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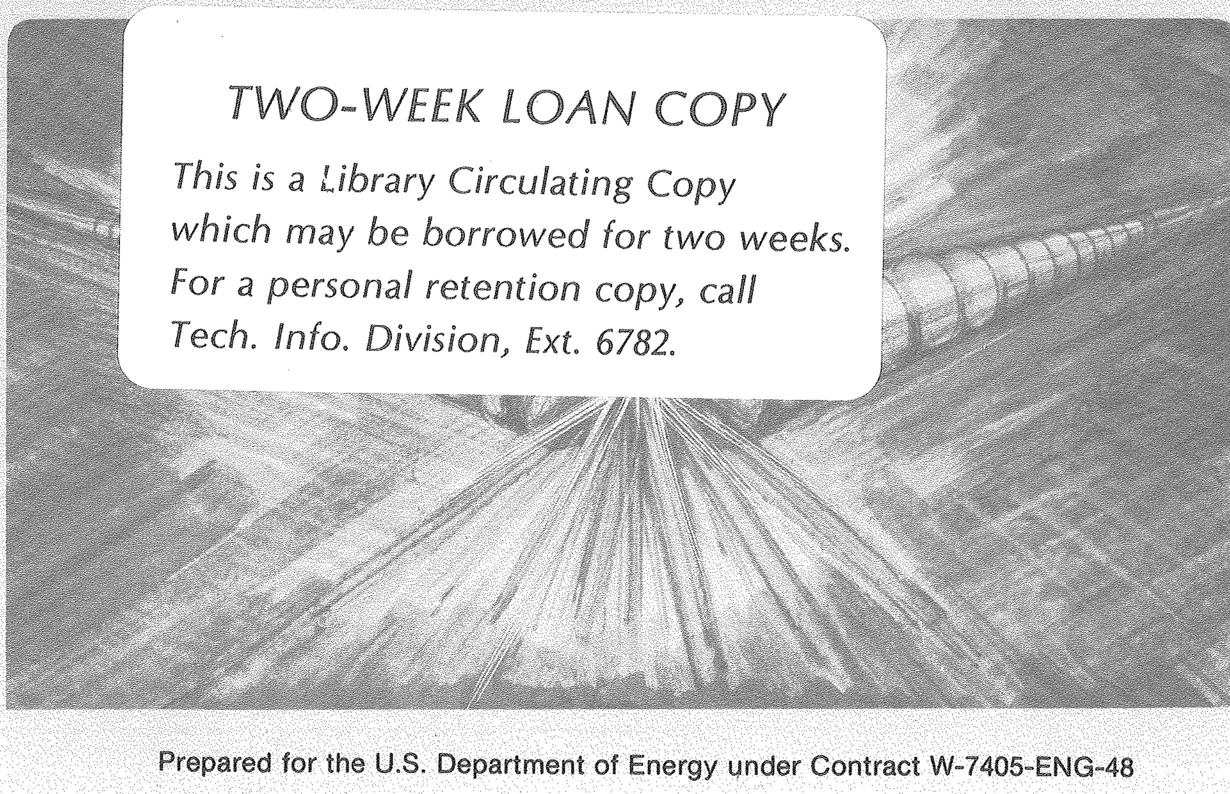

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ON FABRICATION AND BRAZING OF 15A, 120 keV CONTINUOUS DUTY ACCELERATOR GRID ASSEMBLIES*

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The development of high intensity neutral beam injectors at the Lawrence Berkeley Laboratory has progressed from relatively low duty cycle, low energy devices to the next generation of continuous duty high energy units. The earlier pulsed versions were designed with edge cooled grid structures described in a previous publication.[1] The prerequisites set by the higher duty cycle devices no longer allow the edge cooling methods to be employed. Hollow molybdenum grid rails with deionized cooling water flowing at pressures of approximately 1.73×10^6 Pa-(250 PSI) at from 1.135 to 1.89 liters per minute (.3 to .5 GPM) are brazed to Type 304L stainless steel rail holders. Fig. 1.

