TRE, Malvern 1945-50 - Accelerators

In autumn 1945, Bernard joined group S1, under Fry at grade JSO. This meant a move to house 7 in the college site. Although by 1946 parts of the college were being returned to their pre war use, TRE continued in occupation.

In his next notebook marked “Linear Accelerator”, the first date is 12/2/46, concerning circular corrugated waveguides. This was probably a new training session.

Notes start with circular corrugated waveguides., rectangular (Cutlers theories), and S band local oscillators. There are various reports on the current thinking for accelerators. These say work started Nov 45 at TRE. A machine would use S band, might achieve 30-50 Mev, using the BM735 magnetron, circular corrugated waveguides, tapered to accelerate electrons to 99c(?). Names include Harvie and Walkinshaw. Six lengths of differing waveguide exist for testing.

Concerns were starting over radiation protection from such a machine.

The alternative possibility of rectangular waveguides, corrugated on one side, was suggested by Mullett. Another suggested by Harvie was to use resonators fed from coax, in zig zag form. Also are suggestions of developing a synchrotron. Also suggestions of a linear amplifier, pulse generator (Test set 320), and high speed monitor, and Geiger counters? Equipment being made by Dynatron. Document looks to be post April 46. But appendix memos are winter 1945.

In order to explain in simple terms the physics and operation of the accelerator, I tend to like the analogy of a cathode ray tube as used in Television, or radar and oscilloscope

displays. In the CRT electrons are emitted by the heated cathode and are then attracted or accelerated towards the display screen by the application of a very high voltage. The inside of the tube must be completely empty, ie a high vacuum with no air molecules present. On hitting the screen the electrons cause the emission of light at the point of impact. The direction of the beam of electrons, and thus the place on the screen where the light occurs, can be altered by the presence of a magnetic field around the tube. The beam can be modulated by the video RF signal which thus changes the intensity of the light.

In the accelerator, electrons or other particles(?), are introduced to the end of a waveguide, and high energy RF pulses and high voltages accelerate these particles along the waveguide tube. Magnetic fields are used along the length to concentrate the beam along a path required, and of course, the whole waveguide must be pumped down to a very high vacuum. At the end of the accelerator the particles have achieved a very high velocity and often bombard some type of target whereupon they disintegrate into the smaller particles the physicist wishes to study.

When such particles hit targets, they tend to cause the emission of radioactive elements, eg X rays, as was in fact the case with the early colour TV tubes which were operating at very high voltages.

The energy to which these particles are accelerated, or which they attain, is described in MeV, or Million electron Volts. The all important goal at this time was to attain the highest energy possible from any accelerator being built.

0.5 MeV (Mk 1) Accelerator

On 28th April 1946 the Linear accelerator waveguide, priority program of work reads thus.

- First item “Feeds” (Loach), 4cm inner diameter waveguide. (There is a sample of this in the artefacts).

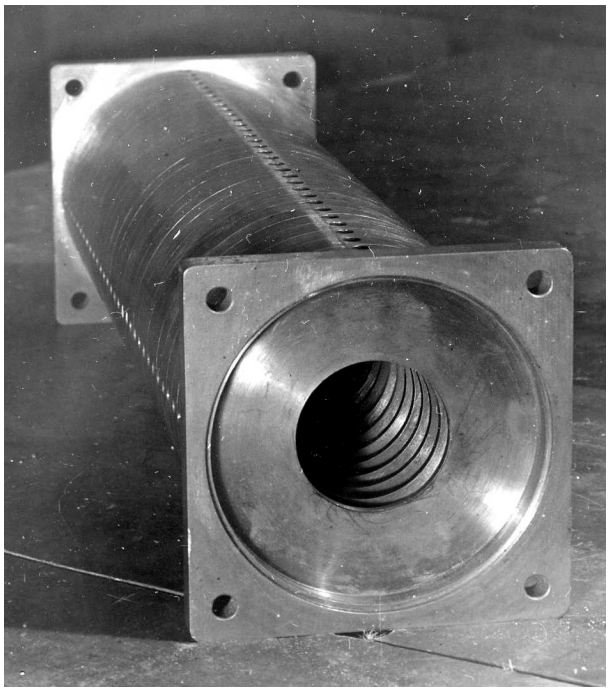
- Item 2, Possibility of Tuning Cavities (Loach)

Meeting on 6th May in Mr Fry’s office. 2.45.pm, to discuss progress on the linear accelerator.

- The intention to have a 0.5MeV electron accelerator in 3 months.

- Mr Loach and Mr Clay are actioned to oversee the provision of a metal dummy load, being designed by BAC.
- Mr Mullett and Mr Loach are actioned against working as rapidly as possible on a rectangular corrugated waveguide although initial trials will have to done on a circular guide.

End of meeting



First section of waveguide for the first accelerator

In July Mullett issued the report “Corrugated rectangular waveguide for the Linear Accelerator”.

In August Mullett, Loach and Gregory issue TRE report 2029, “Experimental work on corrugated waveguides for a linear accelerator. Theory design and practical issues of manufacture.”

Also, Walkinshaw produces the reports “Theory of Circular corrugated guide for linear accelerator”, and “Design of circular corrugated waveguide for bunching section of linear accelerator”.

On 1st August 1946 the group became part of the new AERE . Maybe one can assume that around this point the move to Harwell is becoming inevitable.

