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TITANIUM MELTING

At first I want to make a brief remark on the history of Titanium Ingot Melting in Western Europe.

The first Titanium ingots have been produced in laboratory scale in Western Europe in the early fifties. At W.C. Heraeus GmbH this was in 1953. Several technical approaches were investigated. Finally the consumable electrode technique was adopted.

Because of the need for this wonderful metal, Titanium, development of the necessary production equipment went fast so that in 1957 Vacuum Arc Remelting (VAR) furnaces for ingots up to 400 mm in diameter were being installed in the UK, in France, in Sweden and in the Federal Republic of Germany.

What is required for Titanium ingot melting?

First one has to differentiate between what can be done technically and what one is allowed to do by purchaser's specifications.
The raw material for the Titanium ingot is the socalled Titanium sponge and to a considerable percentage Titanium scrap in various forms.
The conventional production route of a Ti-ingot using a compacted sponge electrode follows the steps.

- Analysis of sponge

- Weighing and mixing, one lot per compact, with alloying elements and scrap (max 45%)

- Producing compacts required in a compacting press and storing them protected from ambient atmosphere

- Assembling and welding consumable electrode together with stub in a Vacuum Plasma Welder

- Storing the welded electrode in a desorption chamber or in a place heated above ambient temperature in order to prevent moisture pick-up

- Double or triple melting in the Vacuum Arc Remelting (VAR) Furnace.

Today's VAR-furnaces are well matured in design and process control.
Computer-controlled melt rate is state of the art.
VAR-furnaces for Titanium ingots up to 1250 mm in diameter and up to 18 tons in weight have been supplied. Some of those VAR-furnaces are NaK-cooled, most of them water-cooled.

Alternative routes for producing a consumable electrode are:

- MIG-welding, i.e. hand welding together solid scrap pieces and compacts, if required;

- MIG-welding together "Nugat" electrode pieces, produced in a Vacuum Arc Skull Melter by overpouring scrap;

- Welding together a "Compound Electrode" in the Vacuum Plasma Welder using sponge compacts and solid scrap pieces.

- Melting together sponge and scrap in:
    - a Non-Consumable Electrode Melter
    - an EB-Melter
    - a Plasma Melter

All the listed routes are being used in practice; the Plasma Melting route soon.
With the amount of high quality scrap unavoidably produced each day, recycling same is a must for economical reasons.
Of course considerable technical and thus economical efforts are necessary in quality assurance for the scrap.
The latest specification of G.E., issued in May this year, covers the EBM-plus VAR-route.
The Plasma Melting plus VAR-route still has to go through approval procedures.
Interpreting this, I would say:

- Triple VAR will stay alive for many years - until EB + VAR and Plasma + VAR experience have proven 100% satisfactory;
- First melts with high sponge percentages will be melted VAR for a long time - until EB or Plasma have proven to be technically and at the same time economically superior.

Bearing in mind, the specific energy consumption which are:

1	kWh/kg for VAR
2	kWh/kg for Non-Consumable Melting
2,5	kWh/kg for Plasma Melting
3	kWh/kg for EB Melting

a Titanium ingot manufacturer must, first of all, have a very strong compacting press in order to include in the sponge compact as much scrap as possible namely up to the above mentioned 45% in the form of chips and swarf.
Besides the other equipment required for electrode preparation, the Vacuum Plasma Welder is a most important piece of equipment.
Before thinking of and considering big investments for a Vacuum Plasma Melter or an EB-Melter, one should start smaller

- by using the available Vacuum Plasma Welder to produce a compound electrode;

- by MIG-Welding the bigger scrap pieces together to form a consumable electrode;
- addition one should consider a three purpose VAR-furnace: one that can remelt electrodes to form ingots and two kinds of castings.

  In the casting mode it will then be possible to actually use a MIG-welded electrode and form by “overpouring” small size scrap part of a new consumable electrode, that can be welded together. The second, maybe more important application in the casting mode, is the production of Ti-castings.

Before I will show you some slides, let me mention that Ti-casting is gaining considerable importance.
Socalled Skull Melters which use a double melted Ti-consumable electrode in conjunction with a water-cooled tiltable crucible have been built and are in operation for pouring weights from 50 kg up to one ton.
At present smaller units down to 2 kg pouring weight gain interest, e.g. for the production of medical implants and for consumer goods in general.
The slides I want to present show only a very small selection of equipment Leybold AG have supplied to producers of Titanium ingots and castings.