Brazing Fixtures

All brazements are made on fixtures constructed of molybdenum and Type 304 stainless steel. These fixtures are designed to insure positive maintenance of relative positions of grid rails and rail holders while allowing for expansion at elevated temperatures during the braze cycle (Fig. 2). A "stop off" mixture of boron nitride - 325 mesh (15 gm) to 34 ml of glycerin is used to prevent diffusion bonds that can take place between clean close mating parts and screw threads under conditions of

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high temperature in dry H_2. These fixtures serve to position rail holders during the bellows brazing operation as well as fixturing the hollow molybdenum rails which are brazed to the rail holders in a subsequent step.

Treatment of Materials

Prior to brazing, the 304L SS rail holders are electro-polished to insure burr-free clean surfaces. The molybdenum rails and bellows are checked for vacuum integrity. After hydrostatic pressurization to 3.45×10^6 Pa (500 PSI) rails and bellows are again checked for vacuum leaks to a maximum of 1×10^{-10} std. atm. cc/sec with a helium mass spectrometer.

Molybdenum rails are straightened and stress relieved by clamping in a grooved molybdenum fixture and heating in a vacuum furnace to 850°C for 1/2 hour then at 1000°C for 1 hour. The rails are then etched to insure bright, clean surfaces for brazing. The etching is done as follows: 10-15 sec in a solution of H_2O, 6 volume, HNO_3, 13 volume, and HF, 1 volume. Rinse in running tap water. Follow by 30 sec immersion in a solution of deionized H_2O 65 ml, CrO_3 20 gr H_2SO_4 (sp.gr. 1.84-Tech grade) 34 ml. (Add acid slowly while stirring). Sequential rinses of running tap water, 2 rinses in distilled water, and a final rinse in 190 proof ethyl alcohol are ultimately dryed with a jet of dry N_2 gas.

Braze Fillers and Cycles

In the edge cooled design a Pd (25%) Cu (21%) Ag (54%) filler metal[2] was selected for its ability to wet molybdenum and its wide brazing range. Brazing was done in a dry hydrogen atmosphere at

925°-930°C, the approximate midpoint of the braze filler metal melting range for a period of 3 to 5 minutes. This was done to prevent blushing of the filler metal into adjacent rail slots that were not to be brazed. Although the filler metal does not become fully liquid under these conditions it does provide for an adequate mechanical and thermally effective joint without blushing problems.

The hollow rails have an additional requirement of vacuum and water-tight integrity. When the edge cooled brazing technique was used the braze failed the vacuum integrity test. At this point, after consultation with the manufacturer of the braze filler metal, it was decided to take the braze temperature to 20°C above the liquidus point of 950°C. Subsequent brazes passed all the vacuum and pressure tests. However, blushing along the rail did occur and had to be removed by controlled acid etching which did not compromise the joint integrity. This is done by using the previously mentioned etching process for 5 to 10 seconds. This procedure was done just prior to final assembly of the grid modules to insure clean surfaces. Extreme cleanliness is required to hold the high voltage gradients present across the grid structure. A 120-kV accelerator requires four different grid assemblies. Each consists of two pairs of rail holder modules (Fig. 3).

Prior to brazing of the grid rails to the rail holders, stainless steel bellows are brazed to each finger of the rail holder (Fig. 4). This was done initially using a NI (18%) Au (82%)[2] eutectic filler metal in a dry hydrogen atmosphere at 970°C for 3 to 5 minutes. In order to obtain a wider spread between the melting point of the stainless steel brazement and the subsequent molybdenum brazement, a change was made to a

Pd (10) Ag(90) brazing filler metal which is brazed at 1075°C for the same time period. This alloy produes an excellent brazement and has economic benefits as well.

Conclusions

This procedure has resulted in the joining of two materials, molybdenum and 304SS, with substantially different thermal coefficients of expansion into a unique high toleranced structure. This design will serve as a test for an accelerator structure 4 times larger capable of 65 amperes at 120 keV currently under construction.