Meeting 18th October 1946, Mr Fry’s office again:

- This has the first mention of the move to The Lees, where Mr Clay is responsible for transfer of the vacuum system from house 7 to Hut 9 at The Lees.

- Mr Wharmby is to assist and Mr Mullett is responsible for installation of circular corrugated waveguide in the vacuum envelope.

- A decision was made to pressurise the complete system (Harvie protesting).

- All components for this to be tested on the Wharmby test table by Loach and Gregory.

- Mention that a new Valve from BTH with a new vacuum flange fitted is to be used.

- Work on and inside the protection shelter was hard on clothes and it was agreed claims for additional clothing coupons could be justified.

The Lees, 1953

Meeting 20th November 1946

To discuss the Mk1 and Mk2 accelerators! A theme which prevails later in this biography, is for things to move so quickly that a machine is often superseded in design before it is built!

- There had been considerable success with the Mk1 (0.5MeV) machine in the last few days.

- Loach was to make vacuum tests along with the help of Cowhig and Clay.

- There was starting to be considerable attention to safety with reference to X rays, and the fire extinguishers needed to be moved from house 7!

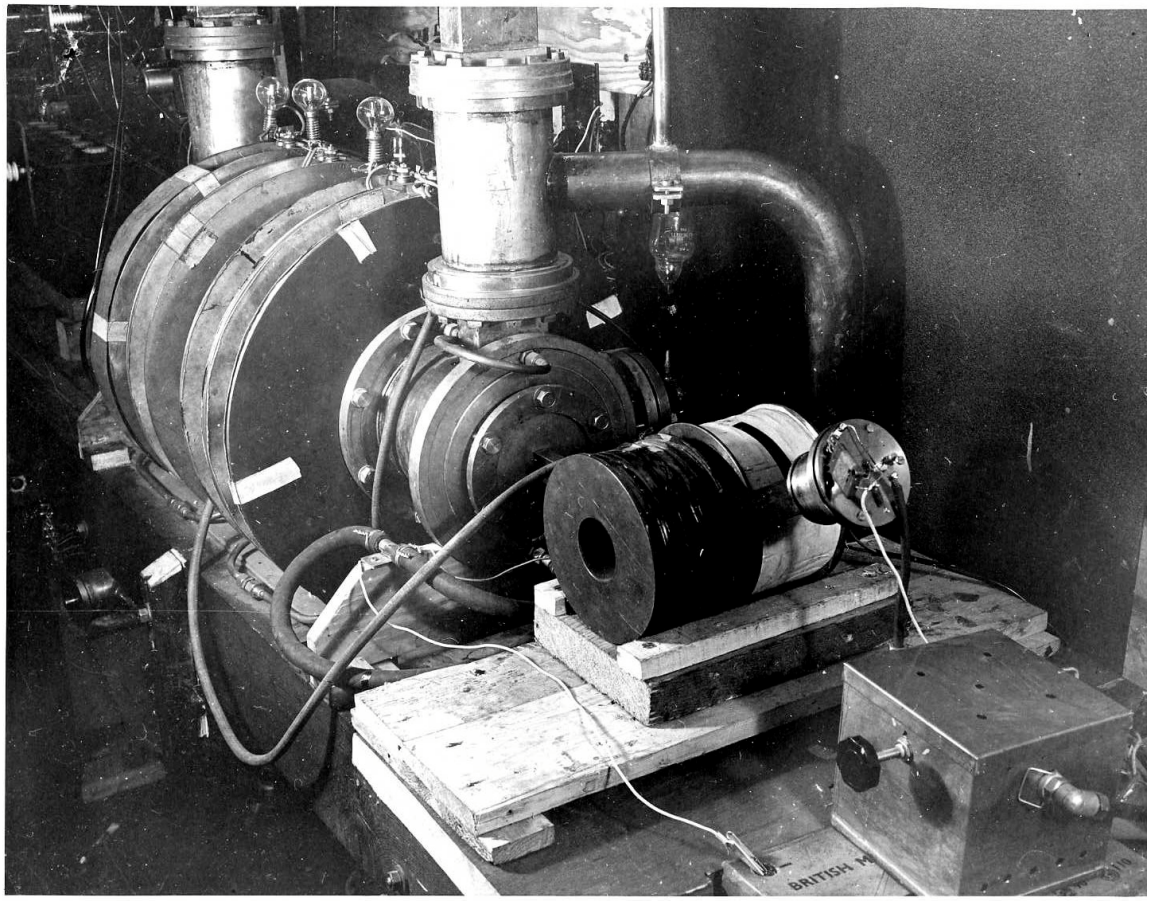
- The Mk 2 accelerator to be 4 MeV. Remote control units would be needed.

His notebooks contain what appear to be many measurements on corrugated waveguides etc during summer 1946, but further notes cease until 1947.

Meanwhile report AE 1004 “Experimental work on corrugated circular guides having continuous variations of phase velocity”, is published by Mullett and Loach in March 1947. This refers to the waveguide used in the 0.5MeV accelerator and for some for the 4 MeV machine. It is noted that work is now being done under TRE MOS (Ministry of Supply) instead of MAP (Ministry of Aircraft Production).

