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Dragon Project Report

PRELIMINARY REPORT

ELECTRON BEAM WELDING EXPERIMENTS FOR BURSTING DISC ASSEMBLIES PART II

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by

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December, 1963

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ELECTRON BEAM WELDING EXPERIMENTS FOR BURSTING DISC ASSEMBLIES

PART II

by

R. HANSEN

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ELECTRON BEAM WELDING EXPERIMENTS FOR BURSTING DISC ASSEMBLIES

PART II

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1. INTRODUCTION

As reported in D.P. Report 198 [1], "Electron Beam Welding Experiments for Bursting Disc Assemblies," special bursting disc assemblies are required for the Dragon Helium Purification Plant. From paragraph 9, "Discussion of Results" in the mentioned report, it can be understood that the Silver-Monel 400 weld was not as good as was hoped. The silver discs, with thicknesses of .002 in, were originally intended to be used as Disc No. 2; see Fig. 1, i.e., on the secondary side of the assembly. It was, therefore, suggested that these silver discs could be replaced by thinner (.0005 in) Nickel discs, because it was thought that Nickel-Monel 400 would make better welds, even with the mentioned reduction in thickness.

The High Temperature Techniques Group of the Dragon Project was asked to find out whether it would be possible to weld these extremely thin discs onto the Monel 400 holders in an acceptable way. This meant, for example, that the leak rate had to be $<10^{-5}$ atmospheric cc/s, ($<10^{-8}$ for Disc No. 1, Fig. 1). This report gives a survey of the experiments done and the results obtained on this particular weld. Also, a leak testing method is described which was not mentioned in the previous report, D.P. Report 198, and it would, therefore, be an advantage for the reader to have read this report first.

2. DESIGN

As described in the previous report, several designs were tried and from the experience gained the design shown in Figs. 2 and 3 was accepted as a suitable one. It was, therefore, decided that the object should be to find out whether we could weld the .0005 in discs to this type of holder, making leak tight welds.

3. RESULTS

The welding set-up was as described in D.P. Report 198, i.e., a chuck holding the specimen revolving at a pre-set speed, and the electron beam hitting horizontally. A picture of the set-up is shown in Fig. 4. Twelve test assemblies were made. The welding data obtained from the welding of these assemblies are laid out in Table 1, i.e., kV, mA, rpm, number of revs and welding speed. The leak rate in atmospheric cc/s is given in the last column.

4. DISCUSSIONS OF RESULTS

Our object was to find out if .0005 in Nickel discs could be welded to the Monel 400 holders. The answer is yes, cf., Table 1, and the micrograph shown in Fig. 5. Leak tightness $<10^{-10}$ atmospheric cc/s has been achieved. One would think then, that it should be possible to reproduce these welds provided the

TABLE 1

WELDING CONDITIONS

	Assembly Material	Disc Material	Voltage kV	Amperage mA	rpm	Number of revs	Welding Speed cm/min	Leak Rate Atmospheric cc/s	Remarks
Test Assembly No. 1	Monel 400	.0005 in Nickel	17	7	4	2	48	$<10^{-10}$	Disc same diameter as holder.
Test Assembly No. 2	Monel 400	.0005 in Nickel	17	4	4	2	48	10^{-4}	Disc not evenly cut. Disc same diameter as holder.
Test Assembly No. 3	Monel 400	.0005 in Nickel	14.5	8	8	4	96	1.45×10^{-7}	Disc same diameter as holder.
Test Assembly No. 4	Monel 400	.0005 in Nickel	14.5	5	8	3	96	$\sim10^{-4}$	Disc same diameter as holder. Top and bottom pieces were not plane, and they were not centred correctly, as could be seen after the weld.
Test Assembly No. 5	Monel 400	.0005 in Nickel	15	7	9	4	108	$>10^{-3}$	Pin-hole in the disc.
Test Assembly No. 6	Monel 400	.0005 in Nickel	16.5	9	6	4	72	$\sim10^{-5}$	Top and bottom pieces were not flat and parallel near the edges. Diameter of disc 1 mm larger than diameter of holder.
Test Assembly No. 7	Monel 400	.0005 in Nickel	16	10	6	4	72	$>10^{-3}$	Top and bottom pieces were not flat and parallel near the edges. Diameter of disc 1 mm larger than diameter of holder.
Test Assembly No. 8	Monel 400	.0005 in Nickel	16	7	6	3	72	$\sim10^{-4}$	Top and bottom pieces were not flat and parallel near the edges. Diameter of disc 1 mm larger than diameter of holder.
Test Assembly No. 9	Monel 400	.0005 in Nickel	16	7	6	4	72	$>10^{-3}$	Top and bottom pieces were not flat and parallel near the edges. Diameter of disc 1 mm larger than diameter of holder.
Test Assembly No. 10	Monel 400	.0005 in Nickel	16	11	6	3	72	$>10^{-3}$	Hole in the disc. Top and bottom pieces were not flat and parallel near the edges. Diameter of disc 1 mm larger than diameter of holder.
Test Assembly No. 11	Monel 400	.0005 in Nickel	16.5	8	4	3	48	$<10^{-10}$	Diameter of disc 1 mm larger than diameter of holder.
Test Assembly No. 12	Monel 400	.0005 in Nickel	17	9	4	2	48	$>10^{-3}$	Top and bottom pieces were not flat and parallel near the edges edges.

