

NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCEGENERAL PURPOSES COMMITTEEProposed Participation in Common Valve DevelopmentNote by T. G. Pickavance1. Introduction

The nuclear physics programme at the Rutherford Laboratory requires not only close support by electronics experts in making equipment for particular experiments, but also a considerable amount of long-range electronics development, to provide electronic equipment of new and improved kinds. No separate electronics research section has been set up under the NIRNS for the latter purpose, but instead an arrangement has been made whereby the AERE Electronics Division, with the help of some NIRNS staff, will undertake long-range research according to NIRNS requirements.

In many of these long-range projects, research and development in industry is required. When this is done through an AERE contract with a firm no special difficulty arises: each proposed contract can be submitted in the usual way for NIRNS approval according to its total cost (or to the due proportion of its cost in the case of a project of joint interest to the NIRNS and the AEA).

In suitable cases however, the AERE arrange for the development in industry through the Common Valve Development organisation, and here approval and financial control cannot be on quite the same basis, owing to the method of working of C.V.D.

2. The C.V.D. organisation

A description of the C.V.D. organisation and their present and proposed programme for the AERE has been supplied by Mr. E.H. Cooke-Yarborough, the head of the A.E.R.E. Electronics Division, and is given in the appendices. Paragraph 2 of appendix 1 sets out the financial procedure of C.V.D., and the reasons why detailed estimates of cost cannot be given before C.V.D. is formally requested to undertake an item of work. Paragraph 3 sets out the advantages of the organisation. These paragraphs are copied from a case recently submitted for AEA approval, and they mention the AERE and the Authority in several places. In general, however, the same arguments apply to the Institute.

3. Proposed NIRNS Contribution

Appendix 2 shows the current C.V.D. work for AERE. Much of this work was initiated before the Rutherford Laboratory requirements began to be distinguishable from those of the AERE, and at present the AERE are bearing the whole cost (except where C.V.D. have agreed to bear part). However, two of the larger items are of direct interest to the Institute, namely pulsed light amplifiers and image converter tubes. Both are required for observing and recording the tracks of high-energy particles in scintillation chambers. The work on high-speed photo-multipliers, the low hole storage diode and the semi-conductor radiation detectors are also of considerable interest to the Institute.

I have discussed with Mr. Cooke-Yarborough the share of interest in these current projects between the Institute and the AERE. It will be seen from Appendix 2 that the estimated cost in 1961/2 is £28,000. If it is agreed that the Institute should pay part of this in proportion to their interest, I would recommend a contribution of £10,000.

The future programme, shown in part 2 of appendix 2 and in appendix 3, is rather tentative, but eight items are briefly described. Items 1, 2, 3, 4 and 6 are of interest to the Institute. The total cost of these in 1961/2, deducting a probable participation by C.V.D. in item 1, is estimated at approximately £45,000, and an Institute contribution of 25% of this is suggested, i.e. an estimated £11,250.

Adding the proposed fixed £10,000 for the current items, the total suggested Institute contribution in 1961/62 is therefore estimated at £21,000, although as indicated in para 2 of appendix 1, this figure can only be approximate.

4. Financial Arrangements

As explained, the financial arrangements for C.V.D. work for the AEA and for the proposed work for us are different from the usual patterns. (though similar to the situation when we ask the AERE to do development work for us) Overall financial control of the C.V.D. programme by the Treasury is through the Controller of the Navy. Control by the Institute of expenditure on individual projects, once they were approved, would be indirect and incomplete. The AEA have however recently reviewed the situation in respect of the C.V.D. work for them, and I suggest that if they have finally agreed that it is satisfactory for them, we could agree that it is also satisfactory for us.

5. Conclusion and recommendation

I think that there are good grounds for using the C.V.D. organisation. It is of course necessary to make arrangements for very close co-operation between the nuclear physicists using the Rutherford Laboratory and the electronics research groups planning long-range work. Such arrangements have recently been established and have now been in operation for six months. In future, therefore, the programme of long-range development including C.V.D. will in general stem directly from the requirements of the nuclear physics users of the Laboratory.

For 1961/62, I recommend a contribution estimated at £21,000, on the basis set out in para 3.

APPENDIX 11. The C.V.D. Organisation

The C.V.D. was formed to co-ordinate valve research and development to meet the special needs of the various Defence Research Establishments. It has continued this function ever since, widening its scope to include semiconductor devices such as transistors, and signal diodes (but not power rectifiers). The organization comes under the Director of Physical Research at the Admiralty.

The C.V.D. places research and development contracts, those for defence research organisations being paid for out of C.V.D. funds. Research and development work to meet specific needs is initiated, guided and progressed by small sub-committees consisting mainly of specialist members of the establishments concerned. These establishments maintain direct contact with the contractor, but are enabled to take into account the similar needs of other establishments, so that duplication and competition for effort between establishments is avoided. Although each sub-committee follows all the contracts in its field, technical responsibility for each contract is placed on an individual member of the sub-committee.

