

## Late 1950s

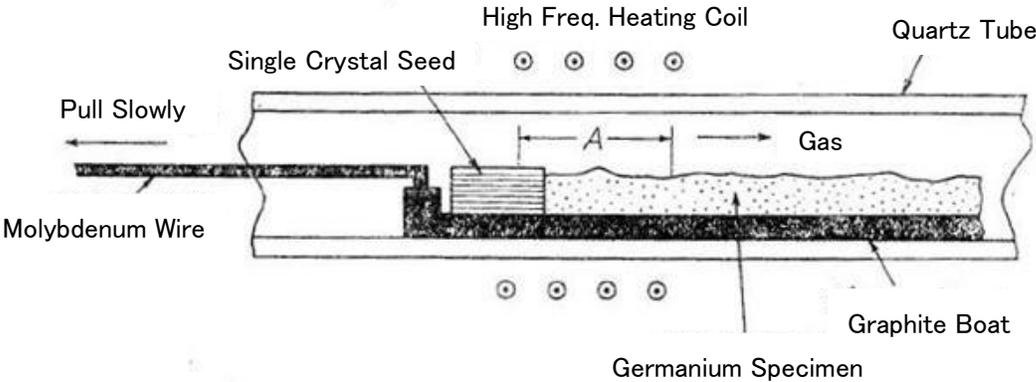
### **Using equipment manufactured in-house to mass-produce germanium transistors**

#### **~ Process Technology ~**

In Japan, production of germanium transistors was started in 1954 by Kobe Kogyo and Sony, and other semiconductor manufacturers also entered this market in the latter half of the 1950s. Japanese companies received patent and technology licenses from US manufacturers such as Western Electric and RCA, and started production of germanium transistors. At the first they had to struggle with very low manufacturing yield. Each company made in-house manufacturing equipment for germanium crystals, and alloy junctions were formed on them to make transistors. They implemented various improvements to the process and managed to start production. The 1950s was the era of “hand-made”, when the basic technology was introduced from the United States, to which Japanese manufactures added many improvements.

As a method of manufacturing the transistor, an alloy method was mainly used. Production of alloy type transistors was carried out by attaching indium dots to both sides of a base N-type germanium substrate and heating it in a reducing atmosphere such as hydrogen to form alloy junctions (in the case of a PNP transistor). The alloy furnaces were made in-house, and they managed to start production by optimizing the process conditions such as atmospheric gases and temperature. Germanium crystals used as substrates were in-house manufactured by each company by a horizontal zone melt method. Horizontal zone melt method was a method in which a germanium seed crystal and powder raw material were placed in a U-shaped graphite boat, and germanium is locally melted by a ring shaped heater or high frequency heating coil, and the melted part was shifted sideways so that a single crystal was grown laterally from the seed crystal. By repeating the process of shifting the melt part, purity of germanium crystal was gradually improved finally to the semiconductor grade which could be used as the transistor material. This was sliced into transistor substrates, but reflecting the cross-sectional shape of the boat, they were in persimmon seed shape, rather than a circular shape. Equipment for horizontal zone melt was manufactured in-house and process conditions were also improved at each company, and it became possible to obtain larger crystals.

By the way, Sony adopted a crystal pulling growth method for their high frequency transistor production, and the transistor made by this method was called grown type.



Example of a horizontal zone melting furnace  
(By courtesy of Kikuchi)