After these welds were done, three spare discs were chosen at random and leak tested. One of these discs had a leak $>10^{-3}$ atmospheric cc/s. The holes in the discs, mentioned in the remarks above, were detected after they were welded to the assembly.

welding conditions are right.

First of all the preparatory work is very important. For example, the two surfaces of the holder have to be smooth and parallel, see Fig. 6.

The knife edges of the holder should be undamaged.

The discs should be cut from completely smooth foil, and the disc edges should be evenly cut without any form of recesses. It would be an advantage if the discs or the foil could be leak tested before the welding. A specially designed tool for cutting the discs is shown in Fig. 7.

Not all the test assemblies were up to the standard required as can be seen from Table 1, and that may, of course, be the reason for some of the bad results.

However, there are also other factors which may influence the results. It is, for example, important that the three parts to be welded together are correctly centred, see drawing shown in Fig. 8. The centring can easily be done by a set-up as shown in Fig. 9. With this set-up the correct weight can also be applied, i.e., the weight necessary to press the pieces together before and during the weld. Chattering of the chuck is also a factor which would cause disturbance in the weld. Therefore, it is necessary that the chuck assembly is of a good quality. For example, it should be heavy to make a chattering free run.

Lastly, it is also important that the intensity of the electron beam does not fluctuate, and that the focusing can be properly adjusted.

With the electrical setting at 16-17 kV and 7-8 mA, and a welding speed 40-50 cm/min a sound weld should be made provided the above mentioned requirements are met.

Fig. 10 shows an example where the two surfaces of the holder were not parallel. As a consequence, part of the disc was burned away before the other two edges were melted.

5. LEAK TESTING - HELIUM PRESSURE METHOD

Three methods of leak testing were presented in the previous report. A fourth method proposed [2] is the Helium Pressure Method. This can best be explained as follows, see Fig. 11. Consider the bursting disc assembly ready welded without any test hole in the side of it, i.e., the inside is at zero pressure. Place the assembly in a container which can be evacuated or filled with helium up to 20 atm accordingly. A mass spectrograph helium leak tester, a pressure meter and a vacuum meter are connected to the container.

The procedure after the assembly is placed in the container is as follows:-

- Evacuate
- Fill with helium up to 10 atm
- Let it stay at this pressure for 24 h

- Release the helium

- Evacuate and connect the mass spectrograph.

Helium which may have leaked into the assembly during the pressurising period will now leak out again and cause a deflection on the mass spectrograph. It has been [2] calculated that a leak rate of 5×10^{-7} atmospheric cc/s can be detected with this method of leak detection.

The method has one weakness, though. The leak may be so big that when the capsule is evacuated after being pressurised, the helium will disappear before the mass spectrograph is brought into action properly and no leak will be detected, although the chance that an eventual leak will be so large is rather small.

6. CONCLUSIONS

As is apparent from this report the weld can be done. Whether production can be considered will depend on good preparatory work of the piece parts and a good tool and how many rejects would be tolerated.

Electron beam soldering is another possibility as mentioned in D.P. Report 198. Welding or soldering by conventional means has not been the object of our work and has, therefore, not been discussed.

7. ACKNOWLEDGMENTS

To Messrs. T. A. J. Jaques, G. Coast, A. Thomson and P. Keegan for their co-operation and interest.

8. REFERENCES

[1] R. H. Hansen, "Electron Beam Welding Experiments for Bursting Disc Assemblies," D.P. Report 198.

[2] G. Coast and B. Aarset, Private Communication, Dragon Project.

