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MACHINING AND WELDING TECHNIQUE IN HOT -CELL

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ABSTRACT

Electron beam welding technique is used for reconstitution of radioactive samples for mechanical properties testing. The second field of use electron beam welding is fabrication of supplementary surveillance containers for VVER 440 reactors.

For samples machining is used electric discharge machine, special saw cutting machine, metalography grinding and polishing machine.

All this machines and supporting devices are remotely operated.

1. INTRODUCTION

The hot cells were constructed in Nuclear Research Institute at the end of 1970. In the first period till 1978, considerable attention was paid in hot cells to verifying the operational ability of fuel elements. In connection with introducing the manufacture of VVER 440 light water reactor pressure vessels in former Czechoslovakia, hot cells were used since 1978 for an extensive program of verifikation tests of the technology of 15Ch2MFA steel production. This program was extended on 1984 to 15Ch2NMFA steel as well as to VVER reactors with the output of 1000 MW.

Between 1980 and 1985, an extensive reconstruction of semi-hot laboratory (a part of hot cells used for mechanical testing of irradiated specimens) was carried out so as to enable to study experimentally the change of mechanical properties of surveillance specimens of VVER reactors. Besides the surveillance program, the main task solved in hot cells in Nuclear Research Institute are the problems of the effects of recovery heating on mechanical properties after their irradiation.

At present, reconstitution of radioactive samples and supplementary surveillance programme of VVER-440 reactor pressure vessel steel is realized. It should enable the quality of information on the effect of neutron irradiation on mechanical properties of reactor pressure vessel materials.

2. HOT CELLS LABORATORY

2.1. Technical description of hot cells

Hot cells laboratory carries out the pertinent preparatory and auxiliary operations, e. g. receiving of irradiated materials, unloading of containers, disassembly of capsules or irradiation rigs and recovery of their contents, sorting of specimens and their inserting into containers used for internal transport and storage, as well as evaluation of detectors to determine the neutron fluence and irradiation temperature. The facility has been fitted with equipment for reconstitution of irradiated sampes (welding, cutting and grinding machines).

Hot cells laboratory contains 20 cells, situated in two floors. The hot cell is in the principle a inside steel box with stainless steel bottom : with 2400 mm, depth 1800 mm and height 3000 mm. Material with the activity up to 10^{14} - 10^{15} Bq (approx. 20 000 - 100 000 Ci) may be treated in the hot cells.

2.1. Hot cells machinery and devices

In connection with the solution of research and evaluation of irradiated construction materials, hot cells are equipped with following remotely handled machinery and devices :

- Assembly for case and probe dismantling
- Cutting machine
- Device for specimen notch grinding
- Vacuum high-temperature furnace
- Electron beam welding unit (see Fig. 2)
- Surface grinding machine
- Band saw RF 115
- Surface grinding machine

- Electric discharge machine (see Fig. 1)
- Set of devices for measuring the dimensions

2.3. Possible operations in hot cells

The set of operation that may be carried out at present in HCs of Nuclear Research Institute is connected with the problems solved in the Division of Integrity and Materials, i. e. work with irradiated construction materials for nuclear power plant components.

Dismantling of specimens carriers in rigs irradiated in the NRI's research reactor LWR-15 is mastered with skill. Further, operations are currently carried out with chains of surveillance specimens from power reactors VVER-440, i. e. cutting of chains and opening of cases with surveillance specimens.

Construction materials may be cut up to the total mass of 5 kg, the dimensions are limited by both the transport paths between hot cells and by the technical possibilities of machines.

In the field of thermal treatment, even prolonged experiments may be carried out in a protective atmosphere with specimens up to the temperature of 1300 °C

The reconstitution of surveillance specimens of the Charpy-V type is possible in hot cells laboratory. New test specimens are expected after its disruption during mechanical test and subsequent welding of nonirradiated ends.

3. SEMI-HOT CELLS EXPERIMENTAL FACILITIES AND METHODS

The semi-hot cells laboratory is situated close to hot cells facility. The face of the cells is shielded by 100 mm of lead for handling of specimens with assumed activity of 3.7 Gbq.