There are some photos, marked on the obverse, with the date 1st May 1947. One shows one section of corrugated circular waveguide, while the other two may be the 40cm 0.5MeV machine?

Report AE1007 details this machine and ideas for a longer machine. Produced by Mullett, “A Travelling wave linear accelerator for 0.5 MeV electrons”. May 1947. This is the small accelerator which first worked in Nov-Dev 46.



The miniature 0.5 MeV accelerator

4 MeV Accelerator (Vacuum system)

At this point notes become scarce, just one entry in notebook dated 1st May 1947, "Diffusion pumps, jet variation". So by this time Bernard is probably working on vacuum systems as mentioned above and other aspects of the 4 MeV accelerator for which details of work start to appear only as reports in 1948.

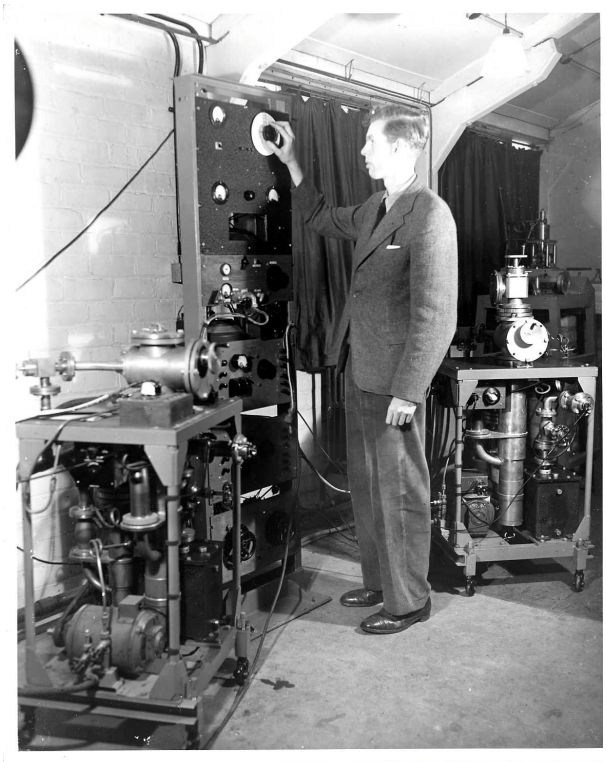
Meanwhile, report "Experimental work on corrugated waveguides and associated components for linear accelerators", Mullett and Loach, is published in "Proceedings of the Physical Society", 1948.

Probably around this time the rest of TRE were completing the move out of the college, as most moving appears to have been done by May 1948, when the open days were held at The Lees.

The only references to the work at this time are photos:

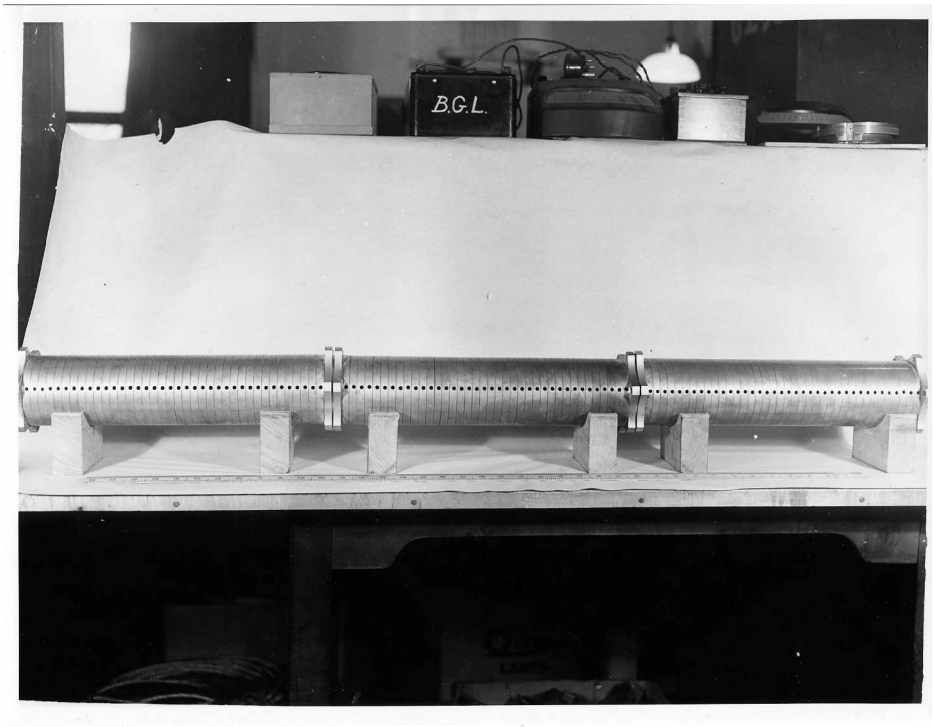
One dated May 1947 shows what appears to be the vacuum envelope to be slipped over the corrugated waveguide for the new accelerator.

The next one dated October 1947 shows BGL working on oil diffusion vacuum pumping equipment, and two more show close-ups of the High Vacuum shut off valves.



