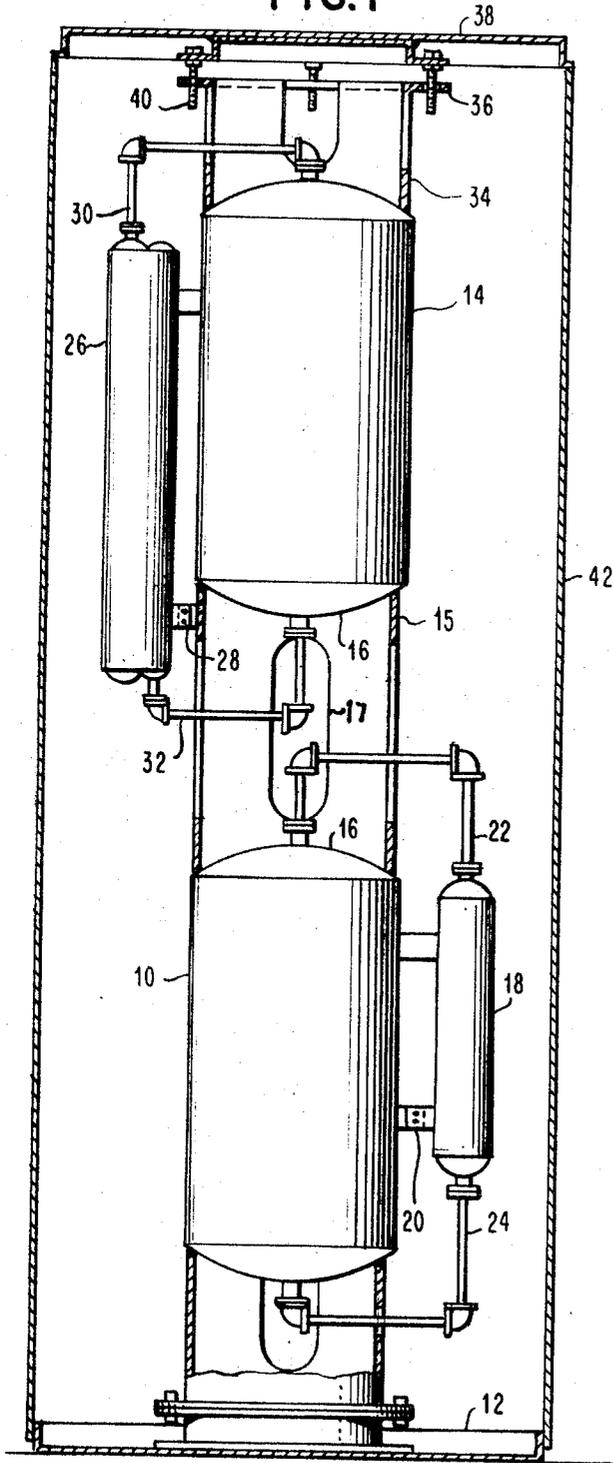


FIG. 2

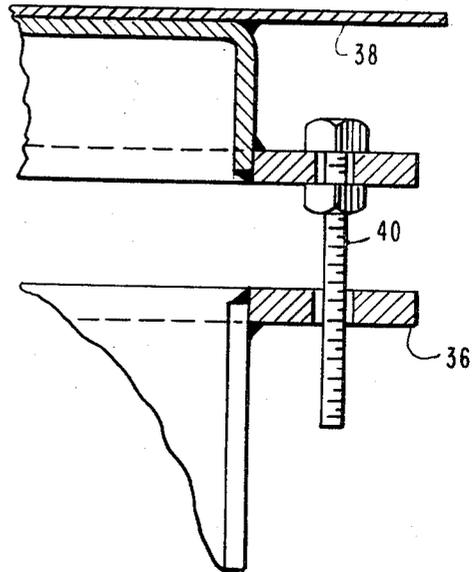
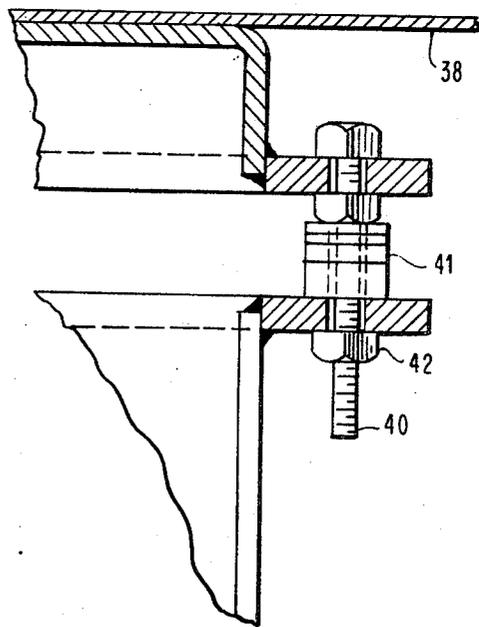


