10th Issue

ORBIT

April 1963

The Journal of the Rutherford High Energy Laboratory

It was three years ago, on 20th April, 1960, that the Proton Linear Accelerator was first scheduled for nuclear physics experiments. This issue of ORBIT concentrates on the PLA - the first National Institute project to fulfill our mandate for Research in Nuclear Science.

The PLA

The History of the PLA

G H Stafford
Head of PLA Group

By 1952 π mesons had been produced artificially in the 180 inch synchrocyclotron at the Radiation Laboratory, Berkeley. It was well established that this particle was closely concerned with the nature of the nucleon-nucleon interaction and consequently a study of its mode of production, its properties and the details of its interaction with the nucleon were essential for the development of the theory of elementary particle physics. However the yields, particularly of positive pions, from synchrocyclotrons limited the scope and precision of the experiments and thinking at Harwell turned to the possibility of building a 600 MeV P.L.A.

The linear machine would have no magnet to constrain the protons and the positively charged pions and it was calculated that with a modest current of 1 microampere there would be an improvement of almost four orders of magnitude in the yield of positive pions over existing synchrocyclotrons. In many other ways too the linear machine had very desirable characteristics - low background, good energy resolution, variable energy and excellent experimental access to the beam. Those responsible for proposing that such a machine should be built were the present Director of the Rutherford Laboratory, Dr. Pickavance, and Professor Cassels, F.R.S. who was, at that time, a Senior Harwell Fellow working with the A.E.R.E. Cyclotron Group.

The technical and engineering problems were tremendous. A 600 MeV machine would be almost 300 yards in length; it would be operated for part of its length at a frequency of 200 Mc/s and at 400 Mc/s for the rest. At these frequencies the total peak r.f. power that would be required was almost 100 million watts and no suitable valves for producing this amount of power were available commercially in Britain. There were also many uncertainties in the physics of the accelerator, such as the best method of focusing the beam, the problem of phasing and control and the engineering tolerances that were necessary in manufacture. Moreover, the only accelerator of this type in the world being used for research was a 32 MeV single tank accelerator built by Alvarez and his collaborators at Berkeley, although there was a 68 MeV 3-tank accelerator under construction at the University of Minnesota in the U.S.A. No machine of comparable size was being contemplated anywhere.

Nevertheless, a decision was made to go ahead with the project. The Valve Development Group in A.E.R.E. was given the job of producing the necessary r.f. power and a P.L.A. Group under Dr. Pickavance was formed in the General Physics Division of A.E.R.E. to design and build the accelerator. By 1955 it was known that the 600 MeV machine would be very complicated to operate. Furthermore, its big advantage over synchrocyclotrons in the yield of positive pions available for experiments had been greatly reduced by the success achieved

(cont'd overleaf)

on the Liverpool cyclotron with a new method of beam extraction. Also the Bevatron had produced antiprotons and it was know from cosmic ray studies that there was a whole new family of unstable "Strange Particles" that might be produced with machines with energies of a few thousand MeV. So it was decided to limit the energy of the P.L.A. to 50 MeV and to concentrate the major scientific and constructional effort that was available on a completely different machine - NIMROD.

There is therefore nothing particularly significant about the energy of the 50 MeV proton linear accelerator (we once tried to christen it RAMROD but it was not looked upon with favour) yet it has turned out to be a very interesting energy region from the point of view of the nuclear physics that can be done for, until quite recently, the energy region between that available with Van de Graaf generators (a few MeV) and synchro-cyclotrons (100 MeV upwards) was not very easily investigated. We have not quite entered virgin territory because the 68 MeV P.L.A. at Minnesota had been working for some considerable time. However, as we have something like a 100 times more proton current a very successful source of polarized protons and a sophisticated time-of-flight device many experiments are open to us that Minnesota would find rather difficult to do.

Protons were first accelerated to 10 MeV in the P.L.A. on 10th November, 1958 and to the full energy of 50 MeV on 12th July, 1959. By this time the Rutherford High Energy Laboratory had come into existence and the ownership of the P.L.A. had been transferred from A.E.R.E. to the National Institute. The machine is now working very well. We operate on a 24 hour per day schedule and in the last five months have provided 2376 hours of useful machine time for the 50 experimentalists who are using it for their research work.