Bernard working on tests of High Vacuum Valves

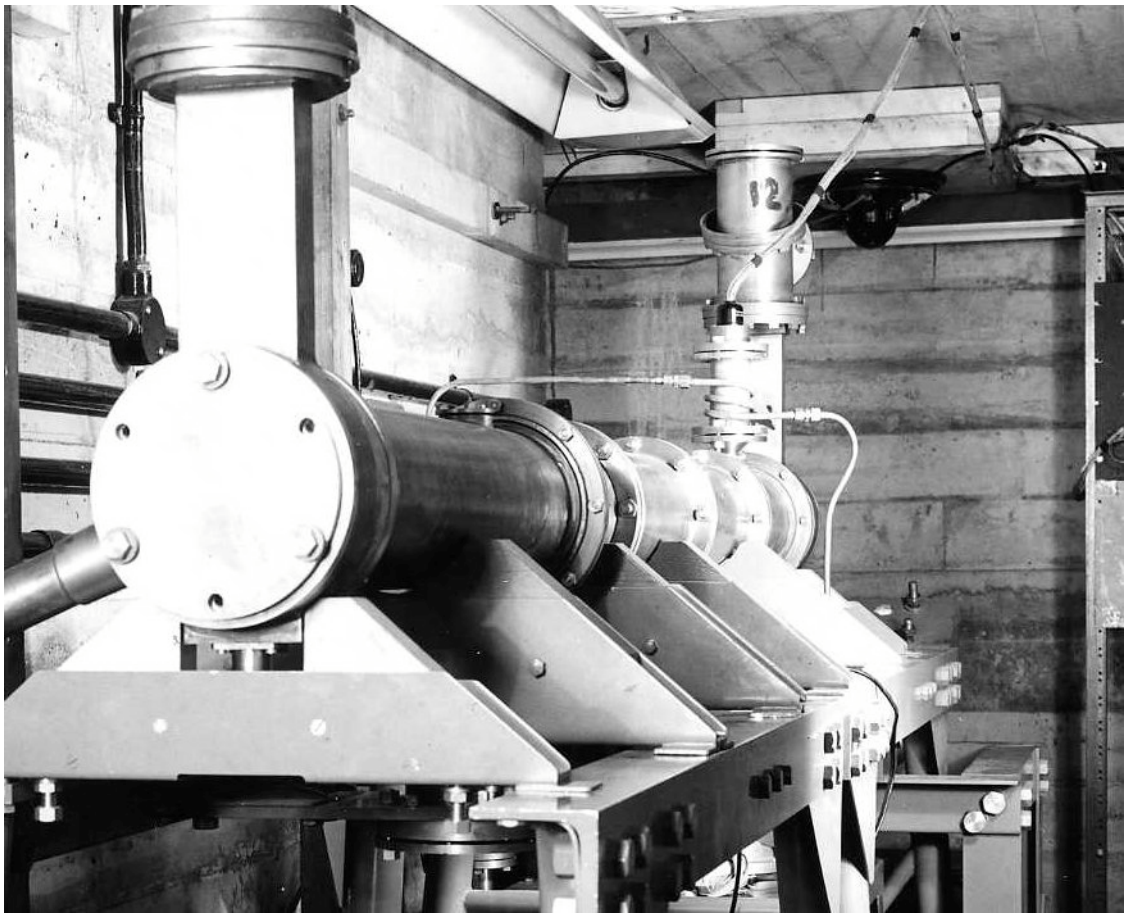
Also photos dated October 2nd show the sections of waveguide ready to be used. Bernard's Avometer clearly labelled "BGL" prominently appears in these photos.



Waveguide core for the 4 MeV machine,

Also, 3 other November photos show various components ready for assembly. These include the electron gun, coax feed, coils etc. The final November photo shows the completed vacuum envelope, presumably with the waveguides fitted, mounted on the stand.

In this photo can be seen an item similar to the 4cm waveguide item in the artefacts, with what appears to be a cooling pipe, octal connector etc, which eventually becomes hidden when the field coils are surrounding it. This may be an Ionisation detector. (see later)



Waveguide within vacuum envelope, showing ionisation detector

There are no more references until further photos in March 1948.

On 29th August 1947 The Lees became a Civil Service establishment under MOS. BGL became a grade AEO.

On a domestic note Bernard is starting to build himself his own oscilloscope at home during the autumn of 1947.

Report AERE R229 “Vacuum equipment for the 4 MeV Linear electron accelerator” published Loach, March 1949, tells the story of his work over this period, probably until mid 1948.