C.V.D. Estimates

Budgeting by C.V.D. is performed in the following manner. In about June of each year the establishments are asked to give C.V.D. a forecast of the new work they expect to ask for in the following financial year. C.V.D. then estimates the approximate cost of the new work which is likely to fall in the next financial year and adds this to the estimated cost during that year of commitments already entered into. This estimate is usually ready by the end of August. It is submitted to the Controller of the Navy and then to the Treasury, and approval is normally obtained by December. At this point C.V.D. are able to inform industry how much effort they will require in each of four or five broad categories of work in the coming financial year and are thus able to make reasonably sure that the right quantity of the right kind of effort will be available. It may be six months or a year before CVD receive from the establishments a formal request for work to start on a particular item and detailed information about what is required. It is not until then that a firm is chosen.

The C.V.D. financial estimates are based on their own estimation of the cost of the work (not on an estimate by a firm) and on a very early and tentative statement of the establishments' likely needs. Consequently the actual expenditure on individual items is likely to differ considerably from the figures appearing in the estimates. The expenditure, within the budget, on individual items is decided by C.V.D., advised by the Policy and Technical committees. The cost of the work is met out of C.V.D. funds, except for that done at the request of the A.E.A., the cost of which is recovered from the Authority.

The above procedure does not allow the research and development cost of a particular item to be estimated in detail before C.V.D. is formally requested to undertake the work. C.V.D. are unable to do this for several reasons:-

- (a) Such an estimate would require consultation with the firm concerned, but C.V.D. does not usually choose the firm until after the formal request to undertake the work has been received.
- (b) Some of the work forms an integral part of a C.V.D. programme in which several organizations are interested and it is impossible to estimate in advance the proportion of this work which should be charged to a particular organisation.
- (c) C.V.D. are not organised for preparation of such estimates, which are not required by the defence establishments.

- (d) C.V.D. have set up an elaborate advisory organisation so that its programme is, in effect, guided by the best-qualified people available in this country. (Many of the members of the Policy Committee are Directors of Establishments), C.V.D. therefore considers itself a responsible organisation able to decide on the allocation of funds between particular items of work. (A.E.R.E. is represented on the Transistor Sub-Committee, the Cathode Ray Tube and Photo Tube Sub-Committee (Chairman), the Semiconductor Advisory Panel, the Technical Committee and the Policy Committee.)

3. The Advantages of using the C.V.D. Organisation

The Authority is under no obligation to place any of its work on industry through C.V.D., so it could be argued that the discrepancy between C.V.D. procedure and our own could be avoided if we place all our work directly with industry. Some of our work is so placed; there are considerable advantages in placing the remainder through C.V.D.

Some of the advantages in working through C.V.D. are indicated below:-

- (a) We benefit from the views and advice of experts from other electronic establishments in specifying work initially and in the course of the work.
- (b) Because some of our work can be made part of larger C.V.D. programmes, it can be done more rapidly and at less cost by taking advantage of equipment, materials, information, etc. already obtained at C.V.D. expense. Thus the existence of C.V.D. contracts on infra red tubes and starlight viewing tubes has greatly helped the work on high-gain image intensifiers.
- (c) C.V.D. chooses firms for a particular work on the basis of their loading and known skills. They thus perform a function which would otherwise have to be undertaken by the E.M.R. office.
- (d) Little of the work initiated by the Authority in the electronics field is likely to be commercially attractive, and we have found that this leads to difficulty in getting industry to allocate staff of high enough calibre. By making our valves and semiconductor work part of the C.V.D. programme, much of which leads to profitable production orders, we get the services of better staff in industry.
- (e) By participating in the C.V.D. programme we are able to obtain early development samples of new devices which would not otherwise be available to us. Thus we were able to complete the development of a neutron time-of-flight spectrometer, for use with the Neutron Project, by using a barrier grid storage tube under development for R.R.E. Likewise we have received 200 development samples of high-speed switching transistors and 400 long-life valves, both developed by C.V.D. and made available to us without charge.
- (g) We make use of very many valves and semiconductor devices developed at C.V.D.'s expense. Our representation on C.V.D. has often enabled us to ensure that these developments take our needs into account.

4. Some Examples

A few results of previous contracts are worth noting. The Ericsson 'dekatron', which owes its current reliability largely to the C.V.D. contract sponsored by A.E.R.E., provides the cheapest scale-of-ten for low-speed counting and logic circuits. A reliable trochotron, which performs similar functions at higher speeds, is now available as a result of a C.V.D. contract sponsored by A.E.R.E. The Swedish firm which made the original trochotron has discontinued the production so that in the absence of the British development we would have been in a serious position regarding our

multichannel analysers and time-of-flight spectrometers. The American trochotron originally used in these analysers has been the most unreliable component. The Chalk River Laboratories report similar unreliability.