There is no doubt that the original arguments which led to the start of the 600 MeV project were correct. The P.L.A. has proved to be a very satisfactory machine to use for experiments and in many parts of the world now plans are being made to build very high intensity proton accelerators - pion factories - as they are called. Some of the groups favour proton linear accelarators, others cyclotrons making use of the recently invented principle of sector focussing.

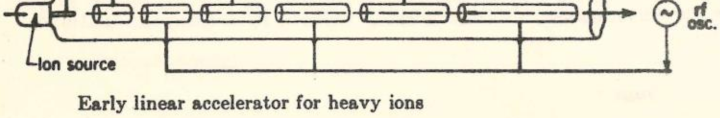
One disadvantage of a proton linear accelerator from the experimenters point of view is its poor "duty cycle". Because of the very large amount of r.f. power that a P.L.A. requires it is necessary to provide this power in pulses. On our accelerator the protons are accelerated in burst 200 micro-seconds long 50 times a second. This means that we have a beam for only 1% of the time that we could have it. This poor "duty factor" is a severe limitation on the experiments that are possible and so recently A.P. Banford has been carrying out some experiments in our laboratory to determine the practicability of operating a P.L.A. at the temperature of liquid helium (4.2°K). At this temperature some metals such as lead and niobium are superconducting and their electrical resistance at radio frequencies is 4 to 5 orders of magnitude less than copper at room temperature. With a superconducting linear accelerator the r.f. power requirements would therefore be very small and this in turn would mean that we could operate the accelerator with a 100% duty factor. Such a machine would be the ideal pion factory. It may sound far fetched but it is theoretically possible and the laboratory work to date is also quite encouraging. At best, however, a superconducting linear accelerator is many years away, but if developments in the physics of elementary particles justify it, who knows, one day we may see a proton linear accelerator working at a temperature near the absolute zero stretching as far as the Newbury road.

The Machine Itself

B G Loach

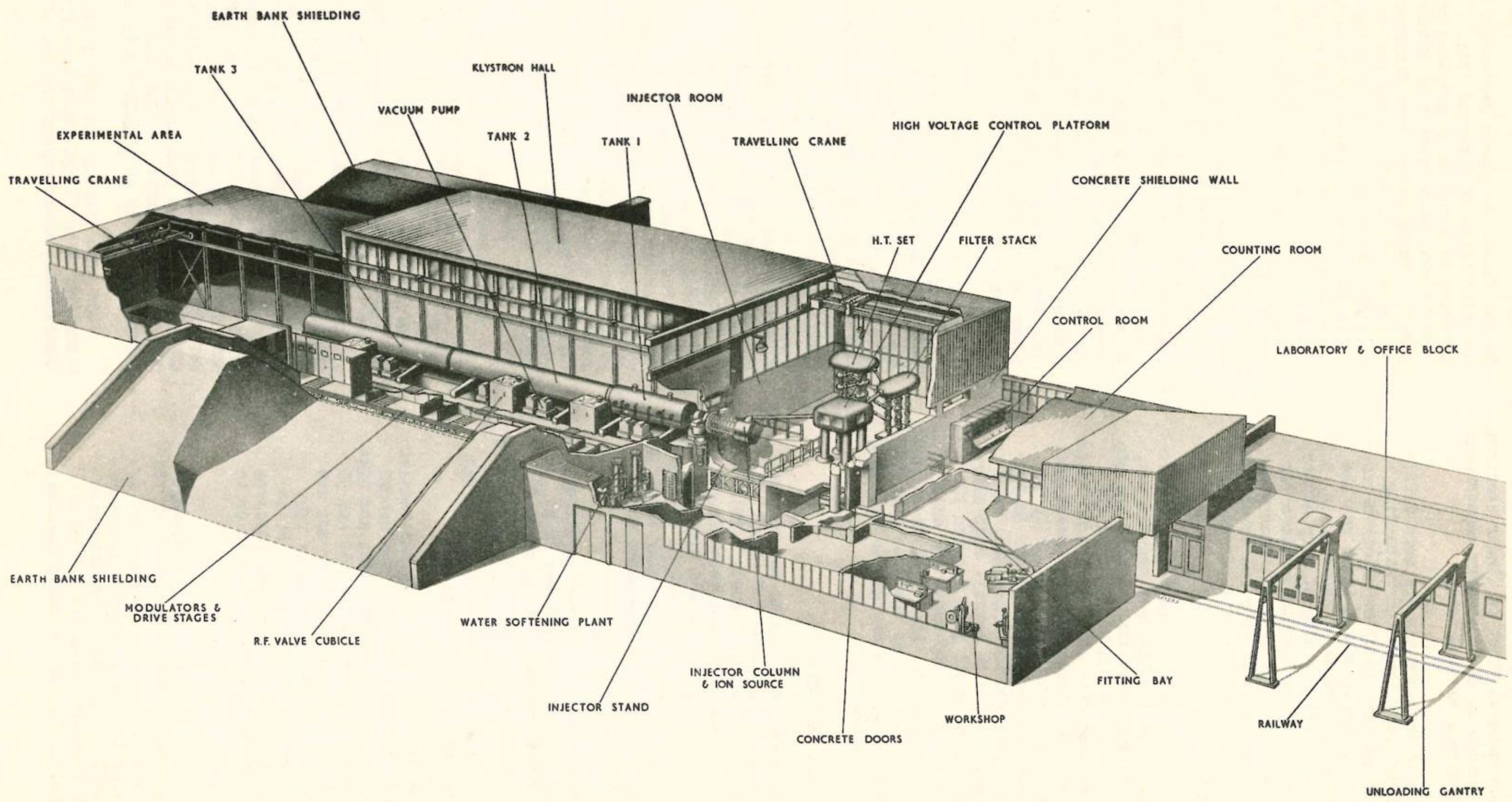
The principle of a linear accelerator (or "linac") was first developed from the earlier ideas of Wideröe by Sloan and Lawrence, who constructed a machine at Berkeley (U.S.A.) in 1931 to accelerate mercury ions to an energy of 1.25 MeV in a length of just over 1 metre. The diagram shows the principle of their device.