FIG. 3



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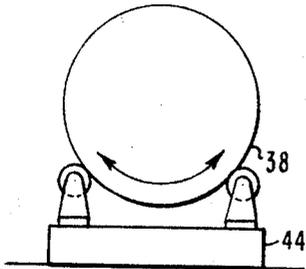


FIG. 5

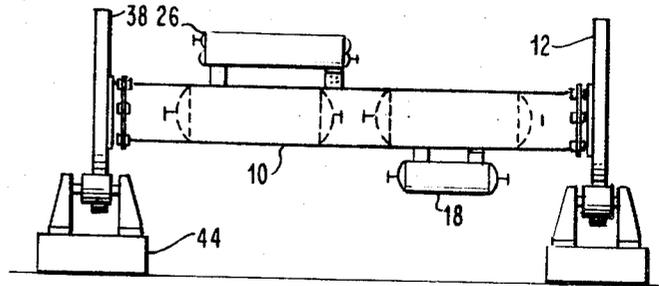


FIG. 4

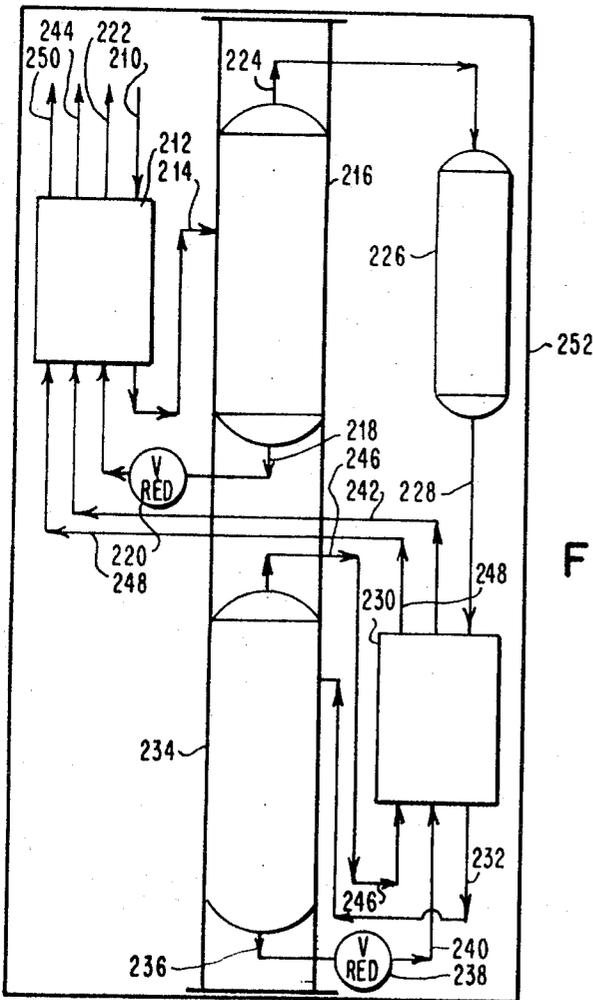
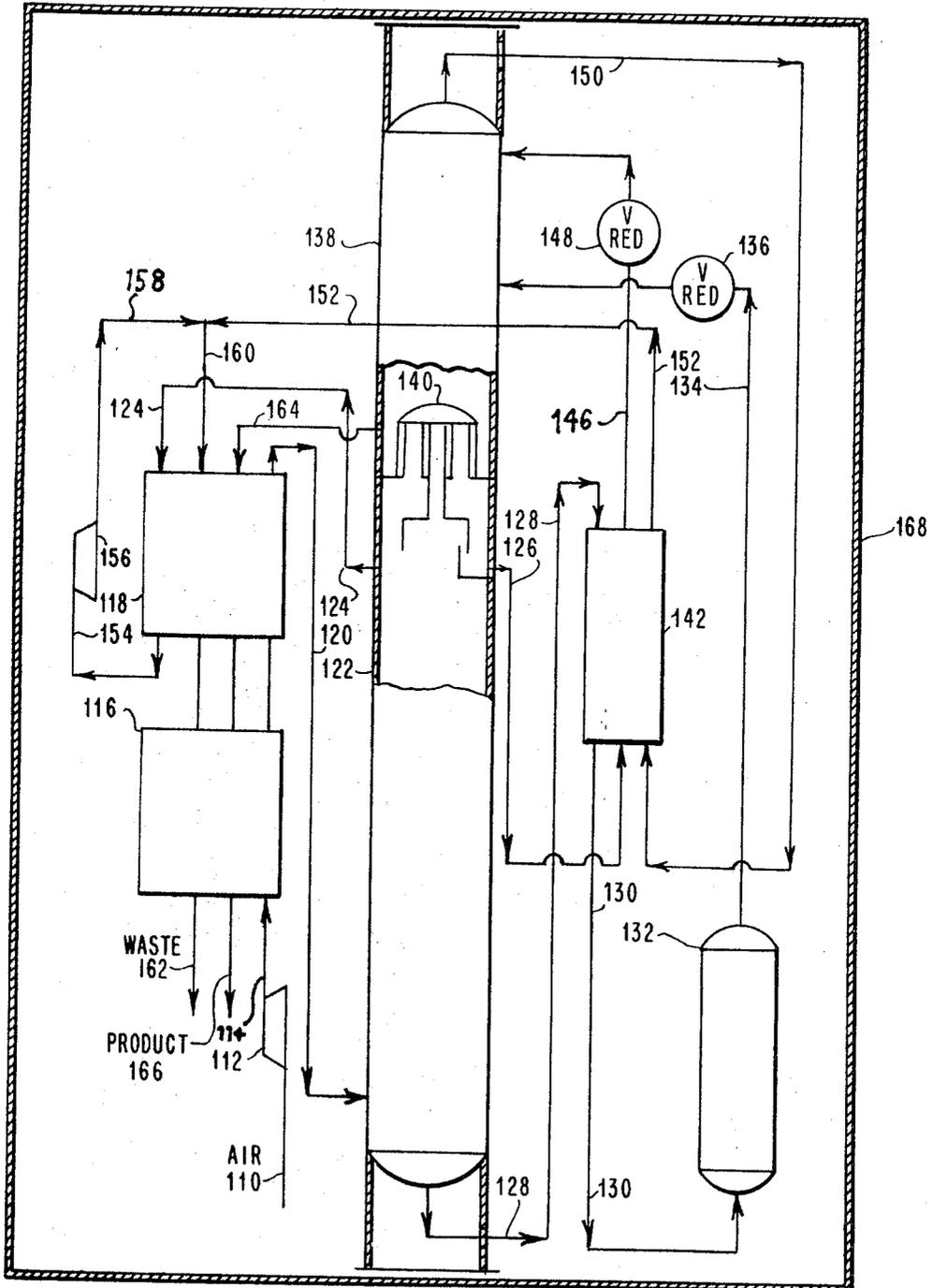


FIG. 7

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FIG. 6



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CRYOGENIC APPARATUS ASSEMBLY METHOD

This application is a streamline continuation of application Ser. No. 767,713, filed Oct. 15, 1968 and now abandoned.

BACKGROUND OF THE INVENTION

This invention pertains to the field of cryogenic processes. More particularly, it pertains to an apparatus for carrying out cryogenic processes, wherein gases are treated by compression, cooling, heating and expansion and wherein various heat exchange, fractionation, gas-liquid separation, liquefaction, absorption, etc. operations are or may be carried out.

Generally, in plants for the cryogenic processing of liquids and gases, a major design problem arises due to the structural requirements of such systems, not only with respect to the stress characteristics resulting from the temperature and pressure ranges in which such equipment operates, but also the problems involved in building and erecting the equipment.