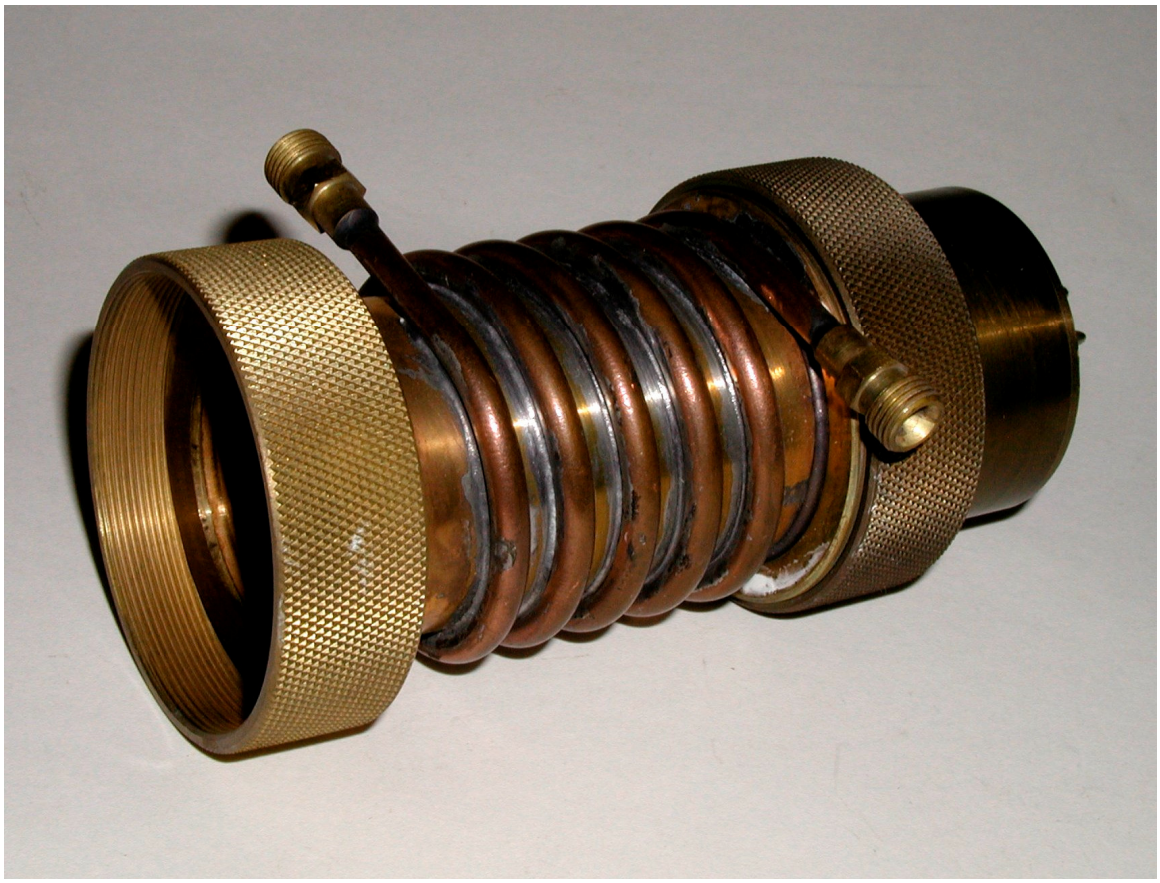
This describes the work shown in the photo, mentioned previously, showing pumping tables and automatic control equipment. This also included work on the diffusion pumps and vacuum gauges, and high vacuum shut off valves. Special shut off valves were needed to keep the pumps warm and running even when the machine envelope was open.

The main problem with obtaining the hard vacuum needed, is to remove all the remaining gas particles which, when approaching a total vacuum, still remain distributed with a

Brownian motion like smoke in space. These cannot be sucked out like the rest of the air, but special oil diffusion pumps are used. Also, the materials used to make the parts of the machine, including the metals, tend to start to shed their own gas particles at high vacuum, especially when heated. Even screw threads had to be of square section to provide a bypass for gassing from small dead spaces!

Automatic control and safety features were designed so that continual pumping was possible when unattended. This became part of the automatic remote control panel outside the concrete shelter.

Special gauges were designed for measuring the vacuum obtained. The report discusses use of GEC ionisation gauges and trying to improve these by designing an all metal triode version. “Work on this is continuing”. This ionisation detector is probably the artefact in the picture below, similar item seen in the picture above.



Prototype ionisation detector

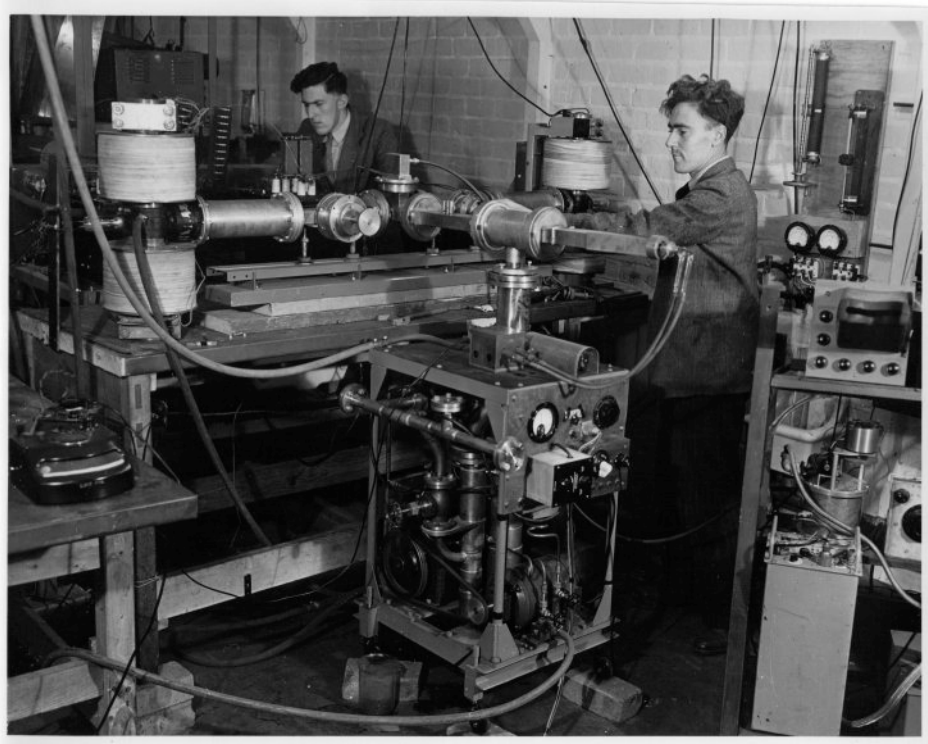
Joints and rubber seals were always a problem issue. The pumping tables were designed and continually developed. R Clay receives an acknowledgement in this report.

