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D.C. beam separator electrode sheets stud fastening by electron beam welding

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Collider Accelerator Department

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EP & S DIVISION TECHNICAL NOTE

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D.C. BEAM SEPARATOR ELECTRODE SHEETS
STUD FASTENING BY ELECTRON BEAM WELDING

Introduction

The present method of attaching threaded mounting studs to the 1/8 inch thick #304 stainless steel electrode sheets of all electrostatic D.C. beam separators (short, rectangular and cylindrical) is to countersink number 10-32 non-slotted stainless steel flat head screws into the sheets, hold them with nut and lockwasher, and then grind and hand polish both sheet and screw heads flush. The disadvantages of this method include:

1. Surface material removal induces internal stresses which aggravate sheet distortion under operating conditions.
2. Polishing debris forced between sheet and fasteners allows discontinuity deleterious to gap voltage and vacuum.
3. Stud replacement, because of damage or a need for different length, is impractical, especially after the sheets are radiation "hot".
4. Protruding studs make sheet storage and handling awkward.
5. The sheets are excessively costly due, in part, to the handwork involved.

Many design changes were attempted in the past to improve the basic design. Limited techniques doomed each to failure. The electrode sheets had to be reasonably light, extremely flat (or adjustably flat as at present), and the top surfaces had to be highly polished to minimize electric discharge between opposing sheets. These sheets had to function in a hard vacuum, over a 15° to 100° centigrade temperature range, and be capable of enduring radiation. Adhesives would not stand up or were incompatible with vacuum, commercial welding techniques of the time caused severe local deformation and sheet distortion, blind screw holes required thicker materials.

Electron Beam Welding

Electron beam welding came to our attention last October. "Electron Standard" of South Windsor, Conn., felt they could electron beam weld flat head screws directly in place, meet the tensile requirements, and fulfill the surface and flatness specifications. They wrote of willingness to assist in a development program. We wanted to prove feasibility first.

Brookhaven National Laboratory owns an electron beam welder, housed in Building 197, and used for AGS Conversion. Permission was received from Pierre Grand to run test samples through the welder at slack periods. The concept of welding a screw directly to the plate was discarded because of disadvantages 3. & 4. first mentioned. It was also obvious that the necessary holding and locating fixture for plain screws could be complex. A simple stud base, or boss, with matching jig assembly (see attached sketch) was designed and parts fabricated. Weld technician, M. H. Schuster, handled the actual welding. His report, plus inspection and tensile test notes are herewith summarized.

Test Data

Equipment: Hamilton Standard Electron Beam Welder

140 kV accelerating voltage

Jig and heat sink: aluminum jig plate

Cleaning material: methyl ethyl ketone

Test sheet: #304 stainless steel, 6" x 6" x 1/8" thick

Stud base: #304 stainless steel, 1/16 or 1/32 weld flange

Definitions: Plate distortion - overall plate twist due to welding

Plateau distortion - height of plate deformation directly opposite welded stud base (mesa or plateau affect)

Plate No.	Weld Flange Thickness (inch)	Number of Welds on 9/16" Circle	ma	Dwell Time (seconds)	Focus	Plate Distortion (inch/6" sq.)	Plateau Distortion (inch)	Tensile Strength (pounds)
5	.062	4	6	.7	Sharp R-40	.003	.006	1910
6	.062	4	5	.7	Sharp R-40	.001	.005	1380
4	.062	4	4	.6	Sharp R-40	.001	.004	810
3*	.031	8	1	.4	Insuff. Penetrat.	None	.005	450
1*	.031	8	1.5	.5	Sharp R-40	None	.004	10

*Inconsistancy of current and time vs. distortion and strength may be due to manual control of dwell time and/or "one sample" variation.

Data Interpretation

The limited number of samples tested, plus the manual dwell time control used, allows only generalization.

1. Tensile strength decreases with heat volume input decrease. It can range from full stud strength (1900 lbs) to none at all.
2. Plate distortion decreases with heat volume input decrease. It can possibly be eliminated entirely, or reduced to usable limits with further optimization.
3. Plateau distortion decreases with heat volume input decrease, but at a rate which makes complete elimination doubtful within the range of usable strength.
4. Reducing weld flange thickness can reduce plate distortion, but the plateau distortion shows no improvement. Penetration becomes poor and molten metal "blown" from the weld causes weakened crater type welds.

Conclusions

It was initially hoped that electron beam welding could be used in the fabrication of sheet electrodes which would require no final polishing, would have no basic plate distortion, would have removable studs capable of a minimum 1000 pound tensile load, and would have a plateau distortion per stud of less than .001 inch. From the data collected, it appears that the plateau distortion is the only item improbable of attainment, and this item can be relaxed to approximately .004 inches maximum per Robert Loper, head of the Beam Separator Group at the AGS.