The positive mercury ions were accelerated in a series of "kicks" by forces they experienced in crossing the gaps between the thirty or so cylindrical electrodes (or "drift tubes"). These formed part of a resonant circuit fed with power at a radio frequency of 10 Mc/s. A radio frequency (r.f.) field is produced in the gaps between the electrodes and the accelerated particles cross successive gaps once each half cycle of the applied r.f. voltage. While the electric field is reversing in direction each half cycle the ions are passing through a drift tube and are screened from the field. The gap spacings are arranged so that the stably accelerated ions always arrive at a gap when the r.f. field is in the correct direction to give them a further "kick". Obviously the spacing and drift tube length must gradually increase as the ions gain energy and travel with greater velocity.



Early linear accelerator for heavy ions

In the 1930's it was difficult to generate much power at high r.f. frequencies and it was impractical to extend this type of machine for much higher particle energies. It was not until after the development of high power r.f. generators up to microwave frequencies during the 1939-45 war that interest was revived in linear accelerators.



50 MeV PROTON LINEAR ACCELERATOR

Development concentrated at first on linear electron accelerators and dozens of machines were constructed ranging in energy from 4 MeV upwards.

Efficient proton accelerators are more difficult to build, their total length corresponding to only the first few centimetres of an electron machine. The first successful proton linac was the 32 MeV machine built by Alvarez at Berkeley in 1947 and its success led to the building of many others, several of which are used as pre-accelerators for proton synchrotrons. All the proton linacs work on the same principle and, with very few exceptions, all are designed to operate at an r.f. frequency of about 200 Mc/s.

Basically, the principle of operation is similar to that of the Sloan and Lawrence machine but, due to the high frequency necessary to keep the gap spacing short, the r.f. techniques required are different. Lumped component circuits are no longer practicable and the drift tubes have to become part of a resonant cavity structure. This cavity is cylindrical in shape and about 3 to 3½ ft. in diameter. As in the Sloan and Lawrence case, when high power r.f. is fed into the cavity, high electric fields are produced in the gaps between the drift tubes, which are supported along the axis of the cavity. Now, however, the field is in the same direction in all the gaps at the same time and accelerated protons travel from one gap to the next in one complete r.f. cycle.