Control equipment

AERE report R224, "Control and Display equipment for the 4 MeV Linear electron accelerator", Gregory, Aug 1948, describes the whole control system, but there is only a reference to the vacuum control rack of Bernard's work.

There are a number of photos of the equipment, probably during development, dated March - April 1948. There were several racks of the control equipment. Some photos are probably of high voltage power and RF equipment (waveguides) and the electron gun?

There is a photo of some people working at waveguides in May 1948.



Cowhig(?) and another working at waveguides, 1948

AERE report R213 "A travelling wave linear accelerator for 4 MeV electrons", Mullett, July 1948, summarises the work to this point. The machine first worked in February 48.

It was found that the concrete 18" shielding was totally inadequate at the beam end. In a lab some 5 metres away the X ray level exceeded 100 times the tolerable level. An extra 30" of concrete had to be added to protect workers in the adjacent labs (huts?)
The only reference to Bernard in this report refers to Report AE1004, corrugated waveguides. However, it is noted that many general drawings of the accelerator were checked and approved by him.

On May 25-27th 1948, Open Days were held at TRE. The film "RDF to Radar was showing". This appears to be confined to the new site at the Naval base HMS Duke in Malvern, where the TRE became merged with RRDE. The Lees is excluded, presumably as this is no longer TRE work, but AERE work annexed from Harwell.

The 4 MeV accelerator report is published in Nature, November 27th 1948, with some references to Bernard.

"Linear Accelerators" by Fry and Walkinshaw, Physical Society 1949, makes references to work of Mullett and Loach 1948, Proc Physical Society 61, 271.

This report is "Experimental work on corrugated waveguides and associated components for linear electron accelerators", Mullett and Loach, work dated March 1948. This is available in the archive and also on the internet.

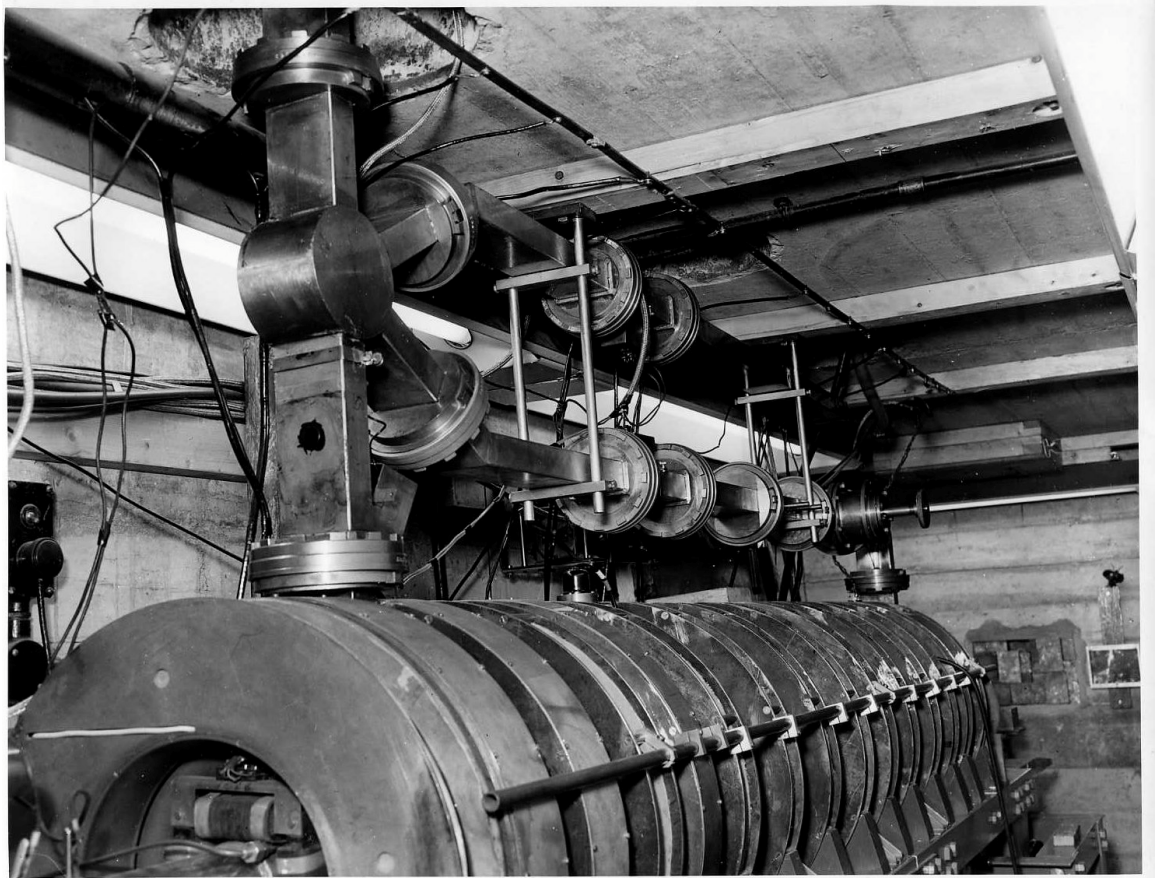
Report AERE R314 An injector gun for a travelling wave linear accelerator, Clay, 1949, also refers to the above reference of Mullett and Loach.