The low temperature requirements of cryogenic processes (under 0°F.) presents structural problems in that the stresses placed on piping and connecting members between major pieces of equipment can become significant. These same large pieces of equipment, however, must have substantial insulation such that the heat loss from a given system is minimal and, thus, the major pieces of equipment tend to be large and bulky and present general problems in equipment handling and placement. Additionally, the connective piping between these pieces of equipment, become extensive and the resulting stress factors in such piping can also become significant. Additionally, of course, the piping must be insulated. Because of the stress requirements, therefore, additional structural members and hardware is required which results in increased cost of a given cryogenic plant.

A second major handicap of the stress requirements and awkward equipment required by such cryogenic operations is that major portions of the plants, in general, are field assembled and it is difficult and sometimes impossible to pre-assemble these pieces of equipment. Field assembly, of course, always presents economic problems, since it can never be as efficient as a shop assembly. Also, however, the size factors of the equipment presents transportation problems with respect to getting the various parts to the plant site.

Thus, the economic disadvantages of structural requirements in cryogenic systems have normally simply been written off as inherent in the economics of such processes.

SUMMARY OF THE INVENTION

We have discovered an apparatus for carrying out cryogenic and low temperature processes wherein the structural design characteristics and assembly difficulties heretofore associated with such apparatus are avoided. More particularly, our invention consists of arranging the major structural piece of operating equipment normally used in such cryogenic processes such as fractionation towers, separators, etc., in a central structural column and attaching the accessory pieces of equipment, such as heat exchangers, absorbers, etc., to the basic structural column, such that the accessory equipment is not only operatively connected to the major pieces of equipment and to each other as required, but are also completely supported by the cen-

ter column. In this manner, the lengths of piping and conduit between the pieces of equipment is minimized and the overall stress requirements of the system are minimized.

The entire column with its attached accessories is then surrounded by a shell which forms a housing filled with an insulating medium. Thus, the entire plant becomes essentially a single self-operating, self-supporting package, without the necessity of separately insulating each unit. The shell and, thus, the housing also become a stabilizing influence for the entire unit assembly.

Another advantage of our invention is that the top and bottom of the basic column may be secured to large circular plates that can be used as wheels. The column may then be positioned horizontally on a set of rollers, the wheel at each end of the column being in contact with the rollers so that the column may be easily rotated. The particular accessories are then easily attached to the center column in the position desired. Thus, the entire cryogenic plant may be assembled at the site. Before or after placing the column in the normal operating vertical position, the shell may be attached to the circumference of the wheels and the shell and wheels thereby comprise the housing for the cryogenics plant to make a wholly covered unit.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of the generalized cryogenic apparatus.

FIG. 2 is an enlarged section of the connection between the housing top and column top of the apparatus when in operation.

FIG. 3 is an enlarged section of the connection between the housing top and the column top during assembly and transportation.

FIG. 4 is an elevation of the apparatus in assembly position.

FIG. 5 is an end view of the apparatus when in assembly position.

FIG. 6 is a schematic flow sheet of the items of equipment as used in an air separation plant.

FIG. 7 is a schematic flow sheet of the items of equipment when used in hydrogen purification plant.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Generally, our invention consists of an apparatus for carrying out cryogenic processes which consist of a basic cryogenic column which is mounted vertically on a fixed foundation. This column incorporates into its structure, the major structural piece of equipment of the cryogenic plant, such as the fractionating towers, separators, or the high and low pressure columns. The accessory cryogenic equipment, such as the heat exchangers, compressors, absorbers, coolers and various conduit and valving means is then integrated with the main column or piece of equipment, such that it is connected operatively to such equipment. The accessory equipment, however, is also connected to the main column in such a manner that it is completely supported by the column. Thus, the major structure of the plant and the various pieces of accessory equipment are integrated into a single unit connected only by structural pieces and conduit means and the integrated unit is then surrounded by a shell forming a housing. The housing can be filled with any type of granulated or

particulate insulating material known to the art, such as expanded polystyrene, vermiculite, etc.

