

9th January 1959.NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCEGENERAL PURPOSES COMMITTEE7 GeV PROTON SYNCHROTRONDESIGN AND MANUFACTURE OF THE MAIN VACUUM CHAMBEROutline

Following the decision to abandon the design of an epoxy resin vacuum chamber of single skin construction, due to the fears of degrading effects of radiation, it has been necessary to establish a radically new approach to the problem. The new design will involve a substantial increase in cost. The main feature of the new design is that it will comprise two chambers, an outer one of epoxy resin which is supported mechanically by the pole pieces which are located within the outer chamber, and an inner one of light construction not subject to any appreciable differential pressure, which can be replaced should radiation damage occur. The design is proceeding at A.E.R.E. with assistance from Messrs. Vickers Armstrongs Aircraft Ltd., but it is necessary to place a contract with a manufacturer who has wide development resources in the special techniques involved, in order that production techniques can be developed prior to manufacture starting on the component sections.

The Project Committee have endorsed the principles of the design and the course of action outlined above, and after a comprehensive survey of the Plastics Industry, two firms are considered to have the resources and background for undertaking this work, on the basis of the quotations received. It is recommended:

- (a) that Messrs. Marston Excelsior be given a development contract for the production of the first section of the chamber and that they should have a contract for the manufacture of the remaining sections on the basis of cost plus a fixed fee, or to a fixed cost acceptable to the U.K.A.E.A.
- (b) That the estimates be increased by £178,000 at this stage.

D.W. FRY
Chairman Project Committee.

7 GeV PROTON SYNCHROTRON

MAIN VACUUM CHAMBER

1. Introduction

The Vacuum Chamber for the 7 GeV Proton Synchrotron is not only one of the major items of expenditure, but one of the most difficult engineering problems on the project because of the essential conditions to be satisfied. It must be capable of being evacuated to a pressure better than 10^{-6} mm Hg absolute, and occupy a minimum of the magnet gap, be non-magnetic and must not produce field distortion due to circulating currents within its skin. The materials used in construction should have a long life and maximum resistance to changes due to radiation.

The earlier design of chamber was a stressed structure of epoxy resin and glass fibre, but experimental evidence now gives strong grounds for believing that its strength would be seriously affected during machine operation by the degrading effects of radiation.

Epoxy resin glass fibre is still considered to be the best material for construction, but in the design now evolved, stresses are low in those parts of the chamber which suffer radiation and the parts most affected are removable for repair or replacement. Eight sections are required for the vacuum chamber, each section having three components approximately 50 feet in length. In addition a further section is required as a spare and an insurance against damage on erection.

The manufacture of such a large chamber in these materials is a most unusual job for which there is no directly related experience in this country although pilot experiments have shown that it should be possible to develop suitable manufacturing techniques, within the time scales required. These techniques must be related to the resources of the firm which will make the chamber and the experience gained during development must be carried over into the final manufacture. It is therefore desirable that a contract be placed with a firm suitable to undertake both the development work and subsequent manufacture.

In order to complete the machine to the required date of December 1961 it is necessary for the first component to be delivered to the site by October 1959. This cannot be achieved unless there is continuity during both development and production phases.

2. Approach to Industry

During an extensive survey of the Plastics Industry, ten firms were selected for inspection by a special working party (see Appendix I). Of these only two are judged to be suitable for the development and manufacturing work. These are:-

Marston Excelsior, Ltd.
(a subsidiary of I.C.I.)
Wolverhampton

De Havilland Propellers, Ltd.
Hatfield,
Herts.

Invitations to tender were issued to these firms, in the form discussed in paragraph 3.

Summaries of the tenders received are given in Appendix II, from which it will be seen that the more attractive offer is that made by Marston Excelsior, Ltd. The Authority have had extensive experience of contracts placed with Marston Excelsior Ltd. some of which have been costed contracts, and as a result have considerable confidence in this firm.

3. Form of Contract

A fixed price cannot be obtained at the start of the work because of the development necessary to establish manufacturing techniques which may influence detail design. A contract in the following terms is proposed:-

3.1. Description of work

3.1.1. Technical study to determine the most suitable constructional techniques.

3.1.2. Production of Models and Samples as necessary to establish techniques.

3.1.3. Development and manufacture of one complete section.

3.1.4. Submission of Drawings and Reports on the progress of items 3.1.1. to 3.1.3. at agreed intervals or as called for by the Authority.

3.1.5. Manufacture of eight complete sections, which is not to commence without prior approval in writing from the Authority.

3.2. Price

The price to be paid for the development work and manufacture of the first section (3.1.1. to 3.1.3.) will be determined from the materials used and from the hours worked and the rates (including overheads and profit) quoted for the class of effort involved. (see Appendix I).