Semi-hot cells are equipped with following remotely handled facilities for mechanical testing of irradiated samples :

1. Tinius Olsen Model 74 Universal Impact Tester instrumented with data acquisition and analysis system :
   - Furnace and cooling box for test temperatures from -190 °C to +300 °C
   - Dynamic fracture toughness and Charpy impact energy testing

2. Roell Amsler RKP50 impact machine for sub-size specimens with a capacity of 50 J :
   - Furnace and cooling box for test temperatures from -190 °C to +300 °C
   - Dynamic fracture toughness and Charpy impact energy testing

3. Two Instron 1342 servo-hydraulic tensile testers with a capacity of 100 kN :
   - Furnace and cooling box for test temperatures from -190 °C to +300 °C
   - Static fracture toughness and static tensile testing

4. RUMUL cycling machine :
   - It is used for fatigue pre-cracking of reconstituted and irradiated specimens.

5. Visual inspection, dimension measurement and fracture examination facility equipped by special computer image analysis systems.

4. ELECTRON BEAM WELDING TECHNIQUE

4.1. Applications

Electron beam welding technique is used for reconstitution of radioactive samples for mechanical properties testing. Reconstitution of Charpy-type specimens (impact, dynamic and static fracture toughness) from inserts of standard dimensions (10x10x14 mm) is carried out and new test specimens are expected after its disruption during mechanical test and subsequent welding of nonirradiated studs.

The second field of use electron beam welding is fabrication of supplementary surveillance containers for VVER 440 reactors. After preparation of inserts using electric discharge machine, containers with the inserts are welded by electron beam welding machine. Typical chain of irradiation capsules for the supplementary surveillance programme is shown in Figs. 3 and 4.

4.2. Reconstitution technique

For the reconstitution of irradiated specimens was developed a computer control high-vacuum electron beam welding machine.

This system consists of the high vacuum part with welding chamber, the electron beam device, the samples positioning part and special TV system for direct observing of the welding process. Because of a high radioactivity of the materials welded, the system is fully computer controled and equipped for remote handling. For the safety reasons a direct man-machine control is also possible.

The main parameter, the beam power of about 5 kW, is suitable for reconstitution of all types of specimens used in Nuclear Research Institute hot laboratories. Reconstitution method and welding machine are shown in Figs. 5 and 6.

The critical question in welding process is the temperature rise during welding process and its time dependence. This problem was carefully verified and the conclusion is that, in welding parametrs used, the temperature in the notch ev. crack position never reach the reactor pressure vessel operation temperature. The time of temperature peak in dependence on insert dimension is only a few seconds. Neutronography stress analysis of reconstituted samples showed no residual stresses in the inserted part of specimen.

4.3. Specimen preparation

As the welding studs is used the same type of material as is reconstituted. After welding, the reconstituted samples are machined by use of electric discharge machine, the desired notch is cut and the specimens are polished for precracking (in the case of fracture toughness testing). The side grooves can be also made.

5. CONCLUSIONS

At present, reconstitution of surveillance samples is realized in hot cells of Nuclear Research Institute.

Reconstitution technique was proved as a very effective and valuable method for re-evaluation of specimens from the standard surveillance programme. Use of this method is very important mainly for determination of different material parametrs from the same specimens (fully similar initial as well as irradiation conditions can be assured).