FIG. 1 shows a general view of the apparatus of our invention and while it is not detailed for a particular type of cryogenic process, it serves to illustrate the manner in which the major structural pieces of equipment as well as accessory pieces of equipment and housing are joined together. As an example, a lower column at 10 is shown attached to the base 12, which is preferably a large circular plate. This column is surmounted by a second column 14 which is supported by the skirts 15. By such means, one or more major structural columns may be supported on top of one another, the only limitation being the height to which such an apparatus can be erected and maintained in a practical manner. In some cases, the skirts 15 may be part of a common shell for both, or all of the separate columns with the heads 16 welded in at appropriate levels. Parts 17 are also provided in the skirts for access to the internal piping. In a typical air separation tower for example, the lower column becomes a high pressure chamber and the upper column becomes a low pressure chamber. Total heights of 50 to 150 feet are common.

Accessory equipment is commonly needed for such columns. As shown, accessory equipment 18 is structurally connected to the lower column 10 by holding members 20. Operating connections are shown at 22 and 24. In a similar manner, accessory equipment 26 is attached to the upper column 14 by holding members 28 and operative connections 30 and 32.

As will hereinafter be explained, the upper skirt or extension of the column at 34 is provided with a flange 36 which is structurally connected to a circular top plate 38 by bolts 40 as more clearly shown in FIGS. 2 and 3. The entire unit may then be covered by an external shell 42 which can be appropriately secured both to the circular base 12 as well as the top plate 38.

The top column 14 is adapted to be immovably connected to the top circular plate 38 during assembly and transportation of the apparatus and movably connected during operation. Specifically, the connection between the top portion of the column and the top plate is adapted such that the vertical movement of the cryogenic apparatus proper as a result of expansion and contraction can take place without interference from the housing.

FIG. 2 shows the connection of the top plate during operation. The plate connecting member 38 and the column connecting member or flange 36 contain a plurality of bolt receiving holes, each hole in the plate member having a corresponding hole in the flange. The diameter of these holes is sized slightly larger than the bolts so that the bolts can easily slide through the holes. As shown, bolt 40 is immovably secured to the top plate member 35 and inserted through the corresponding hole in flange 36, but not immovably secured thereto. Thus, the column and top plate are movable in the vertical plane relative to each other but not in the horizontal plane. The bolt, therefore, acts as a guidepin for the entire cryogenic apparatus as it expands and contracts; however, it does not act to hinder such movement. Alternately, the bolt could be immovably secured to the flange rather than the plate member 38.

FIG. 3 shows the use of spacers 41 and lock nut 42 to immovably secure the upper portion of the column to the upper plate 38. This mode is used only during

shop assembly or transportation of the apparatus including the housing.

FIG. 4 shows the use of the circular top and base plates in the assembly of the apparatus. These circular plates have equal diameters, said diameter being larger than encompassed by the column with the accessory equipment. They are attached to the column or column support members such that the center axis of the plates and the vertical axis of the column define a straight line. In this manner, the plates act as wheels with the main column serving as a connecting axle.

Thus, the main column may be mounted horizontally as shown on roller tables 44. This facilitates rotation of the main columns 10 and 14 for connection of accessory equipment 18 and 26. While in the horizontal position, the cylindrical wall 42, utilizing partial circumferential sections, can now be installed, the top and bottom of the cylinder being the circular plates.

FIG. 5 shows an end view of the assembly of FIG. 4. The apparatus of our invention thereby lends itself uniquely to a rather efficient method of assembly which can easily be utilized in the field. Thus, the individual pieces of equipment can be shipped from the assembly shop to the field site and there with a minimum of structural piping requirements, etc., be assembled as shown.

The cryogenic apparatus of our invention may be utilized in any type of cryogenic process, however, for purposes of more specific illustration, a description of particular applications and combinations of equipment are given.

