

percentage of oxygen recovery and a wide latitude in operational flexibility. The quantity of liquid nitrogen required for the distillation can be related to a temperature difference between the top of the column and a point approximately five trays further down. This phenomenon can be utilized by means of a temperature difference controller to control the speed of the turbine driving the nitrogen compressor so that under any condition of operation of the plant the amount of liquid nitrogen supplied as reflux will always be the optimum quantity equivalent to the lowest total horsepower per unit of useful product.

Distillation takes place in the column and results in liquid oxygen collecting in the reboiler at a purity corresponding to the purity of the principal oxygen product, which for the case being described is 95 per cent. The gaseous oxygen product is taken off at approximately 5 psig and the corresponding saturation temperature, and warmed up to room temperature through heat exchanger (17). Thus the cold from the oxygen product is returned to the system via the high-pressure nitrogen stream.

The purity of the oxygen product bears a definite relationship to the temperature distribution between the liquid oxygen in the reboiler and a point in the column approximately five trays higher which can be utilized to control the oxygen purity either by regulating the valve on the oxygen product stream or by controlling the speed of the turbine which drives the air-charging blower.

The system can make both high-purity and low-purity oxygen simultaneously. A smaller stripper column (13) is situated at a level beneath the main column in such a manner that 95 per cent purity liquid oxygen feeds as overhead to the top of the high-purity column. The overhead gas from this column will be essentially 95 per cent purity gaseous oxygen and simply joins with the low-purity gaseous oxygen stream. The high-purity oxygen product is taken off above the liquid level of the oxygen in the reboiler of the high-purity column and gives up its cold by exchange against some of the high-pressure gaseous nitrogen from the nitrogen compressor through exchanger (18), and is delivered at essentially room temperature as the high-purity product. The nitrogen side of the reboiler of the high-purity column parallels the nitrogen side of the reboiler of the main column. The condensing of nitrogen in this reboiler provides the heat to boil off the high-purity oxygen product and the vapor loading for the operation of the column. The liquid nitrogen condensed in the reboiler flows

by its own pressure head and joins with the liquid nitrogen going into the top of the main column. In this manner the high-purity column can deliver any quantity of high-purity oxygen within the design limits and virtually floats on the system with the main column.

This combination of functions in the Elliott cycle makes it possible to obtain an unusual degree of flexibility in operation. The plant can deliver any quantity of product required over a wide range of variable conditions within the design limits of the plant while maintaining constant purity irrespective of weather conditions, seasons of the year and other factors which effect the performance of a low-temperature process. The various functions will automatically adjust themselves to the lowest horsepower per unit of oxygen product. The plant can operate down to approximately two-thirds of full capacity without any sacrifice of horsepower per unit of oxygen product.

To illustrate how the controls on the Elliott system will respond, suppose the plant is operating at reduced capacity and more oxygen is demanded. The oxygen product valve will open and more gas immediately is withdrawn. While the plant is adjusting itself the need will be satisfied by working on the reserve of liquid oxygen stored in the reboiler. The tendency will be to slightly drop the purity. This indication will be picked up on the temperature difference controller which will increase the speed of the air-charging blower. This increases the flow of conditioned air charged to the main column and immediately requires more liquid nitrogen reflux to effect a distillation. The temperature difference controller at the top of the column picks up the signal that the plant is deficient in reflux and speeds up the nitrogen compressor. The plant will again come into balance for the new operating condition in approximately 30 minutes. When reducing in capacity the reverse procedure will take place.

There is a long history of explosions in oxygen plants resulting from the accumulation of acetylene, which is almost always present in minute quantities in the air, and concentrates in the liquid oxygen in the reboiler of the fractionating column. In the Linde-Frankl type oxygen plants the air can only be precooled to a saturation temperature corresponding to the air pressure, and this is not low enough to remove any acetylene while the air passes through the clean-up heat exchanger or regenerator. Thus the acetylene works its way ultimately into the column. A concentration