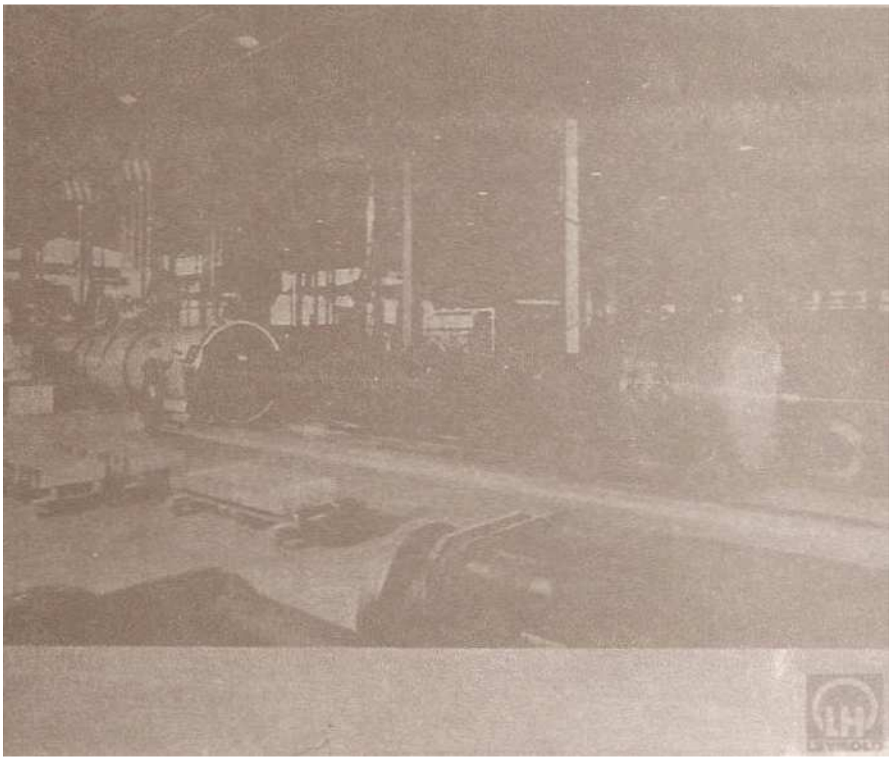

Fig. 1 – Vacuum Plasma Welder for Ti Sponge Electrode

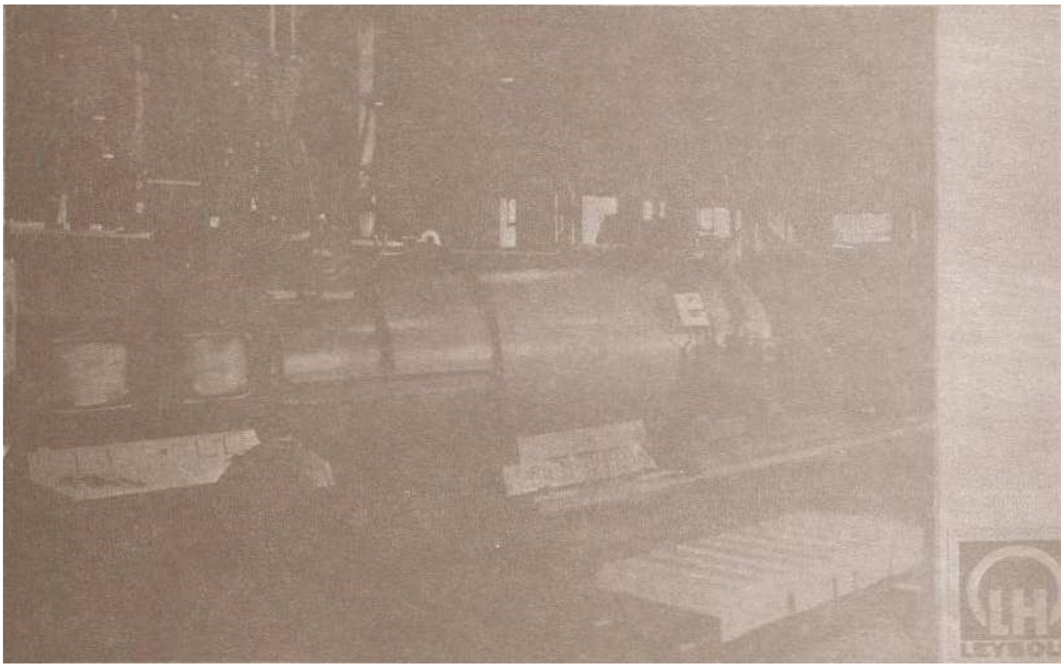