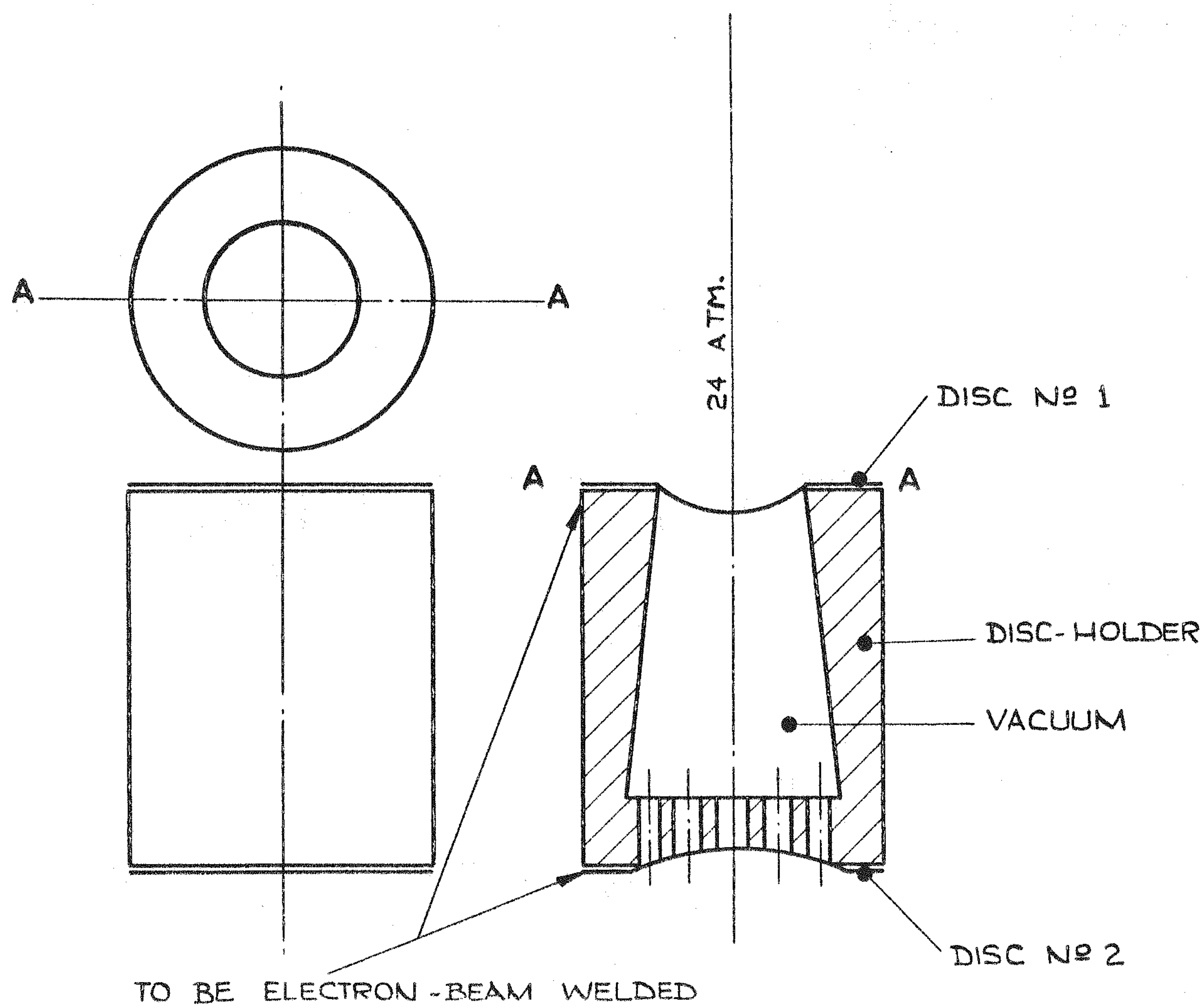

FIG. I THE BURSTING DISC ASSEMBLY

THE DISCS ARE ELECTRON BEAM WELDED TO THE HOLDER.

IF № I DISC BURSTS, DISC № 2 WILL FOLLOW AUTOMATICALLY.

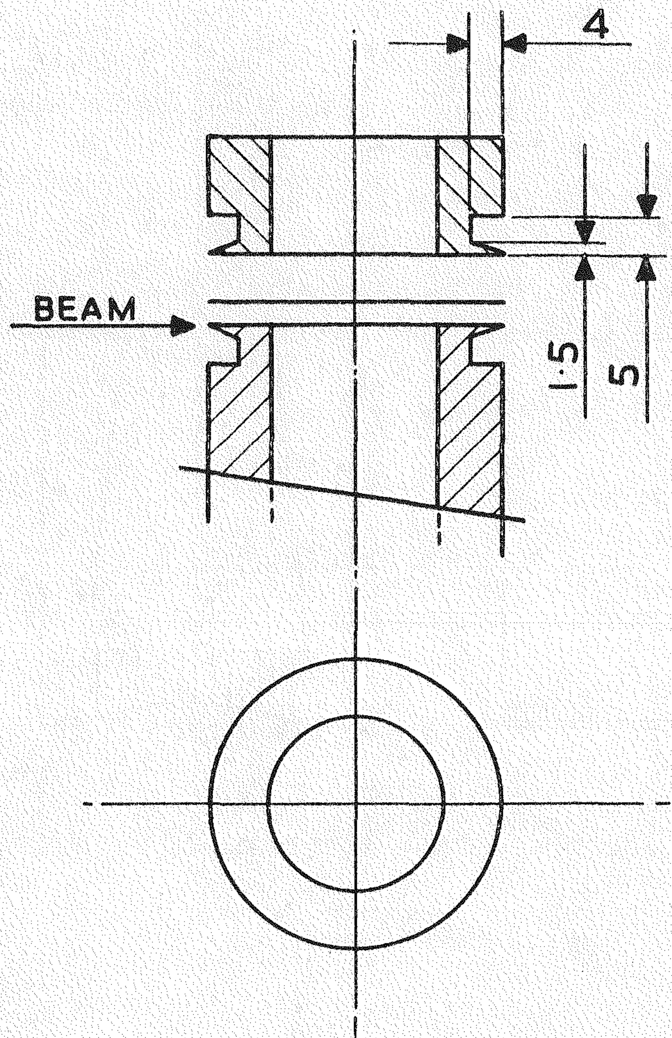

FIG.2 EDGE WELD WITH HORIZONTAL BEAM.