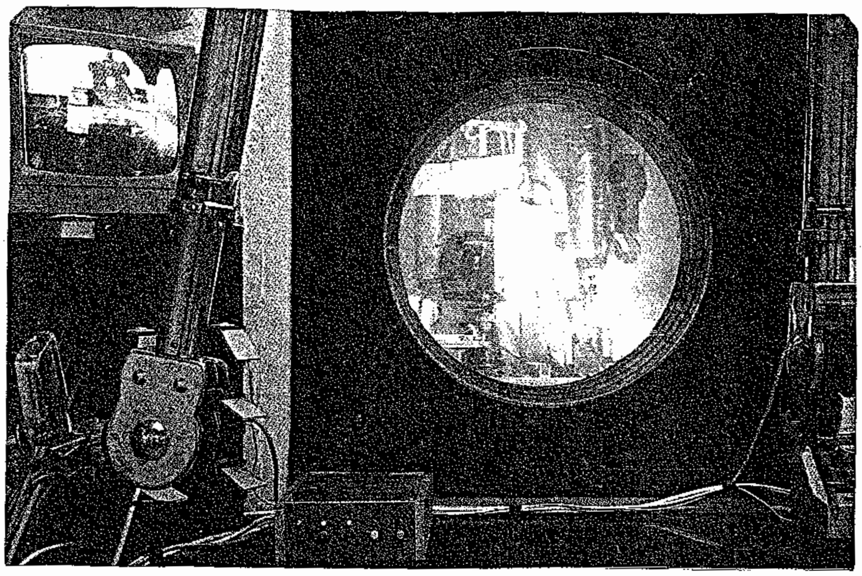

Fig. 1 Electroerosive discharge machine in hot cell

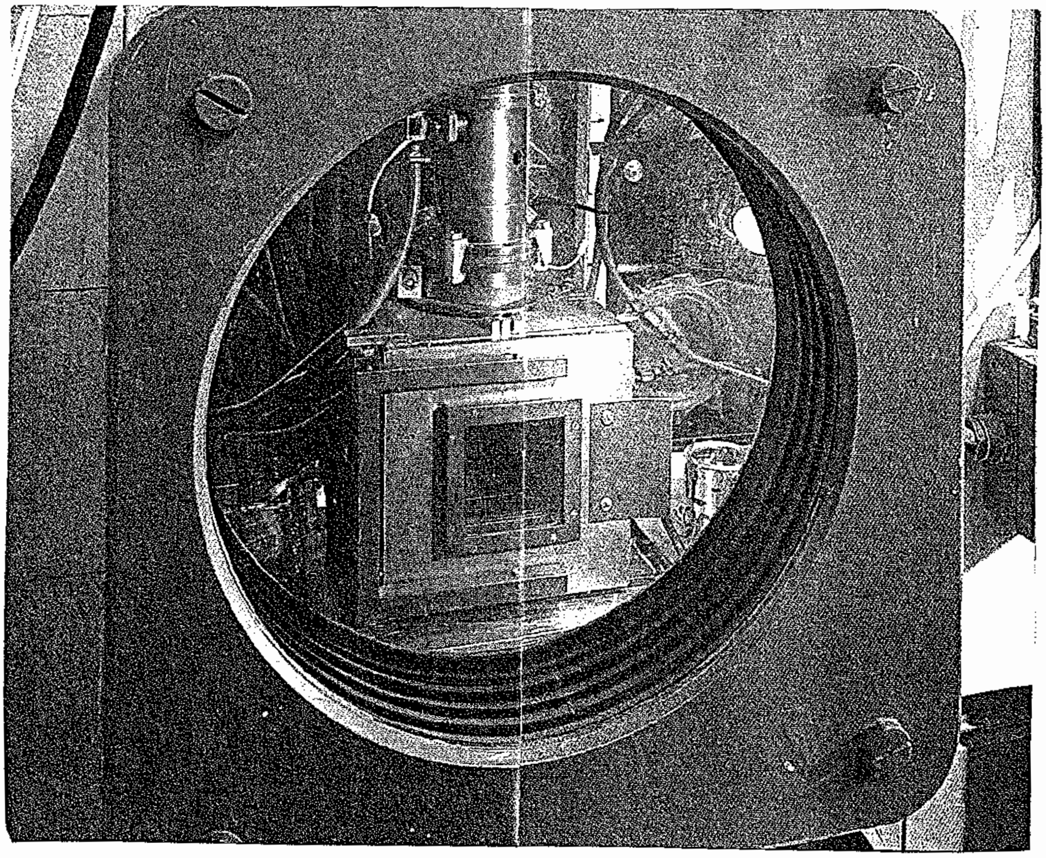

Fig. 2 Electron-beam welding used for reconstitution of specimens from irradiated materials