Fig. 2 – Other view of Fig. 1

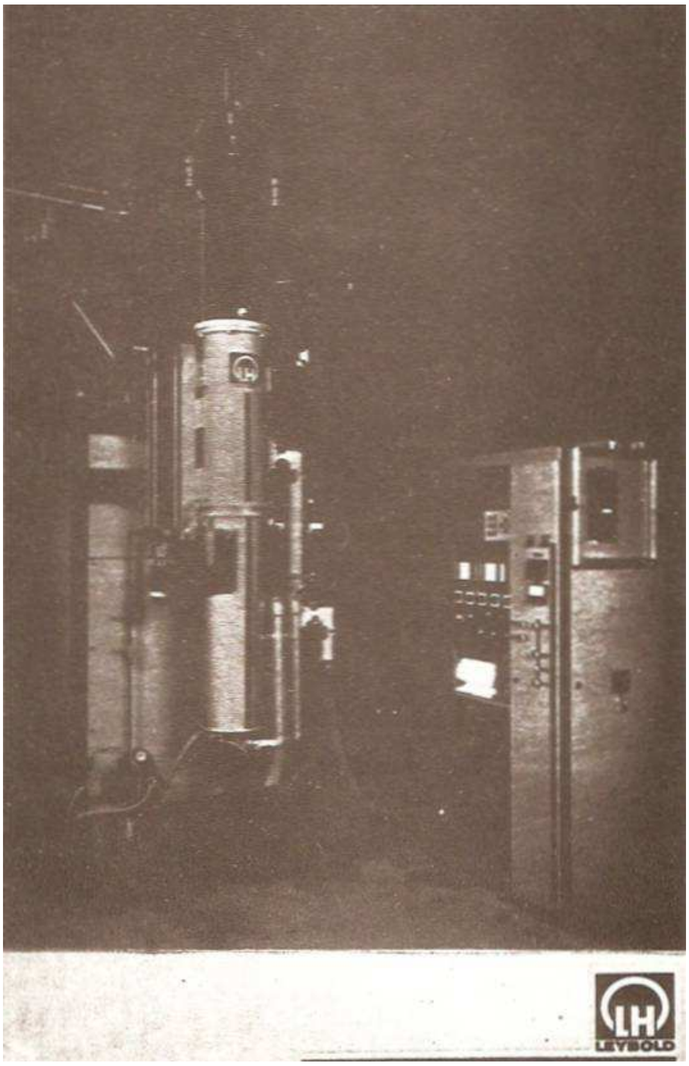

Fig. 3 – Vacuum Arc Remelting (VAR) Furnace L 200
(pilot Plant)