In July 1948 Bernard became grade EO. There are charts showing TRE grade staff exam results dated November 1947.

At this point is a major life event. In September he married Grace, to be his wife for the following 54 years. Having previously been staying at Crown Lea, he would shortly be moving to his first marital address, a flat at Homewood, Abbey Road, Malvern. Soon after that they had a short stay at Wyndover until December 49.

In June 1948, he appears to be doing phase velocity measurements. His note book refers to an experimental length of guide for the medical accelerator dated October 1948. In March 1949 he is looking at power ratios in X band Rat race systems.

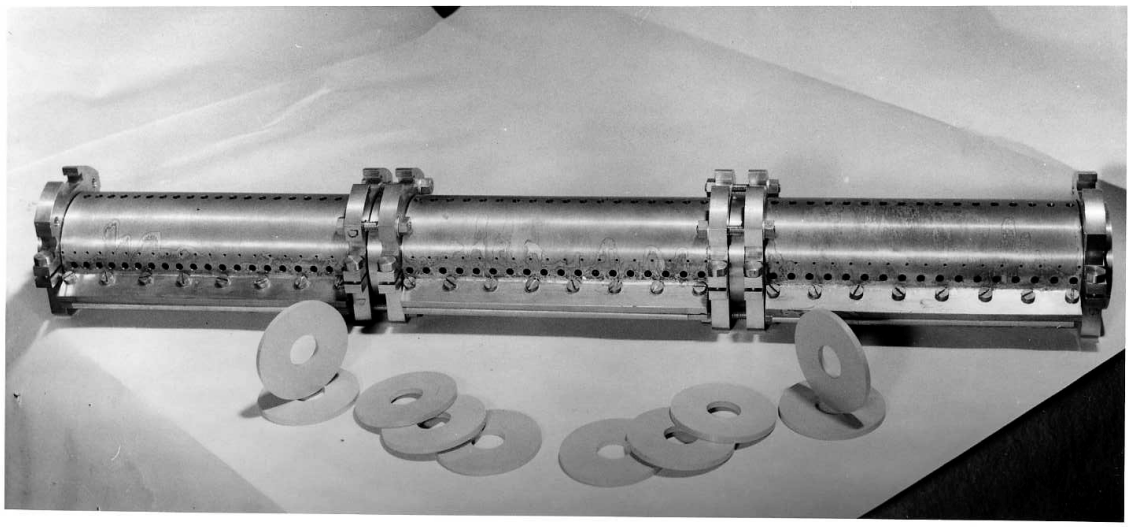
AERE report R391, "Wave guide bridge circuits for the combination of unequal powers with special reference to linear accelerator feed back systems", Mullett and Loach, 1949, summarises the work done during early 49. Use of Rat Race and Magic T. A Rat race seems to be special application of waveguides where RF energy is built up in a circular section of waveguide (Synchrotron mode?). The Magic tee allows energy to be fed back and recycled to increase energy. The photos dated January 1949 show this feedback system applied to the 4 MeV machine. Ben Kingdon was involved with this work and is acknowledged.



4 MeV machine now fitted with feedback waveguide system

In August 1949 “Two Metre Linear Accelerator”, Mullett, AERE R385, describes continued work with the machine but only acknowledges the assistance of a Mr Haddon. So we assume Bernard was no longer directly involved at this stage?. The report refers to the proposed 10 MeV medical machine, a commercial development for the Hammersmith Hosptial, which would be the first medical use of the technology developed at TRE.