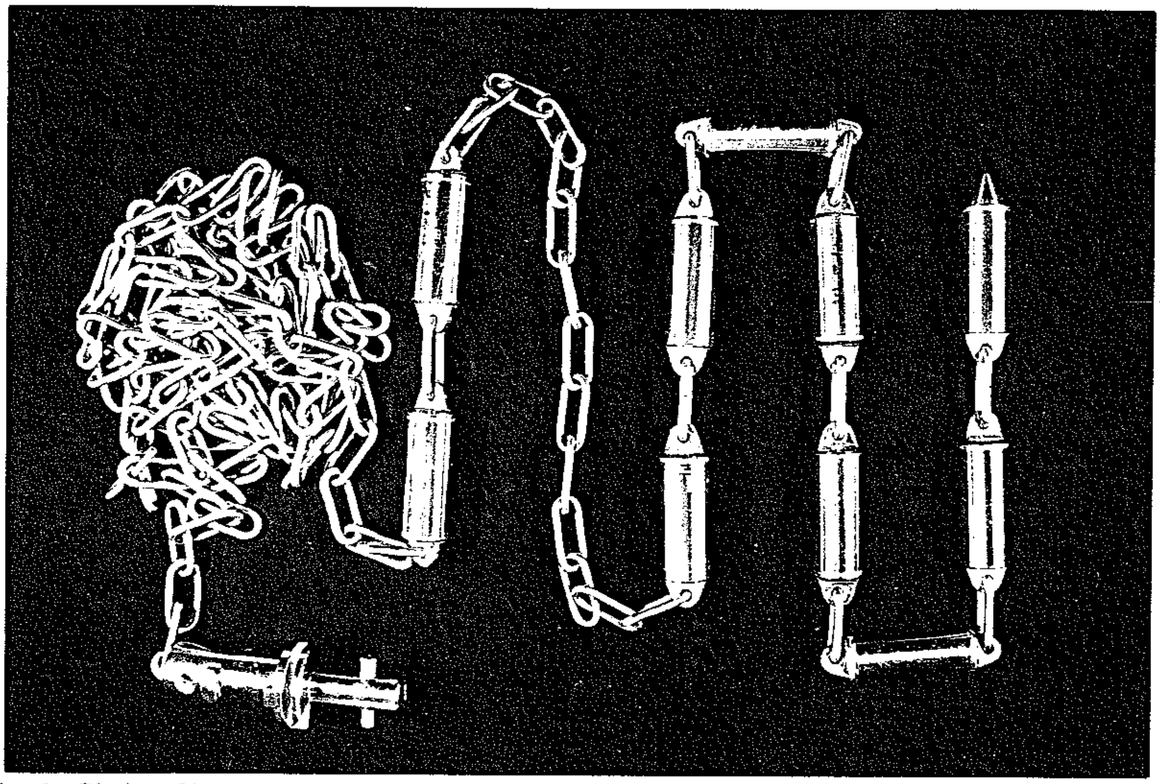

Fig. 3 Chain of irradiation capsules used in Supplementary surveillance programme