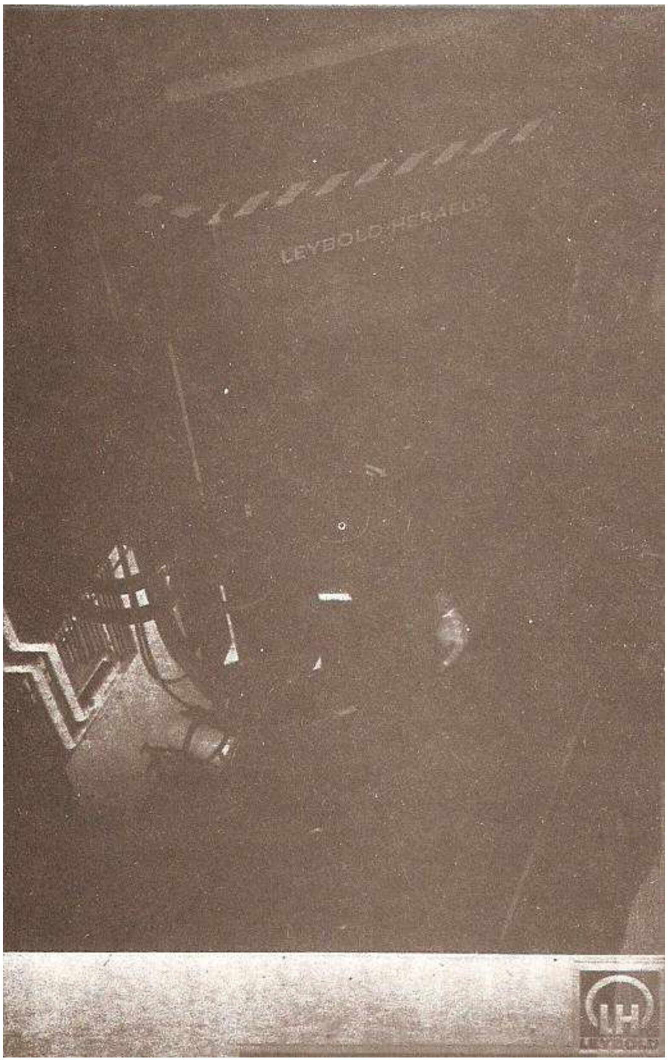

Fig. 4 – VAR-Furnace L 800 P (water-cooled)

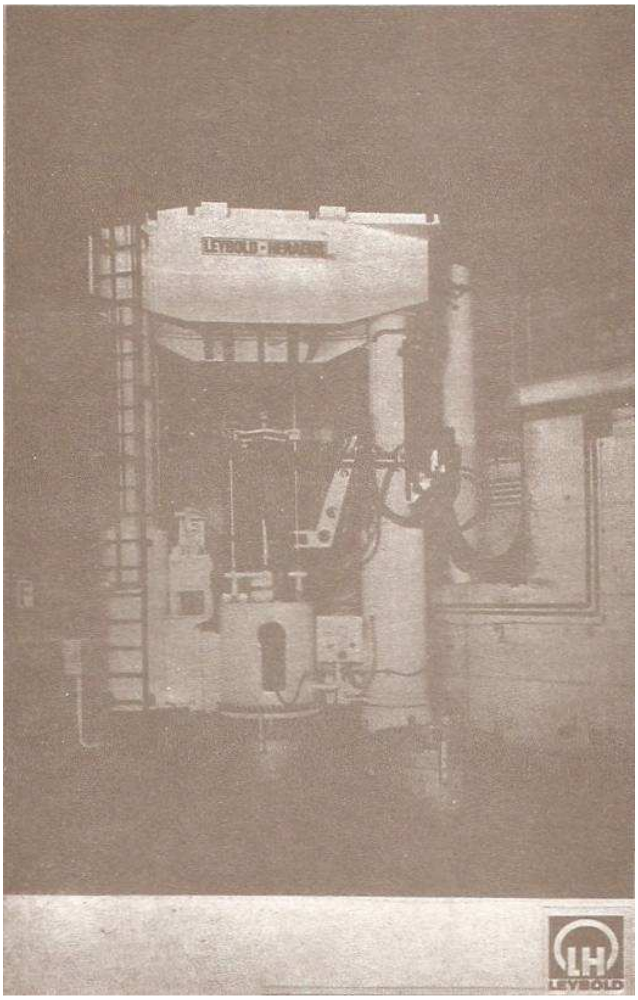

Fig. 5
VAR-Furnace
L 1050 P
(water-cooled)