OUR MACHINE

The P.L.A. is about 100 ft. long and accelerates protons up to an energy of 50 MeV (their velocity is then about ⅓ that of light). This means that the protons have the same velocity as they would acquire by being accelerated directly between two electrodes at a d.c. potential difference of 50,000,000 volts: it is virtually impossible due to the insulation problems, to produce such a steady d.c. voltage.

The machine has three main copper resonator sections or "liners". Each is enclosed in an outer cylindrical steel vacuum envelope which is connected to a number of large (20inch) oil diffusion pumps to maintain a pressure below 10^{-5} mmHg in order to prevent scattering of the proton beam and avoid voltage breakdown in the resonator.

The first tank is about 18ft. long and accelerates protons from ½ to 10 MeV energy; the second and third tanks are each about 40 ft. long and take the protons successively to energies of 30 and 50 MeV. The drift tubes are made of copper and are supported on the axis of each resonator by two radial "stems". There are 42 in tank 1, 41 in tank 2 and 27 in tank 3. A proton thus receives about 110 separate "kicks" to accelerate it up to the 50 MeV energy.

Very high r.f. powers are needed to produce the fields required, amounting to about 600 kW for tank 1 and about 1.25 to 1.5 MW in tanks 2 and 3. It is only convenient to produce such high powers in very short pulses, using radar type modulator techniques. Even then approximately 0.5 MW of mains power is required to run the whole machine!

On the P.L.A. 50 pulses per second are used, each 400 millionths of a second long. The power is produced by a series of grounded grid triode amplifier valves, each capable of producing 1 MW of pulsed power. These valves were designed and developed by the A.E.R.E. valve group and are unusual in their "inside out" construction - having an external, directly heated, cathode and a central anode. The associated r.f. circuits take the form of "built in" resonant sections of co-axial line. Vac-ion pumps are used to produce an operating vacuum better than 10^{-6} mmHg.

Drive power for the main amplifiers is produced by the frequency multipliers and amplifying stages of a common drive chain, starting from a very stable, temperature controlled, crystal oscillator operating at a frequency of 2.5 Mc/s. The 80 MW pulsed power output from the drive chain is divided in the correct proportions and relative phases by a complicated series of co-axial line components. The power is transmitted through very large co-axial lines coupled into each resonator by a large loop. The r.f. power is practically all dissipated in the walls of the liners and drift tubes and these must be water cooled.

People often ask where the accelerated protons come from and are usually surprised to learn that the source is an ordinary bottle of compressed hydrogen gas. The hydrogen is fed into a glass tube (the "ion source") at a low pressure and the molecules are agitated by the electro-magnetic field produced by surrounding the glass tube with a coil carrying an r.f. signal of 20 Mc/s frequency. In the resulting discharge many of the hydrogen molecules are broken up into atoms and further, into protons and electrons. The positively charged protons are "extracted" from the discharge by a negatively charged electrode and pass through a series of focussing electrodes. The ion source is mounted on the insulated end of the "injector column", the opposite end, nearest to tank 1, being earthed. The insulated end is connected to a Cockcroft-Walton electrostatic generator producing a d.c. potential of 500,000 volts. The protons emerging from the source are accelerated down the evacuated injector column ready for injection into tank 1.

One problem not yet mentioned is that of keeping the proton beam focussed as it traverses the accelerator. If nothing is done, the beam will gradually spread out and most of will be lost by collision with the drift tubes. Two focussing methods are used on the P.L.A. Grids are fitted in the entrance aperture of every drift tube in tank 1 and cause a distortion of the r.f. field pattern which results in a weak focussing effect. A better method is used in tanks 2 and 3. This is called by the frightening name of "alternating gradient focussing" and is produced by placing special "quadrupole" electro-magnets inside every drift tube. These are arranged to give alternate focussing and de-focussing forces in two mutually perpendicular planes. (A similar effect can be produced for a light beam using suitably spaced converging and diverging lenses.) The beam is confined to a given diameter by this method with no loss of particles.

The beam leaving the end of tank 3 is transported along evacuated flight tubes to either of the two experimental areas beyond the end of the machine.