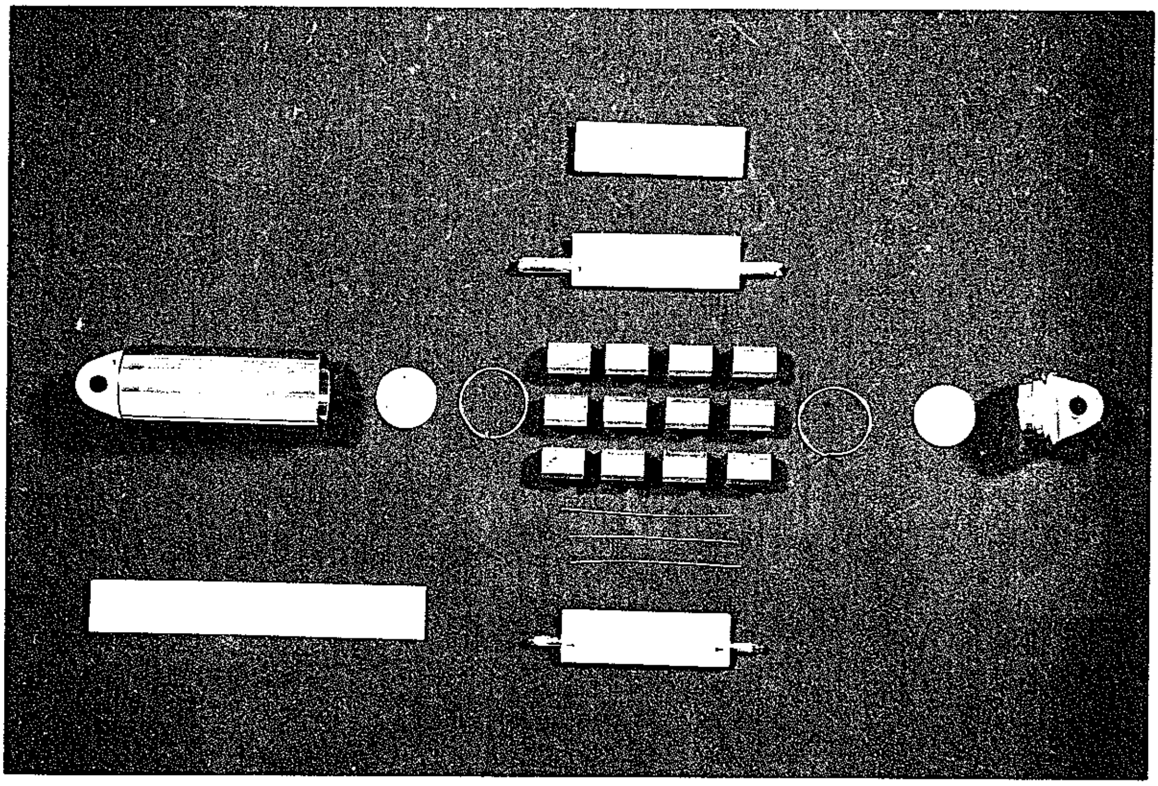

Fig. 4 Irradiation capsule internals used in Supplementary surveillance programme