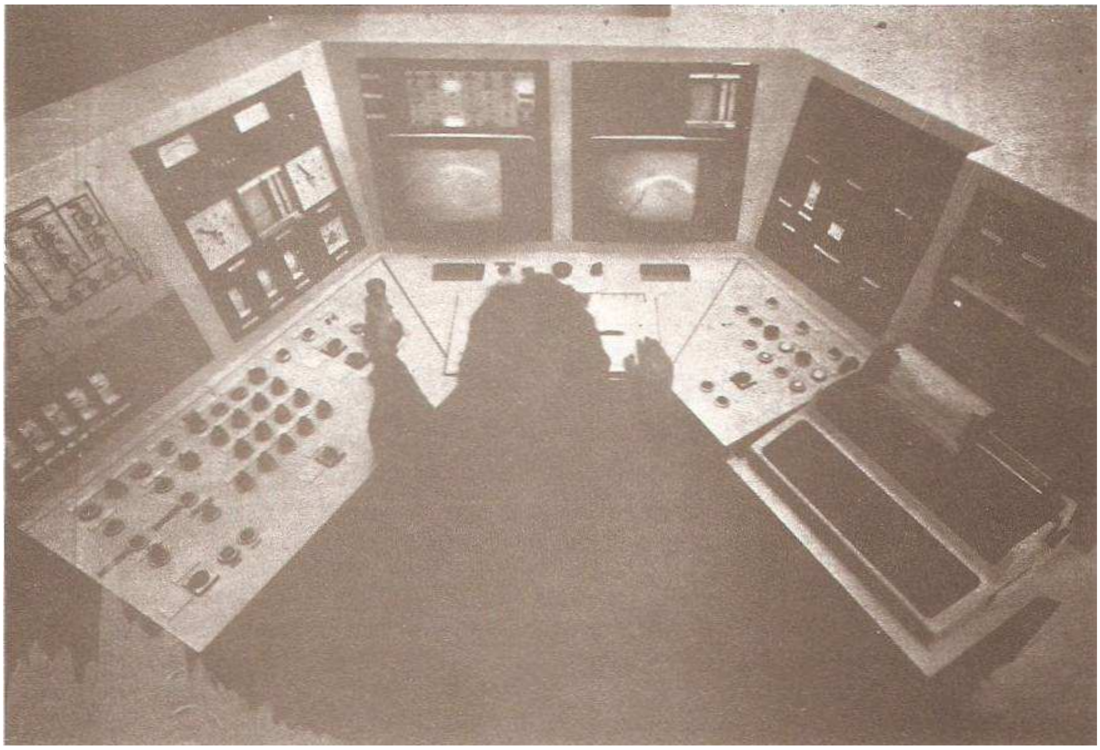

Fig. 6 – VAR-Furnace Control Room

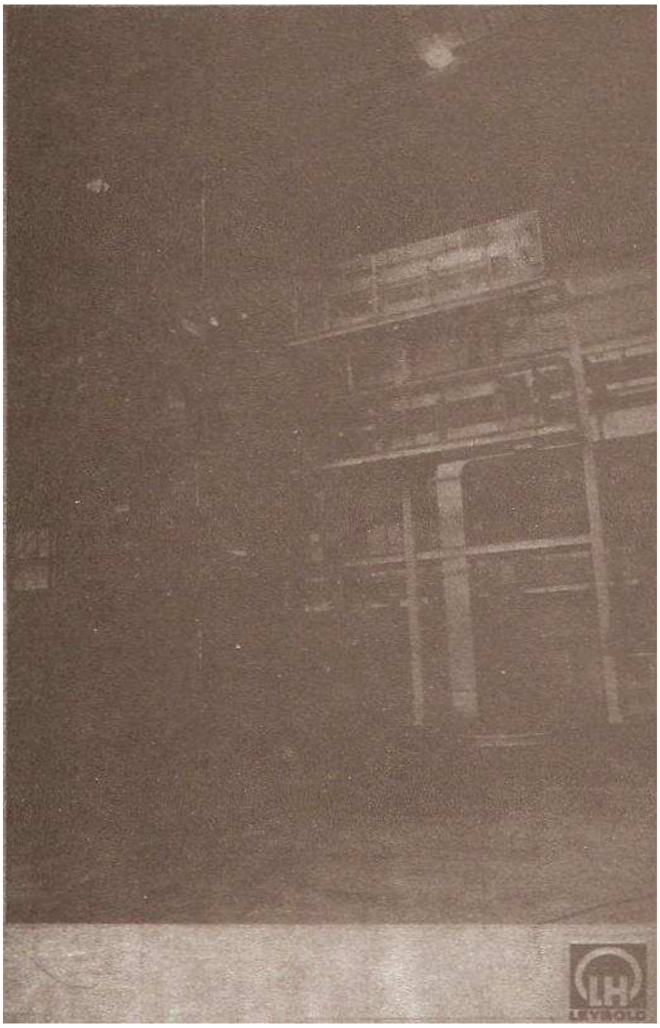

Fig. 7
VAR-Furnace L 1250
(NaK-cooled)

Fig. 8 – Electron Beam Melting Furnace 300 kW
(Overflow Melting)