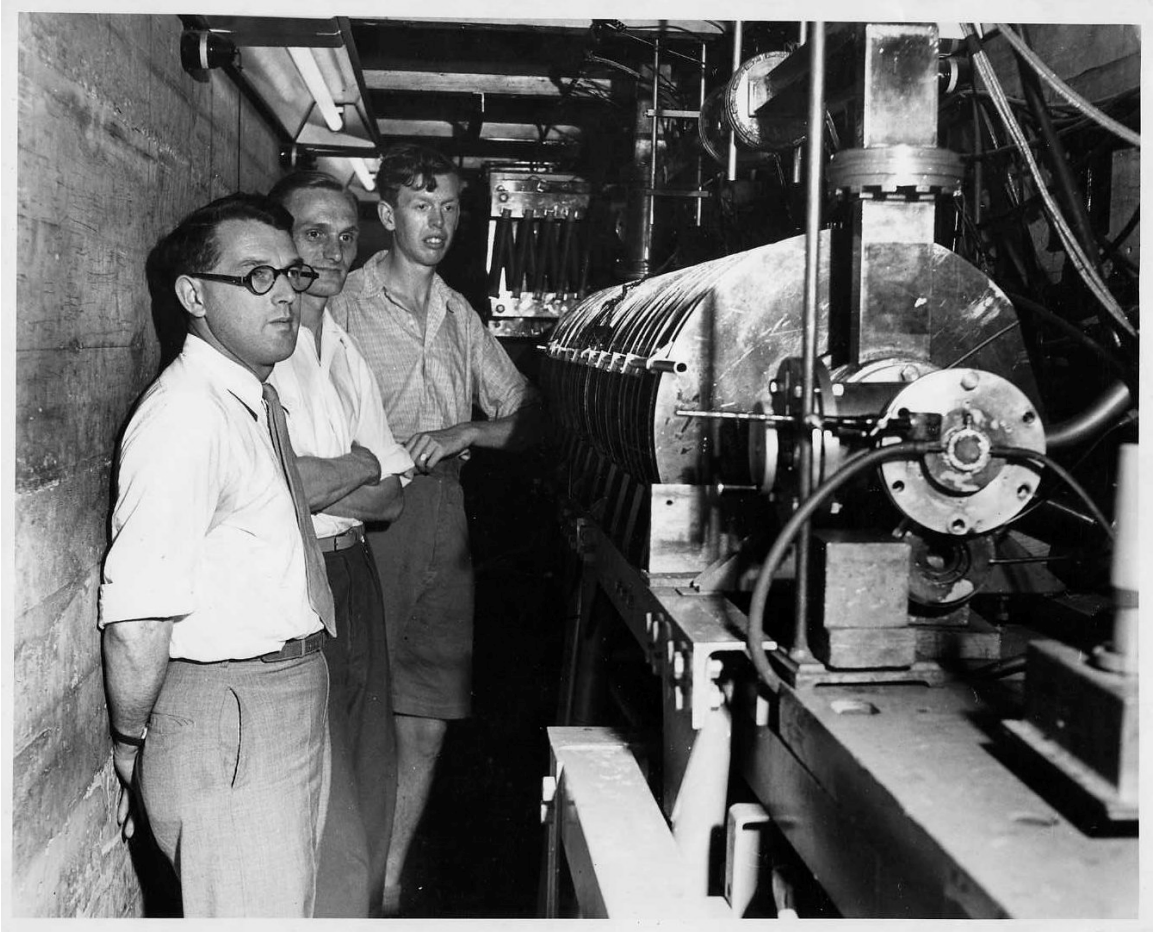
In “Theory of Dielectric Loaded wave guides applied to Linear Electron Accelerators”, Harvie, October 1949, Loach and Mullett are mentioned for their research on the subject so we assume this is what he would be doing at this time. This report refers to dialectric discs, and these may be the discs found among the artefacts.



Dialectric discs, subject of significant development

Bernard's notebook dated September 1949 refers to Schafers dialectric discs ground by a contractor. He is measuring them for quality and most are not considered fit for purpose for a variety of reasons. This work continues into October and then there is no further use of this notebook.

"A circular wave guide magic tee and its application to a wave guide bridge for the combination of unequal powers and a phase shifter utilising circular polarisation", Kingdon, October 1950, seems to be continuing previous work. This refers to the previous report of Mullett and Loach and the work of Mullett generally. A set of photos July 1949 seems to be relevant, showing circular waveguides, and a magic tee? Also loaders etc.



Note the cramped conditions at the Lees
D.Fry, L. Mullett, B. Loach

During 1948, further members of the T.R.E. team, engaged on atomic energy at Malvern, transferred to A.E.R.E. Some have remained, and others have left, including Dr. Denis Taylor, and D. W. Fry, Director of A.E.E. Winfrith.

Front Row, left to right
J. G. Thomason, I.C.I., Pangbourne; R. B. R.-S.-Harvie, SERL, Baldock; H. H. H. Watson, Culham Lab; F. K. Goward, (CERN — Deceased); F. Wingfield, R.R.E.; H. A. Chedzey, R.R.E.; J. B. Marsh, R.H.E.L.;

Second Row, left to right
P. S. Rogers, R.H.E.L.; G. Clarke, R.R.E.; R. H. Wharmby, Rolls Royce, Derby; H. Lyons, Defence Research Board, Canada; G. H. Hirst, Culham Lab; Mrs. Avis Brown. (Husband at R.R.E.); W. T. Cowhig, Shirley Institute, Didsbury, Manchester; Mrs. Joan James;

Third Row, left to right
D. Taylor, Univ. of Strathclyde; J. W. Gallup, English Electric; R. E. Clay, (R.H.E.L. — Retired); L. B. Mullett, Ministry of Transport; L. Metcalfe, R.R.E.; B. G. Loach, R.H.E.L.; C. P. C. Dalziel; J. D. Lawson, R.H.E.L.; W. Walkinshaw, R.H.E.L.; W. Abson, A.E.R.E.; J. Dain, English Electric; J. J. Wilkins, (R.H.E.L. — Deceased); J. M. Weaver, Culham Lab; D. W. Fry, A.E.E., Winfrith;

Back Row, left to right
R. Carruthers, (Culham Lab.); W. A. Gregory; V. Powell; G. T. Hawkins, (A.E.R.E. — Deceased); A. E. Andrew, A.E.R.E.; B. E. Kingdon, R.H.E.L.; L. S. Holmes, Culham Lab; ?. ?. Cox; G. Rae, R.R.E.

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