Convection-heated annealing furnaces are used for the annealing of glassware pieces, and the most commonly used are the LN-1000 x 18 and the 3PO-180 furnaces. These are designed with either a lower firebox only (LN-1000 x 18) or an upper and lower firebox (3PO-180). The hot gases are removed from these along the flues to the smoke extractor. The main disadvantages of the furnaces are the uneven temperature across the furnace and the lack of any means of automatically maintaining the temperature along the furnace.

In 1968, convection-heated annealing furnaces were installed and operated in our plant (Fig. 1). The technical parameters are given below:

- Productivity, kg/h: 1500
- Maximum annealing temperature, °C: 570
- Internal dimensions of annealing chamber (width × height), m: 1.85 × 0.42
- Height of siege above floor, m: 0.875
- External dimensions (length × width × height), m: 22.47 × 3.28 × 2.5
- Conveyor belt (length × width), m: 22.47 × 1.8

Champagne bottles (0.8 liter) are annealed in these furnaces. The specified temperature across the lehr and along the furnace is maintained by the intensive convective heat exchange between the hot air which is moving under control and the articles on the grid.

The furnace is made entirely of metal and consists of nine individual sections which are bolted together. Five of the first sections form the tunnel and are equipped with the heating and hot-air circulation systems.

In order to ensure that the specified temperature is maintained along the furnace and to reduce the heat losses into the surrounding medium, the space between the outside of the soaking pit and the inside of the wall, which forms a heated cavity, is insulated with mineral-silicate wool (Fig. 1). The first five sections are insulated on all sides but in the sixth section only the floor and the side walls are insulated. Around 7 ton of mineral wool is used for the furnace insulation.

Natural gas is used as fuel but the furnaces can be converted for use with electricity or liquid fuel.

The first four sections are equipped with the heating system. Tubular heat-exchange heaters are installed in the side walls. The heaters are 145 mm in diameter and are made from heat-proof steel. The gas−air mixture is conveyed by low-pressure ports above the front inlet part.
of the tubular heaters, from left and right. The gas is burnt inside the heaters which transmit the heat through the wall to the air circulating between the tubes and the annealing chamber.

At the beginning we encountered certain difficulties in raising the temperature and maintaining it at the required level in the first and second sections. By increasing the diameter of the gas nozzles at the ports from 2 to 2.5 or 2.8 mm it was possible to stabilize the working of the ports and to provide the specified regime in these sections.

Temperature uniformity across each section is achieved by the use of ventilators which generate the closed convection cycle of the heat-transfer agent. Four blowers are installed in the first section to ensure that the articles entering the furnace are intensively heated to the annealing temperature. The later sections (2 to 5) have two ventilators each. The convection ventilators provide the air circulation which reaches the heating channel from the upper part of the annealing chamber and then goes under the grid in a vertical direction washing over the articles.

The input to the two ventilators is provided by a 3 kW, 1425 rpm electric motor.

In order to ensure the specified temperature curve in the 3rd, 4th, and 5th sections, ventilators are installed underneath which admit external air into the channels, which flows towards the side channels which are heated by the heaters. These ventilators are automatically opened only when the monitor indicates that the temperature has risen.

The temperature in the furnace is monitored at meter intervals. Thirteen thermocouples have been installed on one side along the whole length of the furnace. There are also apertures for thermocouples on the other side.

Instruments for heat control and for the automatic monitoring of the temperature regime of the furnace are arranged in a console which is placed at some distance from the furnace. Temperatures at each position are monitored by a potentiometer and the temperature regime in sections 1 through 5 is automatically maintained.

The specified annealing-temperature curve is maintained by regulators which automatically govern the system and consist of: the ports, the upper convection ventilators, the lower cooling ventilators, the timing relay, magnetic valves, and photorelays. Above each instrument on the console there is a signal light with its own transformer. When there is a breakdown in one of the units in the automatic circuit, the emergency circuit takes over automatically and this is indicated by the signal lights.

Below are given the optimum parameters for the convection-heated annealing furnaces which have been developed and installed:

- Duration of annealing and cooling ............. 130-140 min
- Speed of conveyor belt, .................. 0.165-0.175 m/min
- Productivity of furnace ...................... up to 1500 kg/h
- Gas required for annealing 1 ton of glassware (40% lower by comparison with the 3PO-180 furnace) ................. 25 m³
- Power of electric motors (16.8 kW in the 3PO-180 furnace) .................. 22.2 kW

The normal annealing-temperature curve for bottles at the Plant is shown in Fig. 2. This ensures that normal annealing occurs throughout the length and breadth of the furnace.

The lehr grid is made from high-grade steel wire. The grid has been in use for three years and is at present still in a satisfactory condition.