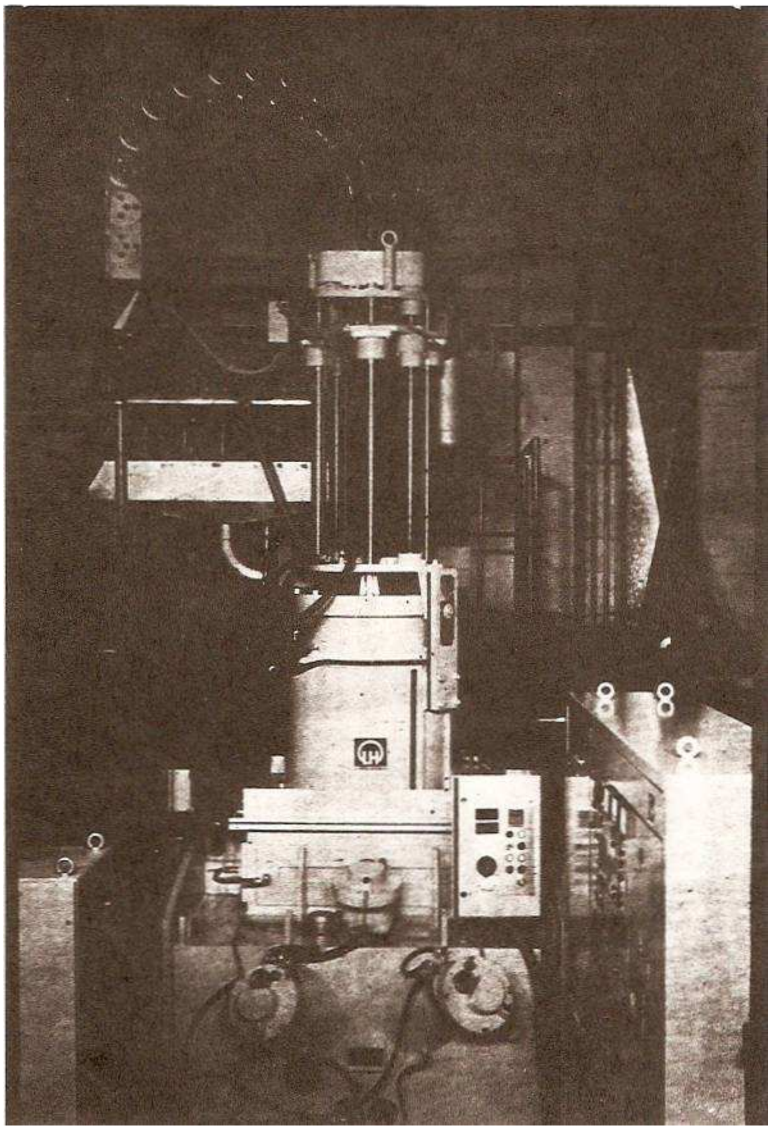

Fig. 9 – Vacuum Plasma Melting Furnace (500 kW)