The most important measurements are given (in millimetres)

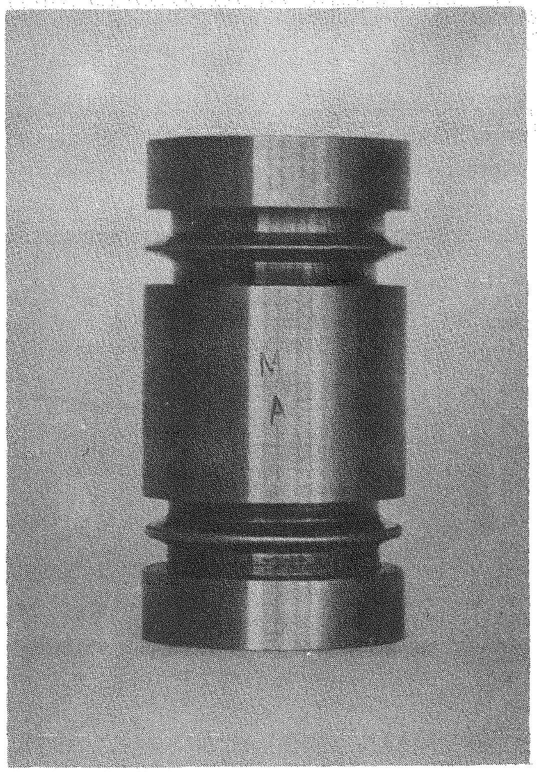

FIG. 3. BURSTING DISC ASSEMBLY

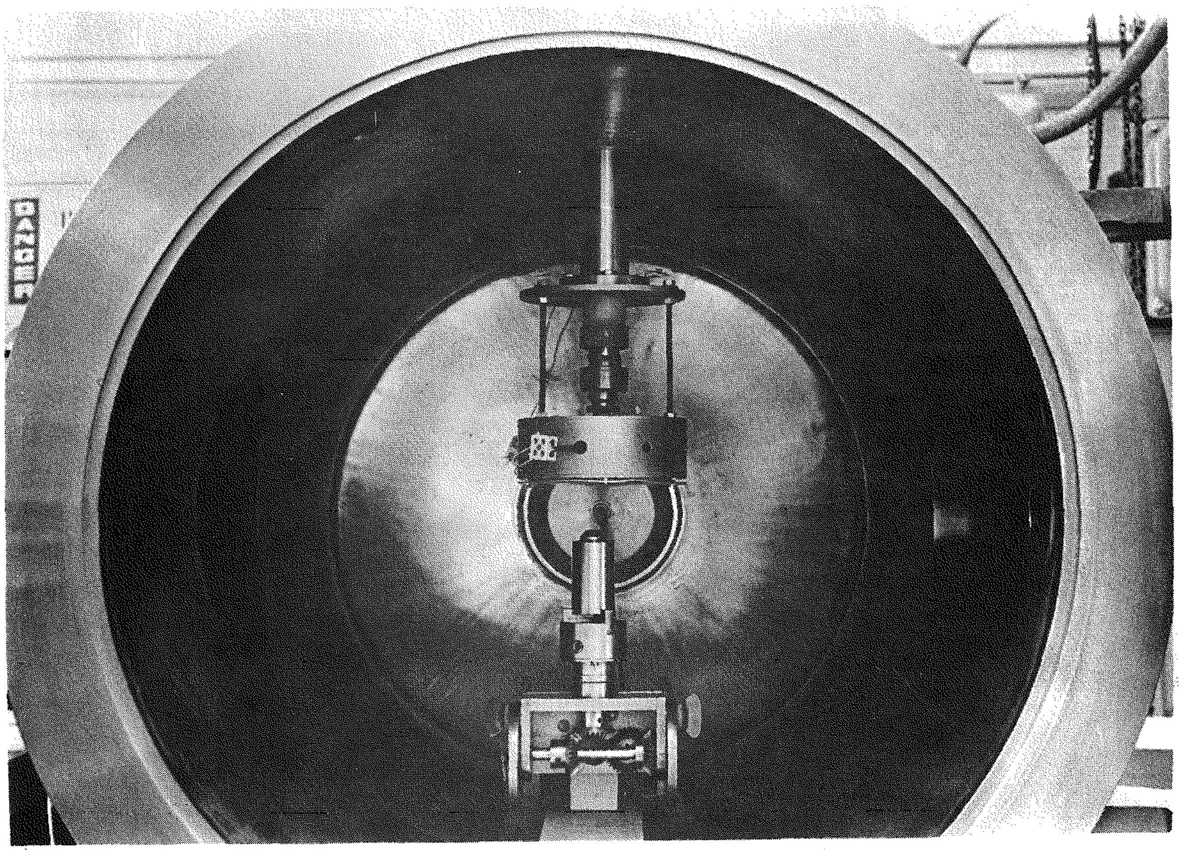

FIG. 4. THE ELECTRON GUN AND CHUCK ASSEMBLY

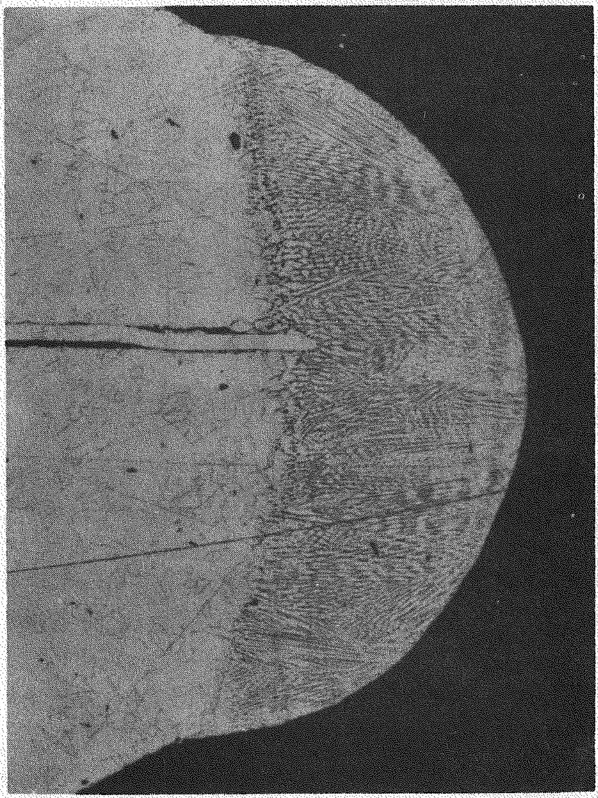

FIG. 5. WELD SECTION OF BURSTING DISC ASSEMBLY X125

Materials:

Holder: Monel 400
Disc: Nickel, .0005 in thick.