THE MACHINE ITSELF (cont'd)

Further quadrupole magnet lenses are used to keep the beam focussed. In each area a large bending magnet can be used to deflect the beam along a number of different beam lines, on each of which a different nuclear physics experimental apparatus can be set up.

When the machine is operating the levels of radiation produced around the machine and in the experimental areas are such that it would be dangerous to health for any person to remain there. The machine is therefore surrounded by concrete screening walls and earth banks and must be operated remotely from the main control room. This is the reason for the apparently bewildering array of buttons, meters and oscilloscopes which are provided to monitor and control the machine performance and output beam at all stages. Adjacent to the control room are two counting rooms where most of the electronic equipment associated with the nuclear physics experiments is located.

A drawing of the PLA appears on page 3. Some changes in plant layout have been made since the drawing was prepared. In this short account it is not possible to describe all the features of the machine and such items as the polarized proton ion source and the beam deflector system for time of flight measurements must be left for another time.

Nuclear Physics on the PLA

R C Hanna

Associated with the PLA are some fifty experimental nuclear physicists, the majority from Universities; in addition there are two teams largely made up from N.I.R.N.S. staff, and one from A.E.R.E. What are they doing and how do they do it?

Before trying to answer these questions, let us consider what sort of an 'animal' a 50 MeV proton is, because this largely determines what can be done with it. First, it is not energetic enough to produce mesons, or the 'strange' particles. But it has enough energy to overcome the repulsion from the positive charge on any nucleus, even uranium, easily; and once within a nucleus it can cause havoc, for each neutron or proton within a nucleus needs only 6 MeV or so of energy to set it free. There's enough energy to knock many nucleons out of any nucleus, and they can come out singly or tied together in small groups; the main problems in our research are to design experiments which single out the least complicated of all the events that can happen.

There are other consequences of the high energy. The protons whisk through the electron clouds surrounding atoms losing energy to them rather slowly, so they have good penetrating power (their range is about 5 mm of copper) and can see many nuclei along their path through targets. We don't need to be restricted to very thin layers of target material. Large currents of protons and thickish targets give plentiful yields from nuclear reactions (and considerable levels of residual radioactivity - usually just a nuisance). With their high momentum, the beams of protons are not easily bent and focussed; magnets for beam spraying and analysis are large objects (upwards of twenty tons) and quadrupole focussing lenses no toys.

So much for 50 MeV protons in general; what of 'our' protons in particular? There are two very important features of a PLA - it has a beginning and an end, both accessible. Protons can be selected before being put into the machine, and they come out in a well defined beam which can be transported to any one of a dozen or so experimental rigs. There can be lots of protons, 10^{13}/second or more, or very few (we've worked with 10/second), and they have their energy fixed to better than 1% at present, with scope for further improvements. Their worst feature is that they're only present for 1% of the twenty four hours per day the machine works. Although the physicists have not adapted to coming awake for just 200 μsec. fifty times a second, some of the electronic circuits have; they gobble data frenziedly while the beam is on, and send pulses to more leisurely equipment such as pulse height analysers in between bursts of protons. Within this generally unwelcome 'coarse' time structure there is a much more useful 'fine' structure. Protons arrive at targets in bursts less than 10^{-9} secs long, and by suitable preselection these bursts can be spaced up to 0.2 μsecs. apart, so that all secondary particles produced from one burst will have passed a detector before the next burst arrives. Similar timing precision is possible at the detector, so that velocities of secondary particles, can be measured very accurately and without confusion, by the 'time of flight' method. The other use we make of 'preselection' of protons to be accelerated is in the polarized proton source, where hundredweights of sophisticated hardware, operating at a potential of 500 kV above ground, let us prepare beams of protons whose axis of spin points in any direction we fancy.