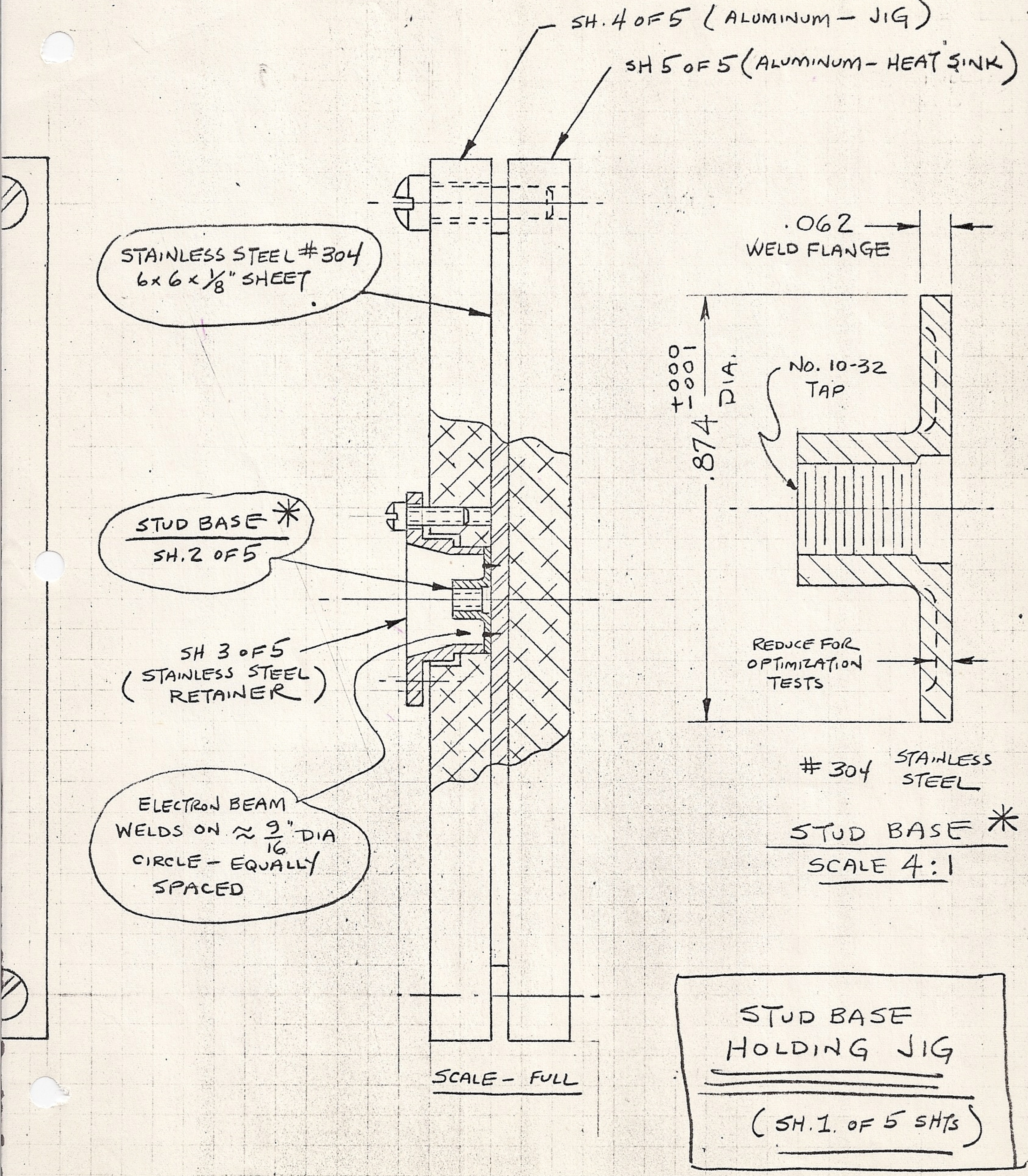
Beam welding should therefore, prove satisfactory for this application.

Further Development and Fabrication

The BNL welder is large enough to be used for fabrication of electrode sheets D13-M-2030-4 and 2031-4 which will shortly be required for the new short separator now on order per AGS account number 59139. It would, however, require approximately one week of set-up time before it could be so used. Further development, using larger sheets and multiple studs would also require such a set-up modification. The present BNL welder schedule is too heavy to allow inclusion of such modifications, development, and actual fabrication of the necessary sheets (needed approximately June, 1969). Outside fabricators will be approached for final stud base design, welding technique and jig development. It may prove economically sound to fabricate the jig, plates and stud bases here, and have only the welding done off site.

cc: Beam Separator Group
Department Administration
Design Engineers
A. Schlafke, W. Walker

Attachment: Sketch - "Stud Base Holding Jig"


SH. 4 OF 5 (ALUMINUM – JIG)
SH 5 OF 5 (ALUMINUM – HEAT SINK)
STAINLESS STEEL #304 6 x 6 x 1/8" SHEET
STUD BASE * SH. 2 OF 5
SH 3 OF 5 (STAINLESS STEEL RETAINER)
ELECTRON BEAM WELDS ON ≈ 9/16" DIA CIRCLE – EQUALLY SPACED
SCALE – FULL
.062 WELD FLANGE
.874 +.000 −.001 DIA.
NO. 10-32 TAP
REDUCE FOR OPTIMIZATION TESTS
#304 STAINLESS STEEL
STUD BASE *
SCALE 4:1
STUD BASE HOLDING JIG
(SH. 1. OF 5 SHTS)

J.C.W. 12/11/68