Welding Specifications:

17 kV
7 mA
2 revolutions at 48 cm/min.

Leak Rate: $<10^{-10}$ atmospheric cc/s.

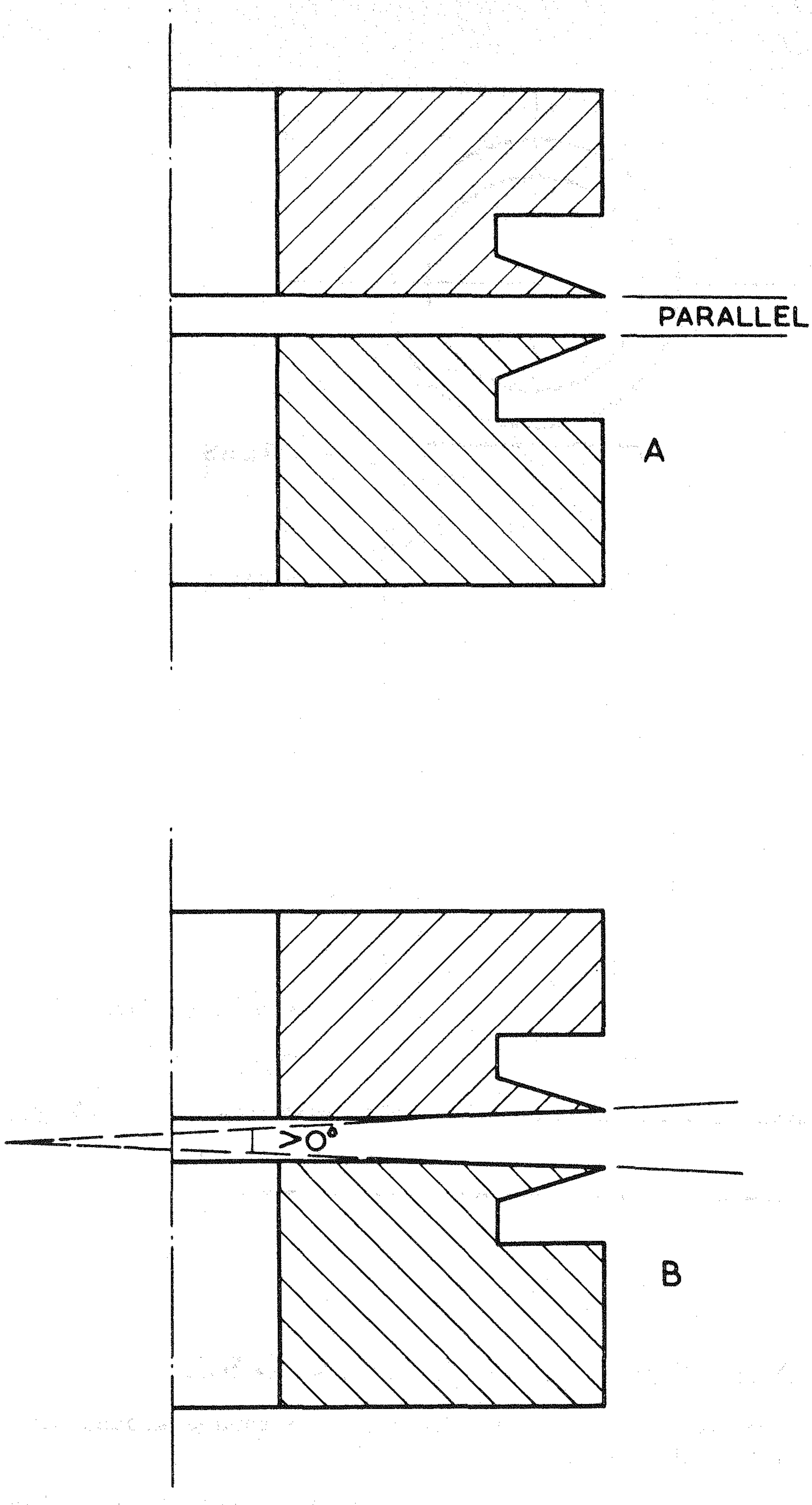

FIG.6 EXPLANATORY DRAWINGS.

The surfaces have to be parallel, like in A, particularly near the knife-edges, and not like B.

The knife-edge should be undamaged.

If one attempts a .0005 in disc weld as in B, failure is likely.