Acknowledgments

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References

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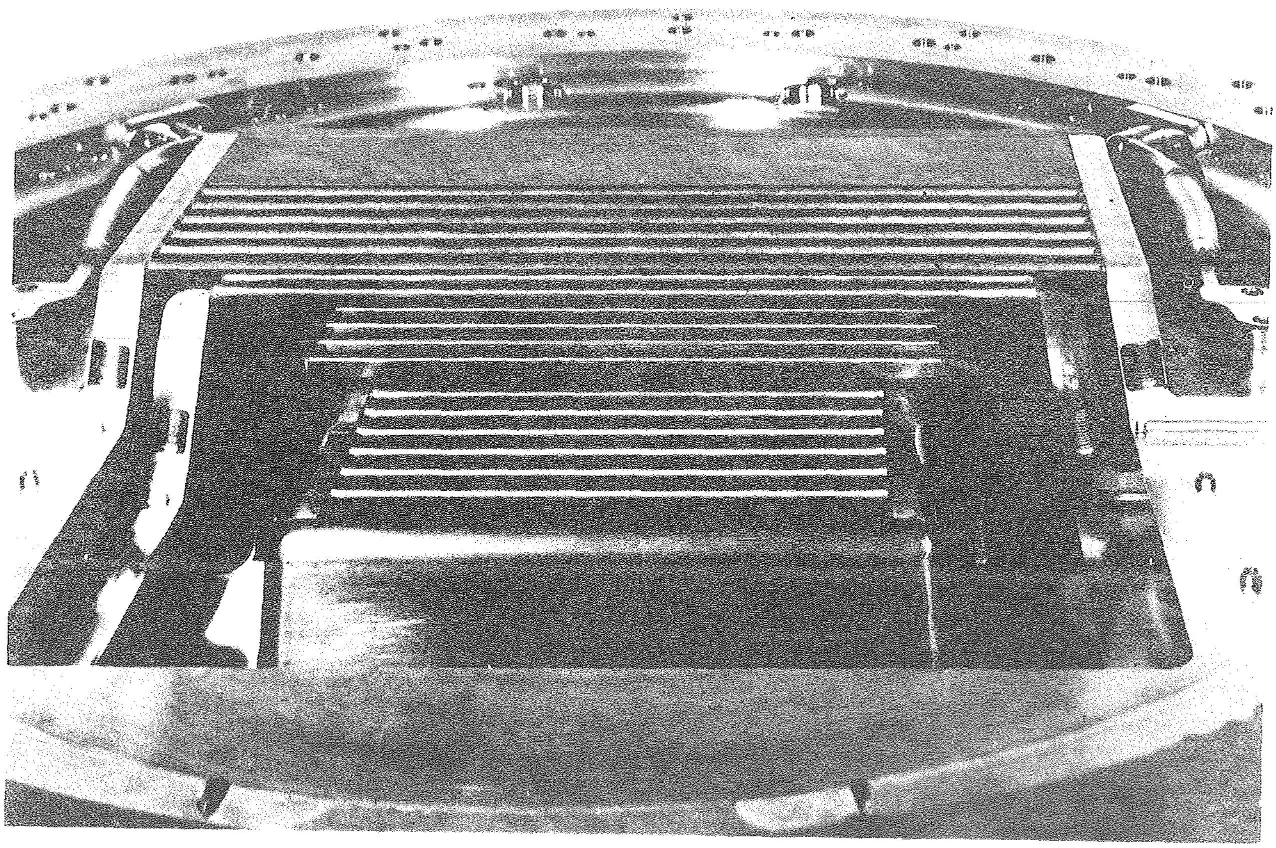

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Fig. 1 - Grid modules shown as installed in accelerator assembly