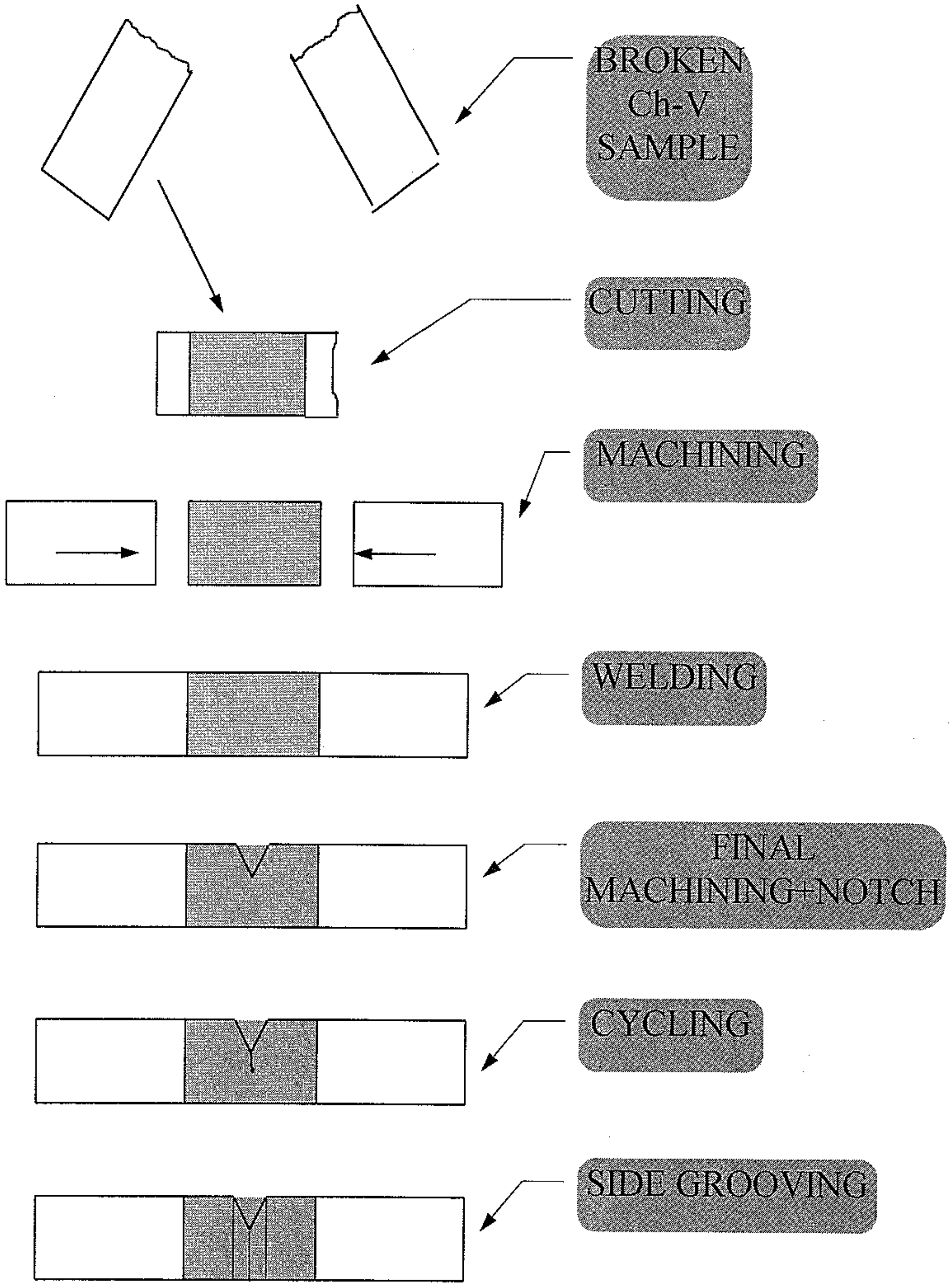

Fig. 5 Reconstitution of Charpy-V type surveillance specimen

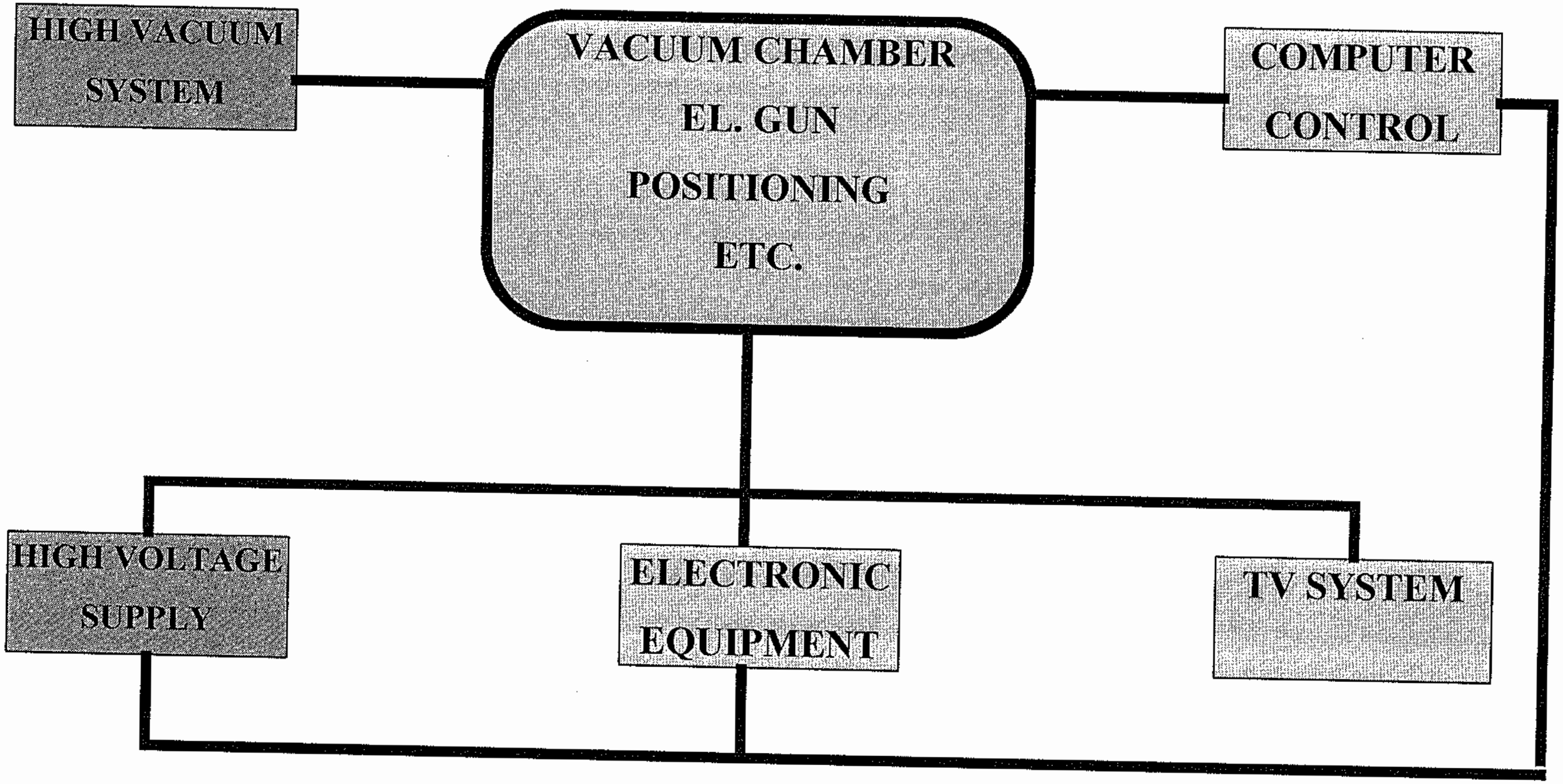

Fig. 6 Electron beam welding machine