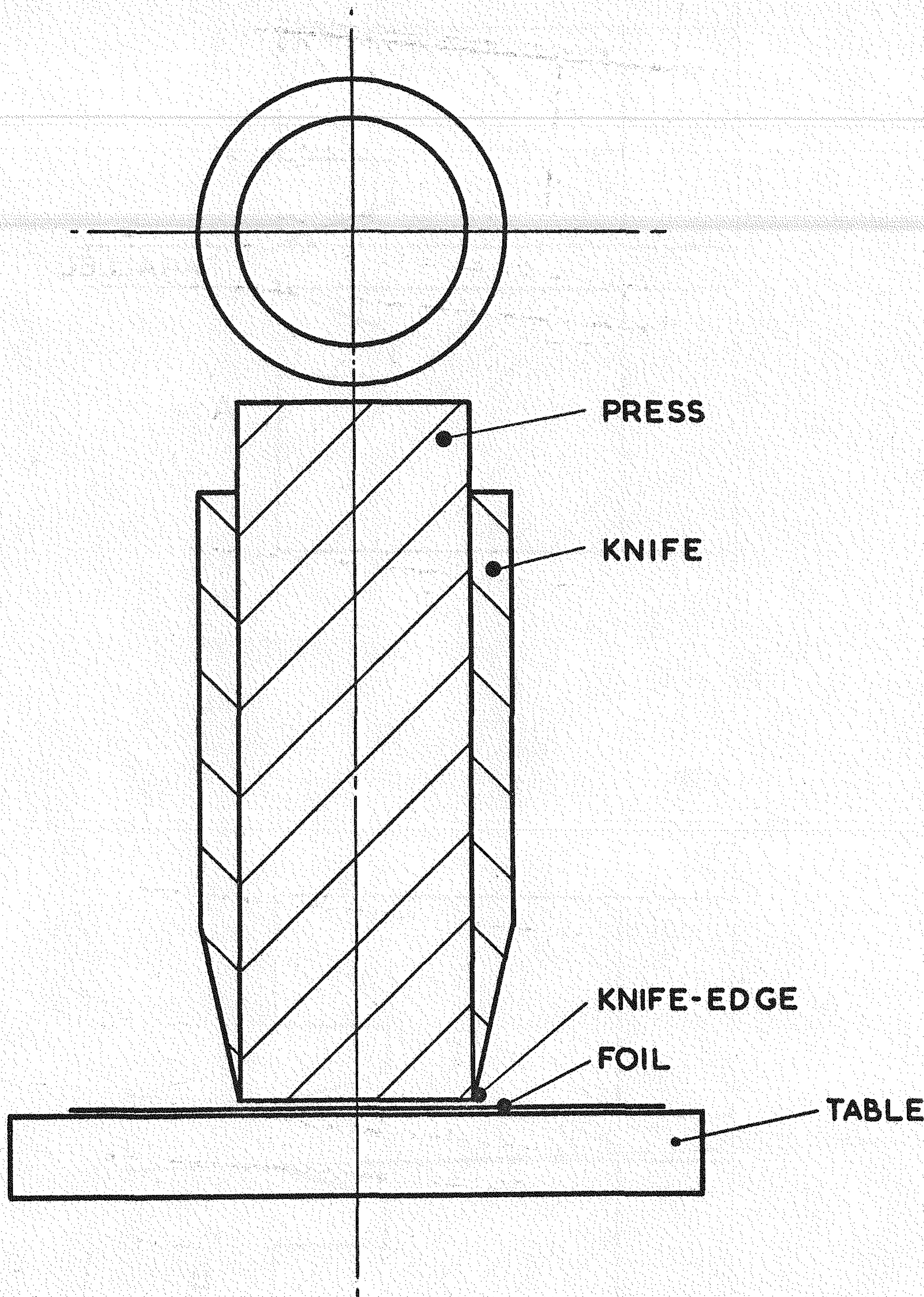

FIG. 7 TOOL FOR CUTTING THIN DISCS.

The press is pressed on the foil, the knife is turned around with the necessary pressure to cut the disc.

The two parts of the tool should be made by hardened steel. There should be a very good "slide-fit" between them, particularly between the knife-edge and the press, for example, B. S. H6-g 5.

To secure a certain pressure on the knife when cutting, it could be screwed on the press, using a fine machine thread.