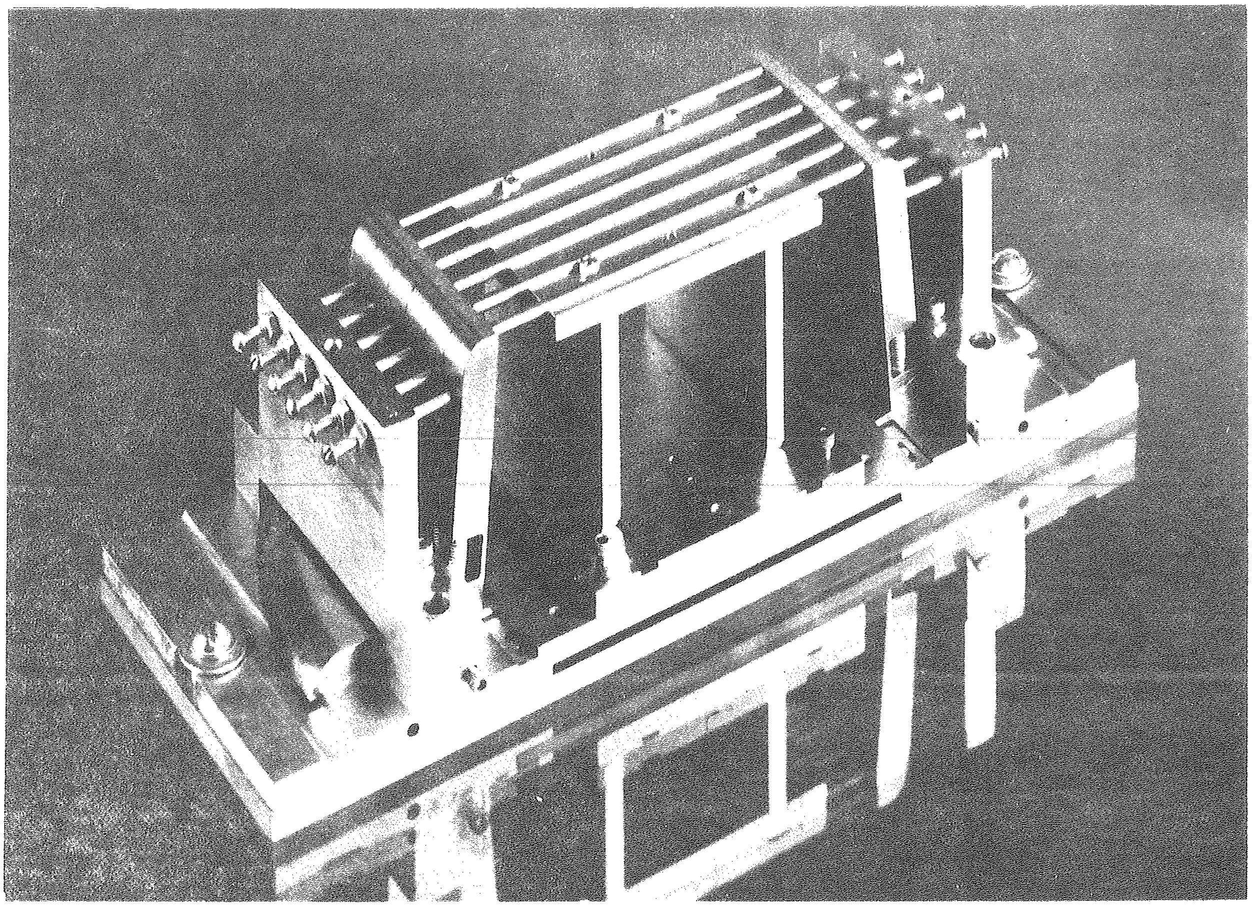

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Fig. 2 - Grid module on brazing fixture