With all these techniques available, and teams with a variety of interests there are many different types of experiment. One major activity is the study of the forces between isolated protons; here the interacting entities are simple, the energy too low to introduce the complication of meson production, but the nature of the force so complex that many different experiments, each of high precision, are needed. We have measured the absolute scattering cross section to 1% (this represents the area a target proton presents to a proton in the beam). Next comes a measurement of the asymmetry in scattering - it turns out that the tendency of a proton to be scattered to the left rather than the right depends on whether its spin is pointing upwards or downwards relative to the plane of scattering. For proton proton scattering the tendency is very feeble (only 3% more of the protons in a completely polarized beam will choose to go left rather than right at 50 MeV), but exact magnitude is very important, and has been determined as 0.0316 ± 0.0017, an accuracy unattainable without a polarised source (and much hard work, too). The next generation of experiments on the proton proton system are to show how the spin direction changes in the scattering process, and the first of these measurements (of the "depolarization parameter" which measured how many protons retain their original spin after scattering) has been carried out successfully. Two more are being started. Already much of the proton proton interaction can be explained in terms of the clouds of the mesons tied to the protons. Other features may be due to ω and ρ mesons; this is a field where Nimrod and the PLA may 'interact'.

Add a proton and two neutrons, and we study proton- α particle collisions where the asymmetry effects can be enormous - 90% of spin up protons going left for one angle of scattering; change the scattering angle 20°, and 75% go to the right. Similar oscillations in the effect happen with heavier elements. There is a large programme to study these 'polarization angular distributions', as well as the 'differential cross sections' and the total probability of the proton reacting with the nucleus and to interpret all the results together on the 'optical model'. This 'model' attempts to correlate elastic scattering of protons from a variety of nuclei over a range of energies in terms of a few numbers describing the size of the nucleus, the fuzziness of its boundary and so on.

Apart from elastic scattering, there is an enormous variety of 'reactions' that can occur at 50 MeV. One of the simplest is radiative capture. The proton is swallowed up and only γ rays are emitted, sometimes even only one gamma ray. Experiments show this particular reaction to be relatively rare, but not so rare as it should be!

Neutron emission can be studied very precisely by the time of flight method. When a proton striking a deuterium nucleus knocks the neutron out in a forward direction in most cases the neutron has a very well defined energy. This looks a particularly good source for neutron experiments. Interesting things happen with the more complex nuclei, in which neutrons outnumber protons. It seems that a proton can eject one of the 'excess' neutrons and occupy the hole left by the neutron. The energy of the neutron does not then depend on which 'hole' the neutron came from; the neutron energy differs from the proton's by an amount fixed by the Coulomb repulsion felt by the proton. The effect changes in importance with energy and size of the nucleus, and more work is needed to understand it properly.

Time of flight is also a useful technique when charged particles are ejected. Their energy can be measured from the intensity of the light flash they produce in a scintillation counter, and with velocity from the time of flight apparatus, electronic circuits can do the not too difficult sums to work out the particles' mass ($E = \frac{1}{2} mv^2$ - or very nearly). With additional counters to measure rate of loss of energy, the charge can be found too. By this method protons deuterons H^3 He^3 and α particles have all been identified as reaction products, and the angular distribution relative to the incident protons shown to agree with calculation in some cases. The (p, He^3) and (p H^3) reactions are particularly interesting; they can be pictured as resulting from the incident proton plucking a proton-neutron pair, or a pair of neutrons, out of a nucleus. To be effective, the 'pair' must be preformed in the nucleus. It seems that whereas in light nuclei the existence of the two sorts of pairs, and so the probabilities of the two sorts of reactions, is equally likely, in heavy nuclei neutron pairs predominate - the Coulomb force due to all the other protons acts on protons but not on neutrons, and breaks up the neutron proton pairs.

It's evident to us all that many years of interesting work lie ahead; improvements to the machine and new experimental techniques constantly come along to help us look at more and more complicated behaviour in the nucleus.

Dates for your Diary

Friday 3rd May	Dinner Dance at the 'Chicken in the Basket' (All tickets have now been sold)
Saturday 29th June	Director's Garden Party
Saturday 13th July	Rutherford Laboratory Open Day
Friday 19th July	Staff Meeting in the Cockcroft Hall

Correspondence has been received by the Assistant Director addressed as follows -

Mr. L. B. Mullett,
Director's Suit,
Building R.1

'Professor Bruno Pontecorvo, formerly nuclear physicist at Harwell ... has been awarded a Lenin Prize for unclear research ..'