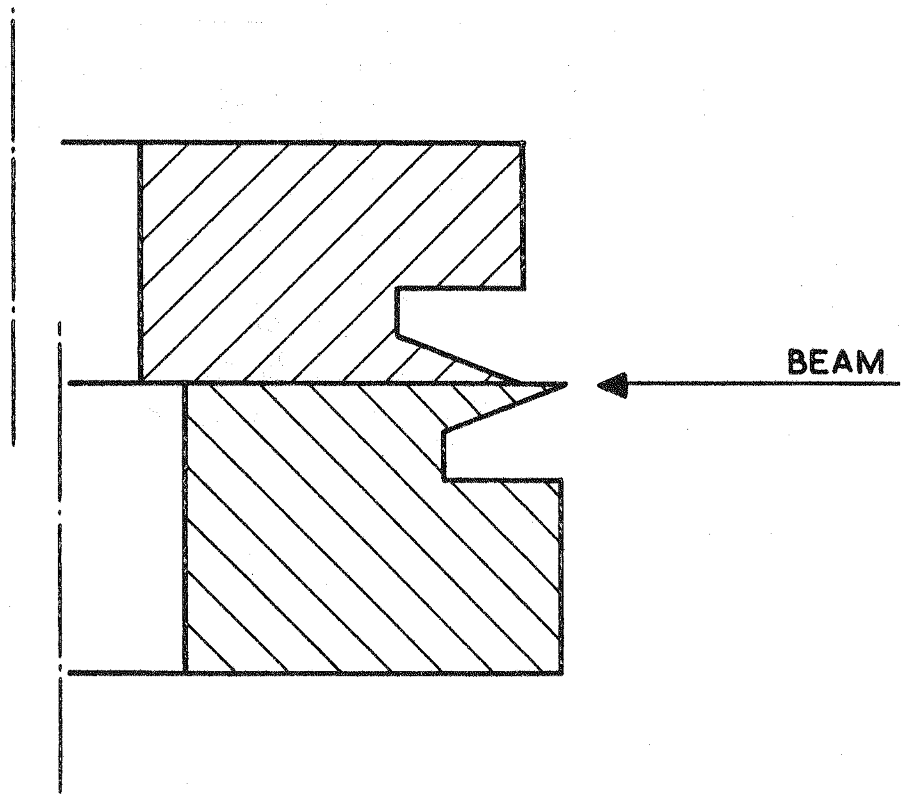

FIG. 8 INCORRECT CENTRING.

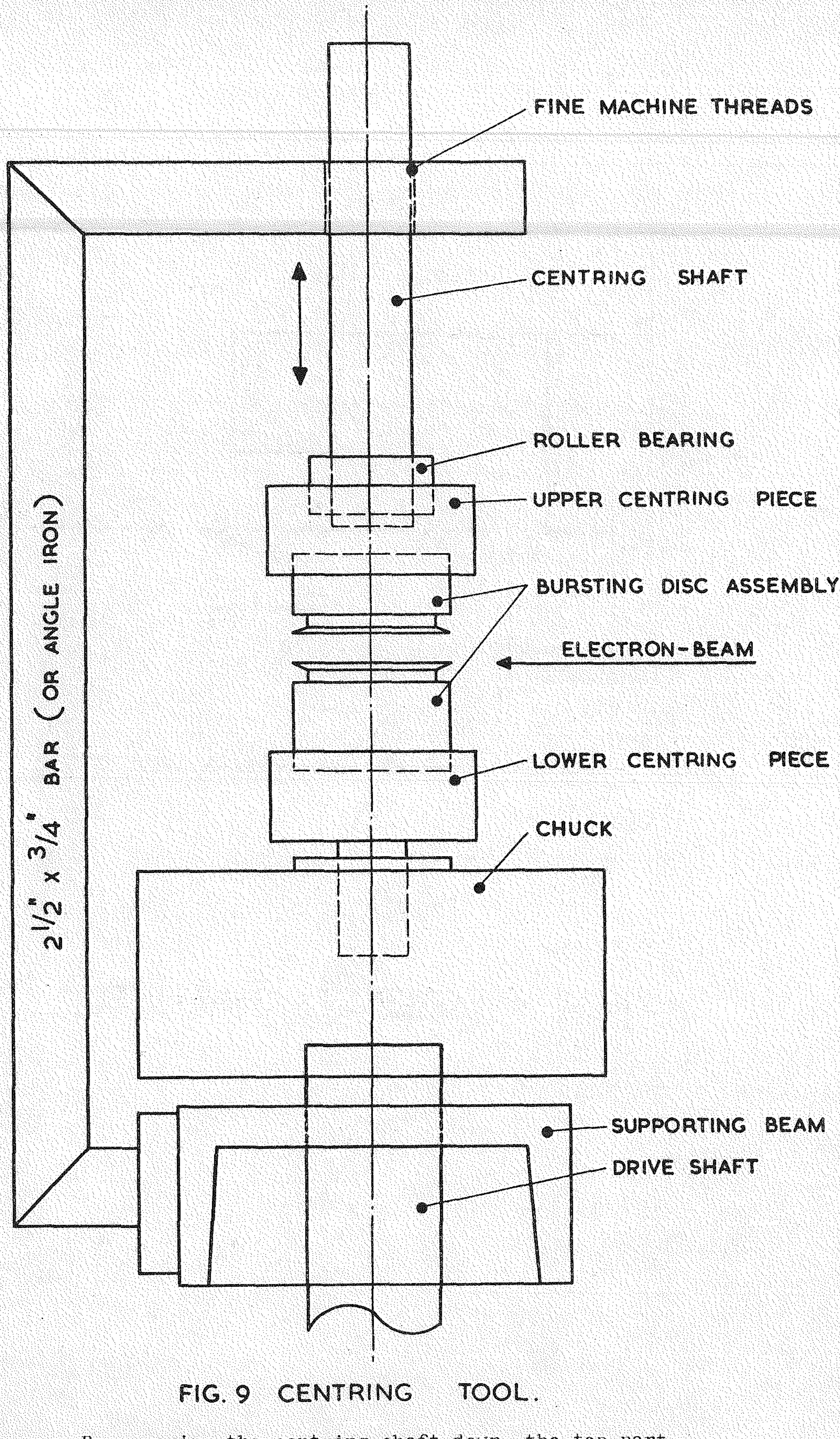

FIG. 9 CENTRING TOOL.

By screwing the centring shaft down, the top part of the Bursting Disc Assembly is pressed and centred on the lower part.

The Upper Centring Piece will follow the rotation of the chuck because of its support by the roller bearing.