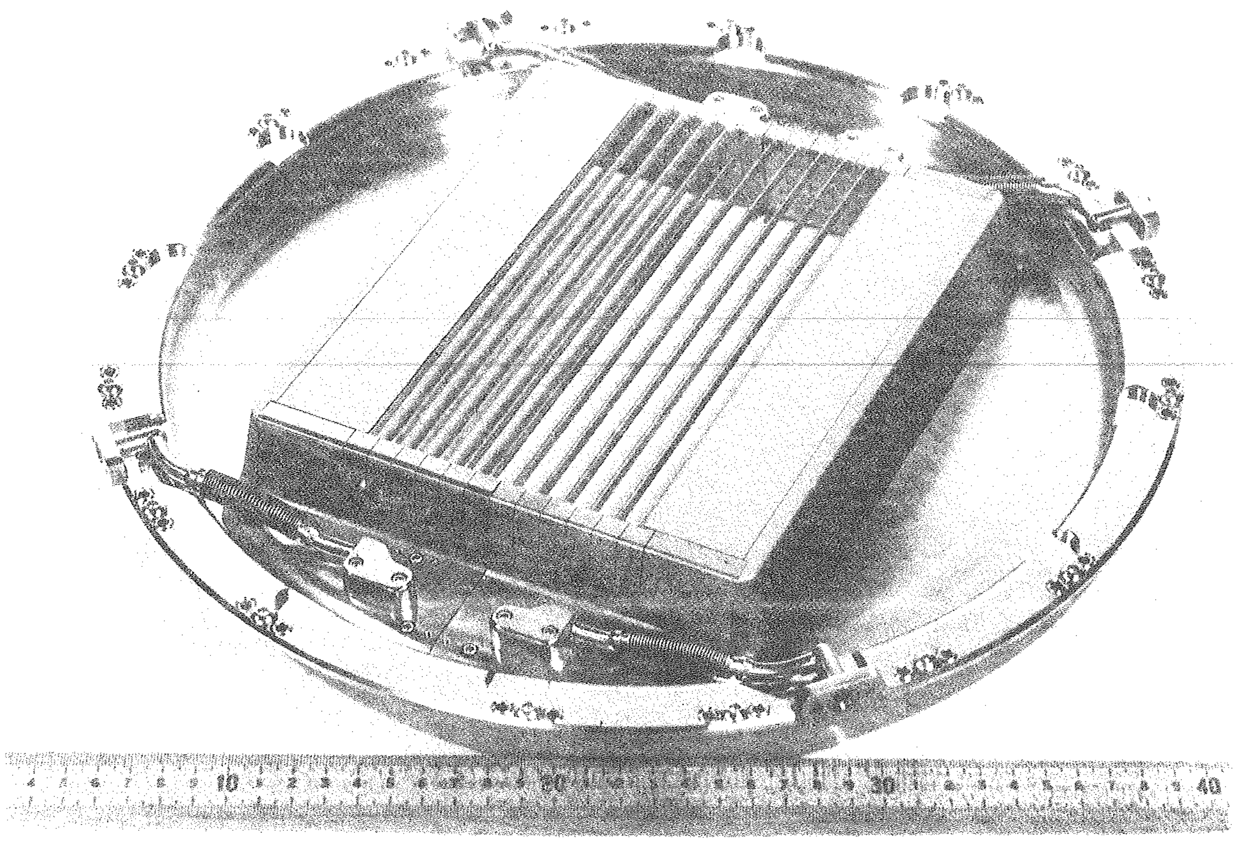

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Fig. 3 - Source grid module assembly

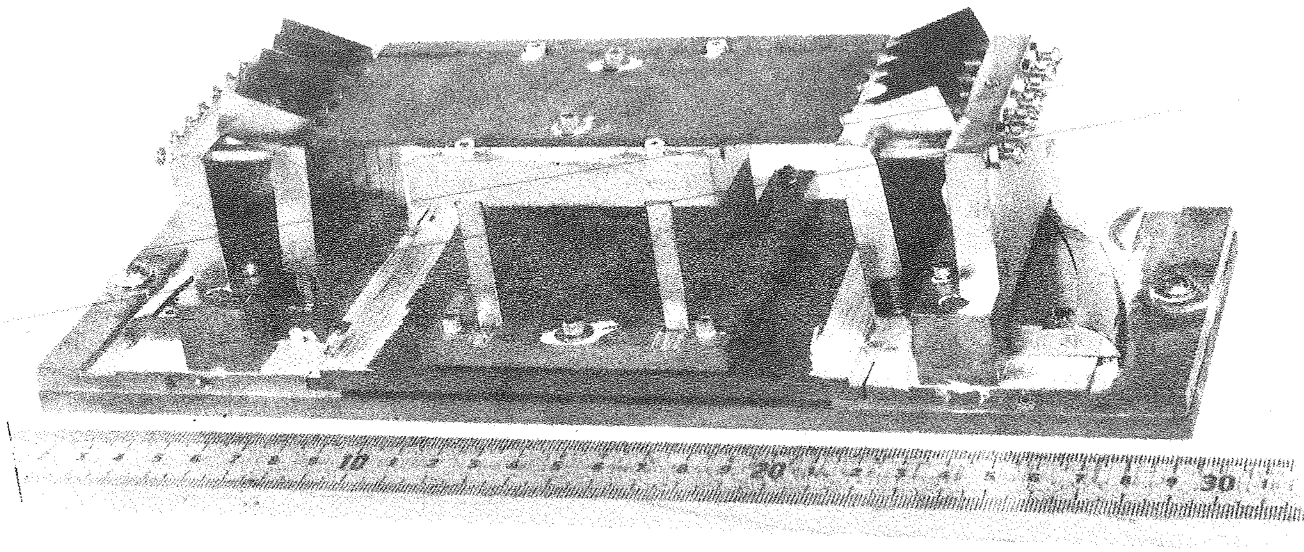

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Fig. 4 - Bellows to be brazed to rail holders on fixture