A major part of the current programme is directed at image intensifiers. The most important application of these is to the recording of the tracks of energetic particles by the scintillations they cause in suitable media. This would give much better time resolution than cloud chambers, bubble chambers or spark chambers, thus permitting the use of higher intensities and the more rapid accumulation of rare nuclear events.

APPENDIX 2

CURRENT WORK 1960/1 and NEW REQUIREMENTS 1961/2

CONTRACTOR	CONTRACT	PROJECT	DESCRIPTION	COST TO 31.3.60	ESTIMATED COST 1960/1	ESTIMATED COST 1961/2	ESTIMATED TOTAL COST
<u>Part 1. CURRENT WORK 1960/1</u>							
E.M.I. Research Labs.	6796/58	VX 5091 VX 5092	Multiplier Photocells	£ 11,791	£ 11,000	£ 2,000	£ 25,000
English Electric Valve Co.	6795/58 (6424/49)	RP 2-1	Study of pulsed light amplifier	48,583	16,000	10,000	75,000
Mullard	6793/58 (95580/44)	RP 8-10	Study of image converter tubes	14,753	8,000	8,000	31,000
G.E.C.	9293/47	VX 3324	Low Hole Storage Diode	4,288	3,700	-	8,000
Standard Telephones	6687/59	VX 7522	Logarithmic Amplifier	1,702	2,000	-	4,000
Ferranti	15069/55	VX 1533	P-N Junction Radiation Detector	-	3,000	3,000	6,000
(Not yet placed)			P-N Junction Light Source	-	3,000	5,000	8,000
<u>Part 2. NEW REQUIREMENTS 1961/2</u>							
Fast multi-layer triggered device			<u>ESTIMATED DURATION</u> 2½ years	-	-	10,000	30,000
High speed and other nuclear radiation detectors			2½ years	-	-	20,000	50,000
Small signal low noise transistor			2 years	-	-	10,000	20,000
Highly stable voltage reference			2 years	-	-	10,000	20,000
Study of logarithmic devices			2 years	-	-	10,000	20,000
Ceramic triode, 500°C ambient			3 years	-	-	10,000	30,000
Wide range logarithmic amplifier			2 years	-	-	3,000	6,000
			(Round figures)	80,000	50,000	100,000	330,000

APPENDIX 3Tentative Programme of Future C.V.D. Work

(See Part 2 of Appendix 3)

1. Fast multi-layer triggered device

This is for the generation of very short current pulses (10^{-9} sec. or less) at accurately defined times for the developing and testing of high-speed pulse circuits. C.V.D. agree that this is of sufficiently wide interest for them to contribute half the cost if the proposal goes forward.

2. High speed and other nuclear radiation detectors

Semiconductor radiation detectors for heavily ionizing particles are potentially faster than scintillation counters and can give much better energy resolution. The object of this work is to realize these potential advantages. At present this forms part of the S.E.R.L. research programme but industry is likely to be brought in soon.

3. Small signal low noise transistor

Present transistors cannot provide adequate amplification at very low currents. This limits their usefulness as d.c. amplifiers and as amplifiers of pulses from ionization chambers or semiconductor radiation detectors. If this limitation could be overcome the noise level of a transistor should be less than that of a valve (since the electrons in the transistor need not be hot) and would allow better use to be made of the inherently high energy resolution of semiconductor radiation detectors.

4. Highly stable voltage reference

The avalanche breakdown voltage in a semiconductor diode can have high stability possibly as high as that of a standard cell. Because such a device would be generally useful C.V.D. would pay half the cost. A commercial development may, however, meet this need.

5. Bulk conductivity high energy particle detector

This is an extension of (2) above the beta particles and possibly gamma rays. The problem is much more difficult because larger sensitive volumes are needed and speeds are unlikely to be high. S.E.R.L. are working on this at present as part of their research programme.

6. Study of logarithmic devices

Logarithmic circuit elements are often needed, notably in reactor period meters and in situations where it is necessary to produce a pulse voltage proportional to the product ratio or some other function of other pulse voltages. Simple theory indicates that certain semiconductor devices should have the desired properties. Work is required to overcome the limitations of practical devices.

7. Ceramic triode, 500°C ambient

This is for use in close proximity to pulse ionization chambers in nuclear reactors. It is possible that the need will be met by American high temperature valves.

8. Wide range logarithmic amplifier

This follows an existing contract at S.T.C. which has been confined to the study of logarithmic characteristics of thermionic double diodes. The proposal is for a single thermionic triode or pentode as a wide-range logarithmic amplifier. This complements (6) above, but its application is likely to be confined to reactor period meters and the like and not to include pulse multiplication.