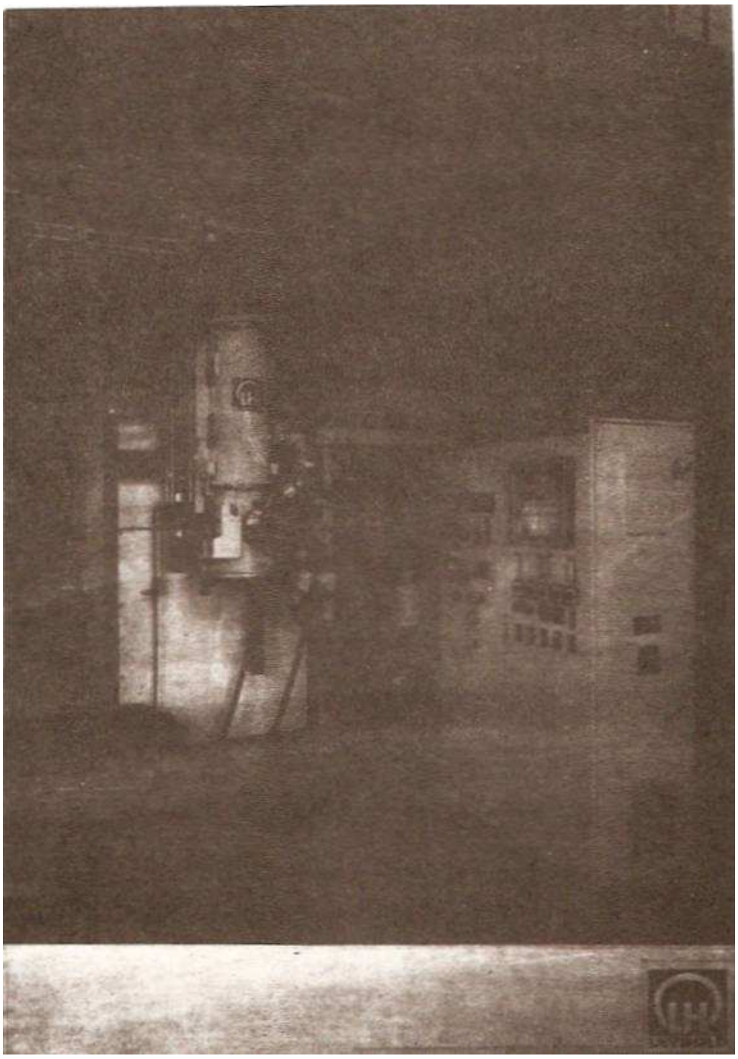

Fig. 10 – Vacuum Arc Skull Melting Furnace
(50 kg pouring weight)

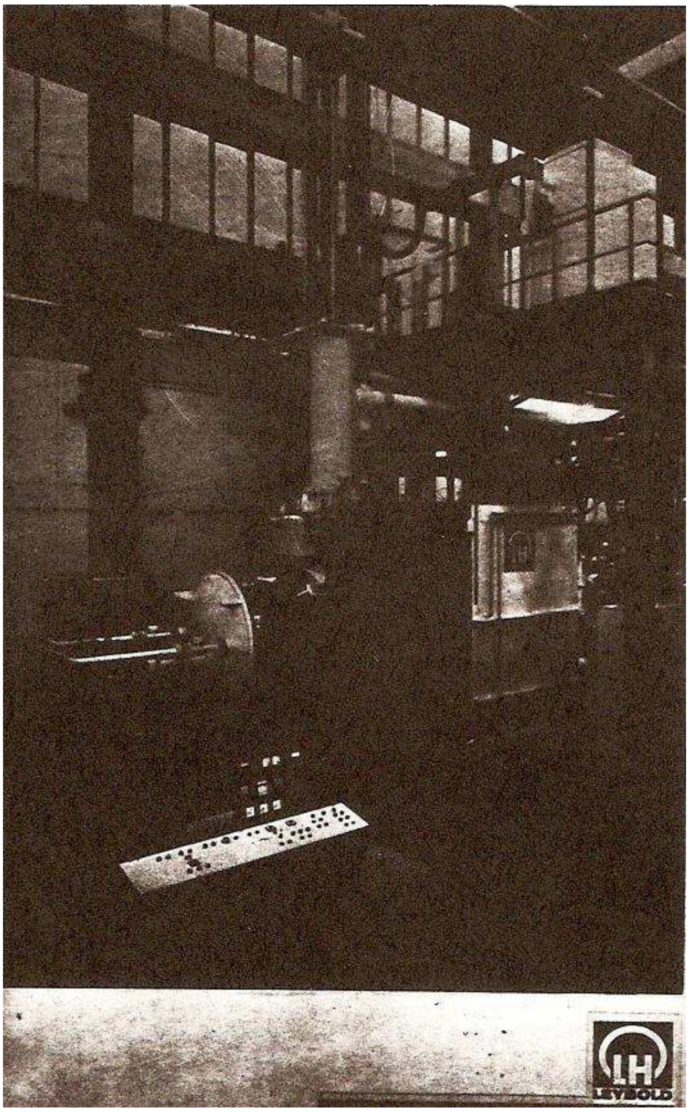

Fig. 11 – Vacuum Arc Skull Melting Furnace
(300 kg pouring weight)