The price to be paid for the remaining eight sections will be either a fixed price which is acceptable to the Authority, or a price which is calculated on the basis of:

- (i) the materials used
- (ii) the cost of hours worked at rates which are reduced from those shown in appendix I by elimination of the profit element
- (iii) a fixed sum in respect of profit.

4. Finance

The provisional sum in estimates based on the earlier form of chamber is £147,000.

In order that the cost of the new chamber could be assessed, both Marston Excelsior and De Havilland were invited to submit a rough estimate of the likely overall development and manufacturing costs based on their limited knowledge of the work. The estimate given by Marston Excelsior for the new chamber is £325,000 which is close to the sum of £350,000 estimated by the Project Team. The De Havilland estimate is £450,000.

Additional provision is necessary in the estimates to cover the cost of the new vacuum chamber and if the contract is placed with Messrs. Marston Excelsior and the final cost does not exceed their present estimate, the additional authorisation required is approximately £173,000.

The cost of the complete chamber has been estimated on the basis of incomplete information. When the actual cost of the first section has been determined prior to work starting on the Production Sections, a more reliable estimate will be submitted to the General Purposes Committee.

The anticipated commitments and payments are shown in Appendix III.

5. Recommendations

It is recommended that:-

- 5.1. The General Purposes Committee give approval to the placing of a contract as outlined in this paper with Messrs. Marston Excelsior, Ltd.
- 5.2. The estimates be increased by £178,000 at this stage.

APPENDIX I

SUMMARY OF APPROACH TO INDUSTRY

1. From the beginning of the investigation the following specialised companies and research organisations have been visited to obtain advice and comments on the design:

British Plastics Federation

Royal Aircraft Establishment, Farnborough

Principal Resin Manufacturers

2. The following firms have been cited in connection with our requirements for a 6 feet long test section and for the 50 feet curved sections for the 7 GeV machine.

1. Mendip (Thermo-Plastics)
2. Miles Structural Plastics
3. Alexander Wright
4. Flexo-Plywood
5. Fleetland Ltd.
6. Microcell Ltd.
7. Sars Laminated Wood Products
8. Air Service Training
9. Bristol Aircraft
10. Marston Excelsior
11. De Havilland Propellers.

It was the considered opinion of the specialist visiting party that the firms from 1 - 8 had not the technical resources or the capacity for the satisfactory execution of the 50 ft. sections.

3. Seven firms however were invited to tender for the manufacture of a 6 feet test section. Three of these submitted a fixed price, two showed interest only on a cost plus basis and the remaining two declined to tender. The contract for this test section was placed with Marston Excelsior, who submitted the lowest tender. This component has been delivered and is on test. It shows work of a high standard and we are very satisfied with the technical development of Messrs. Marston's manufacturing techniques.
4. In considering the three firms with satisfactory technical resources it was necessary to relate the methods proposed to the programme to be achieved. The Bristol method seemed unlikely to meet the time scales required, and the capital cost of tooling would have been large. Therefore only Messrs. Marston Excelsior and De Havilland were asked to tender.
5. After considering the tenders, the facilities of both firms have been re-examined and it is recommended that the final selection be made entirely on a financial basis.

APPENDIX II

COMPARISON OF PRICES

Overall rates per man hour including overheads and profit	De Havilland	Marston Excelsior
<u>Development</u>		
1. High Grade Technical	£3. 0. 0	£1. 18. 1
2. Ancill. Technical		1. 5. 9
Designer	1. 7. 9	
Drmn.	1. 5. 3	
Lb. Tech. and Intergrade Eng.	2. 15. 0	
Junior Tech. & Eng.	2. 0. 9	
3. Skilled	1. 18. 6	1. 6. 2
4. Semi-skilled	1. 13. 2	1. 1. 10
<u>Manufacture</u>		
5. Skilled	1. 18. 6	1. 9. 10
6. Semi-skilled	1. 13. 2	1. 5. 0
7. Material Handling charge	7%	10%
Estimated Total Cost	£450,000	£325,000

De Havilland

Many contract conditions including design rights rejected. Overhead and profit rates not quoted. Not prepared to offer a fixed fee tender, and will only undertake the work on a cost plus basis using their rates shown above.

Marston Excelsior

All contract conditions accepted except that Marston Excelsior required progress payments. Overhead and profit rates are quoted. Prepared to quote for a fixed fee or fixed price contract. If a fixed fee contract is selected by the Authority the hourly rates would be the rates shown above reduced by the 11% profit element quoted.

APPENDIX III

ANTICIPATED COMMITMENTS AND PAYMENTS

The following tables indicate the sums of money which are expected to be committed and paid in each financial year, with respect to the Vacuum Chamber.

Anticipated commitment on Contract	
1958/59	1959/60
£95,000	£230,000

Anticipated payments			
1958/59	1959/60	1960/61	1961/62
Nil	80,000	170,000	75,000