FIG. 6 shows the general arrangement of equipment about the center structural column for a plant adapted for air separation and liquid oxygen and nitrogen production. As shown in FIG. 6, air at 110 is compressed in compressor 112 and introduced through line 114 to heat exchangers 116 and 118. The air is cooled in the heat exchangers by direct heat exchange with product gases. The cooled, compressed air is then removed from heat exchanger 118 through line 120 and introduced to a high pressure fractionation tower 122. From tower 122, the nitrogen overhead at 124 composed of a vapor portion and a liquid portion is formed. A rich air bottoms material is formed in the lower portion of the high pressure tower. The nitrogen liquid overhead is removed through line 126 and passed in heat exchange with the rich air liquid bottoms which are removed from the tower through 128, in heat exchanger 142. The heat exchange accomplished in heat exchanger 142 may either be a reboiling step or a super cooling step with respect to the liquid bottoms.

The liquid nitrogen stream is removed from heat exchanger 142 through line 146, is expanded through reducing valve 148 into the low pressure tower 138. The rich air in line 128 after heat exchange in heat exchanger 142, is removed through line 130, passed through absorber 132 into line 134 and is then expanded through reducing valve 136 into the low pressure tower 138, where reflux is established between the nitrogen vapor and the crude liquid bottoms.

In the low pressure tower 138, heat is supplied by the condensation of nitrogen in the high pressure tower 122 through the inter-tower reboiler 140. An overhead high purity product fractions is removed from the low pressure tower 138 through line 150, is passed through heat exchanger 142 and removed through line 152. It is then combined with an expanded stream in line 158

into line 160 and is passed through heat exchangers 118 and 116 and removed as a product or waste gas in line 162. A high purity bottoms fraction is removed from low pressure tower 138 through line 164 and is passed through heat exchangers 118 and 116 and is removed from the system through line 166 as product.

The nitrogen vapor overhead from high pressure tower 122 is removed through line 124 and is passed through heat exchanger 118. It is then introduced through line 154 to expander 156 which produces a low pressure cold gaseous stream. This stream in line 158 is then combined as described above with the stream from line 152.

The structural connecting pieces between the accessory equipment, i.e., heat exchangers 116, 118, compressors 112, expander 156, absorber 132, valves 136 and 148 and all of the integrated piping are now shown for clarity. The exterior of the housing 168 is shown, however.

FIG. 7 shows the combination of equipment that would be used for a typical hydrogen purification system. As shown, an impure hydrogen feed at 210 is cooled by heat exchange with cold product vapors in heat exchanger 212 and is introduced through line 214 into separator 216. A condensed impurity fraction is removed from separator 216 through line 218 and is expanded through valve 220. The refrigeration obtained from the expansion is utilized in heat exchanger 212 and the contaminant is removed as a fuel gas in line 222.

A purified overhead vapor is removed from separator 216 through line 224 and is passed to absorber 226. It is withdrawn through 228 and passed in heat exchange with cold product vapors in heat exchanger 230. This cooled stream is then removed through line 232 and introduced into a second separation zone 234. A condensed contaminant fraction is removed as a bottoms material through line 236 and is expanded through valve 238 into line 240. The refrigeration obtained from this expansion is then used to provide the cooling for heat exchanger 230. The warm contaminant stream is removed through line 242, is passed through heat exchanger 212 and is removed as a low pressure fuel gas

in line 244.

The high purity overhead from separator 234 is removed through line 246, is passed through heat exchanger 230 and 212 and is removed as a high purity hydrogen fraction in line 250. Once again, the structural connecting members are not shown for clarity, however, the outer portion of the housing is illustrated as 252.

Obviously, many modifications and variations of the present invention are possible and in light of the above teachings, it is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. The method of assembling a cryogenic apparatus normally having a vertical position, and mounted on a fixed foundation, said apparatus including a fractionation section within a cylindrical cryogenic column, and interconnected heat exchangers, tanks and piping mounted on the column and connected to the fractionating section whereby the heat exchangers, tanks and piping are supported from the foundation through said column, said method comprises:

- a. constructing a cylindrical cryogenic column with a fractionation section therein and circular support members at the top and bottom;
- b. placing the column in a non-working horizontal position and rotating said column on said support members;
- c. installing heat exchangers, tanks and piping on the column during the rotation of the column about its central axis when in the horizontal position;
- d. elevating the column to a vertical position and mounting the lower support member on the foundation;
- e. surrounding said column with a cylindrical shell attached to the lower support member;
- f. filling said shell with insulation to permit minimal heat leak;
- g. and stabilizing said column by attachment at the top by interconnection between the top support member and the shell.

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