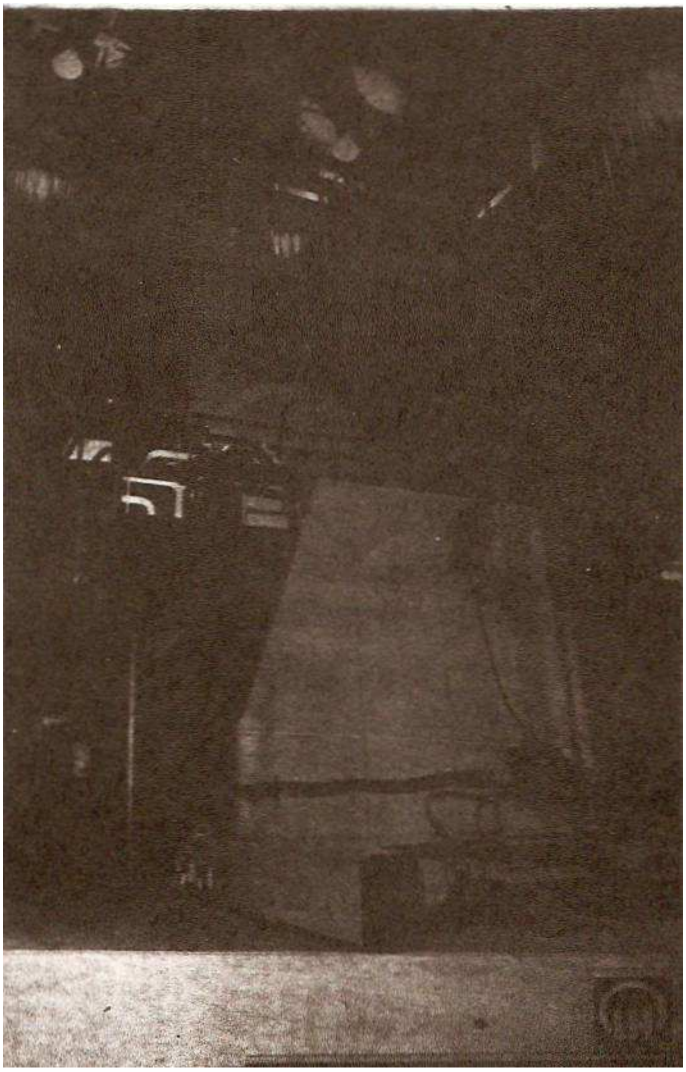

Fig. 12 – Vacuum Arc Skull Melting Furnace
(750 kg pouring weight)

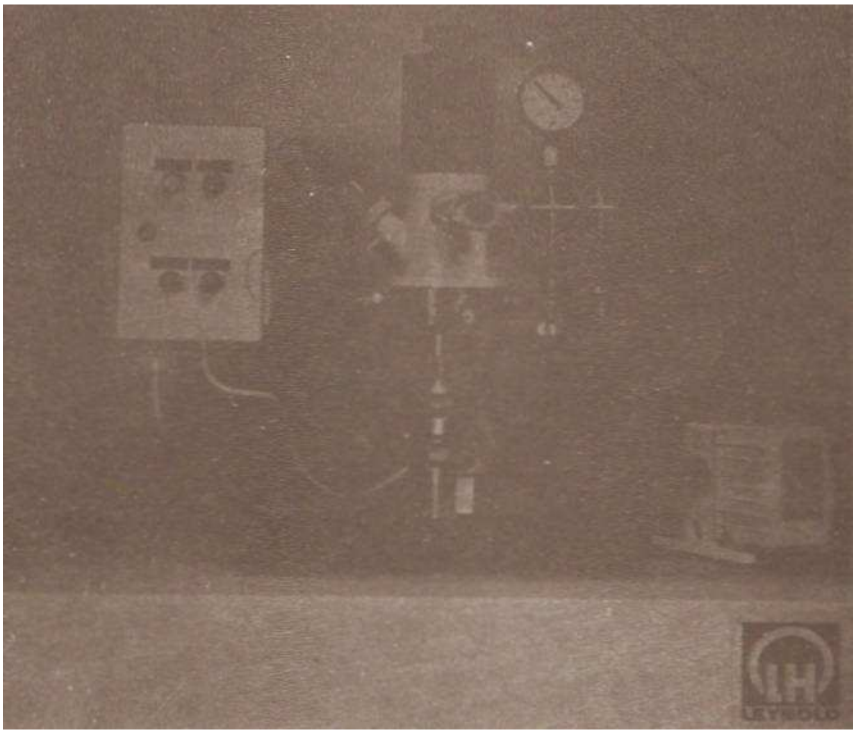

Fig. 13 – Vacuum Arc Button Sample Melting Furnace