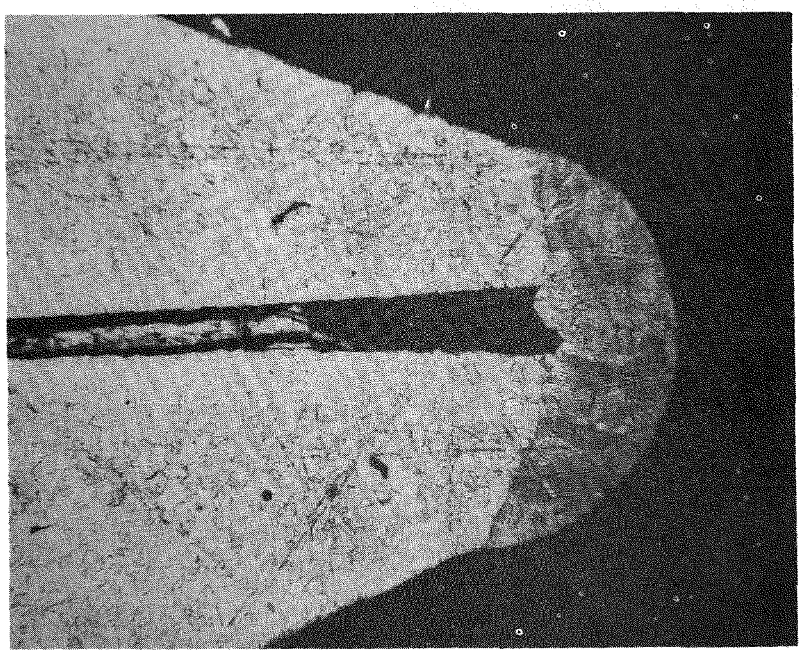

FIG. 10. UNSUCCESSFUL WELD X80

The surfaces of the holder were not parallel, and as a consequence, part of the disc burned away before the other two edges were melted.

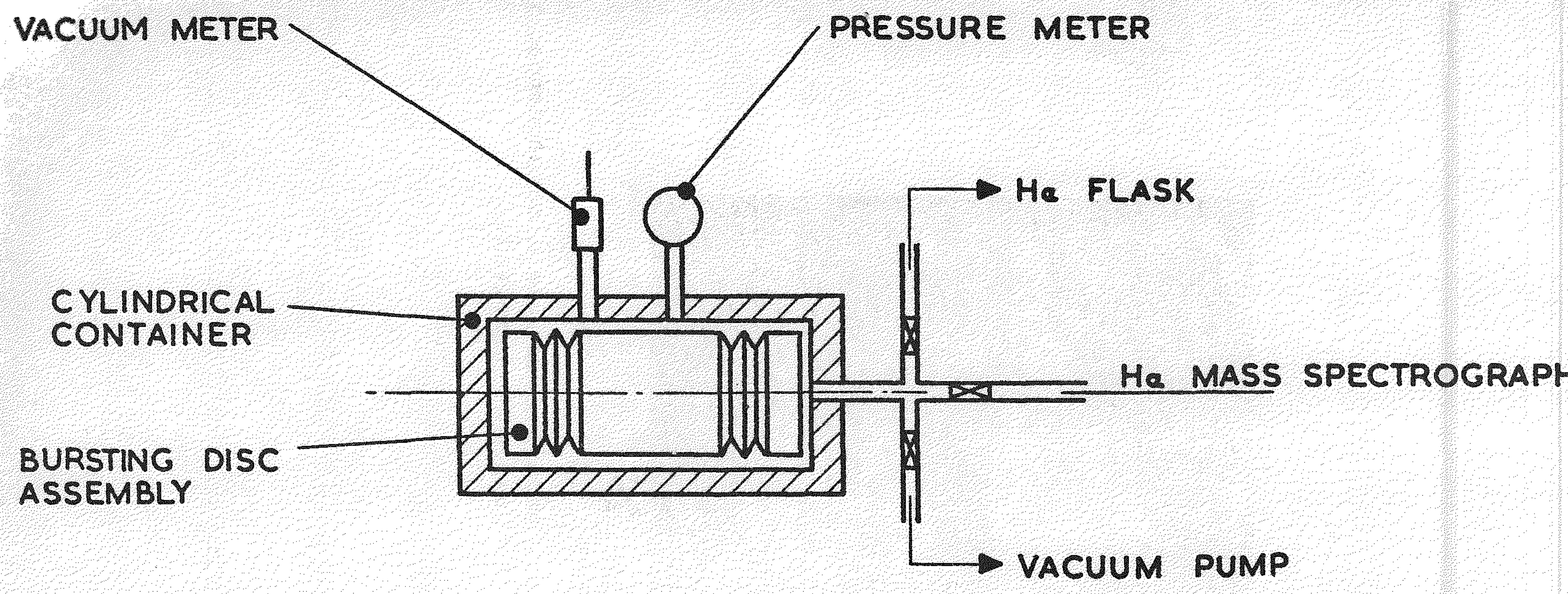

FIG. 11 HELIUM PRESSURE LEAK-TESTING METHOD.

1. The cylinder is pressurised with helium, for example, 10 atm for 24 ho

2. The cylinder is evacuated.

3. Helium mass spectrograph is connected.

Operations 1, 2 and 3 with the right sequence use of the valves.

A leak in the Bursting Disc Assembly 10^{-7} atmospheric cc/s should be detected.