The Observer, Sunday 21st April

EDITORIAL

A frequent topic of conversation in the Laboratory is that of signposts, notices, roads etc. ... and it has been the subject of several letters to ORBIT. Obviously the matter is under discussion and the prevailing situation will no doubt be greatly modified when the Laboratory site assumes a more permanent look. We thought however that readers would like to know what is intended at this stage and reasons for the present arrangements.

To this end Dr. Valentine has agreed to comment on some of the points from the following story of a visit which was addressed to the Editor by a Flying Officer from RAF, Abingdon and which is recounted as near verbatim as can be remembered.

"It has taken me nearly three quarters of an hour from driving past the main entrance to AERE to finding you here. I remembered you saying it was next door to the Harwell site so I kept my eyes skinned for a signpost. When I began to leave all buildings behind I turned back to try again and finally went to the police on the gate at AERE. They directed me through that odd arrangement of straw bales. Do you have stock car races at weekends or something?

Anyway, I came down that long road until I reached a gate manned by policemen. I couldn't understand why the place was fenced round - you are often talking about the work of the National Institute being free from security trappings and I expected to find buildings set in open gardens with a commissionaire at a reception office, not the appearance of a secret establishment.

When I asked to be directed to you, the policeman didn't know you. You never told me you were so junior - anyone would have thought I was asking for a road sweeper. He advised me to try at a gate further down. Same thing happened and I was directed to inquire in 'that building there'. There I was halted by an enormous notice saying Entry Forbidden Unless Authorised. This was rather confusing because I hadn't a clue whether I was authorised or not. My first thoughts were that some radiation danger existed and fearing for my progeny I asked several people was it alright to go in. No-one seemed to know and I finished back with the policeman. I was getting pretty frustrated by this time.

Once inside I eventually found someone who knew you and by a slow question and answer process found you at last. And as for helping people to find their way about ..." The conclusion is left to the imagination of the reader.

Since this visit, some months ago, several of the points have been cleared up. For good measure let us add a few related thoughts.

The recently posted road names - Road Four, Road Six etc. seem somehow lacking in poetry. Would some system like Neutrino Road etc. .. using the list of elementary particles be more exciting? It would then be most interesting to see whether the rate of discovery of new particles outstrips the development of the site or vice versa.

People rarely stop in obedience to the Halt sign near the cooling towers. Would a white line across the road help?

Is the PLA gate the better choice as the main entrance? From a safety point of view, it is easy to be lured into collision with traffic travelling down the runway indicating left, which is actually turning at the road junction and not into the gate.

Most of these points will be under review and it will be interesting to have some information relayed to the Laboratory.

DR. VALENTINE REPLIES:

Many of the points raised are of general interest and I welcome the opportunity of letting members of the Laboratory know what we are doing. Some of the matters are within our control and some not. I shall deal with the points in the order in which they have been raised.

(1) We would very much like to have the entrance to the Rutherford Laboratory more clearly marked. Some time ago we applied to the Ministry of Transport for permission to erect two signs on the A34, one on either side of Fermi Avenue. The application was turned down; we have appealed but so far have not had a final answer. However, A.E.R.E. have agreed to have a sign on their land facing the A34 and to place an additional sign on Fermi Avenue.

(2) The straw bales and the ground on which they sit belong to A.E.R.E., who are aware that the present arrangements are unsatisfactory. They intend, very soon, to replace the bales with an arrangement of white lines and cats eyes which, together with a dual carriageway along the north-south section of the road, will provide a system of rights of way, varying at different times of day according to the traffic requirements.

(3) I would not have thought that even the most sensitive nature would be offended by a 4 ft. high perimeter fence. In fact, we have been chided by the police for not taking greater precautions to protect our property against the depredations of the local baddies.

(4) The visitors' entrance is now clearly marked and the gatekeeper is armed with enough information to find anyone in the Laboratory. We would like to know of any difficulties encountered by visitors. Before long "You are here" maps of the site will appear at strategic places. These should be a great help to members of the Laboratory when they are directing visitors.

(5) The question of "Entry Forbidden" notices on buildings is a thorny one. Access must obviously be restricted to some buildings because of dangers of various kinds. Quite apart from that, we are torn between preventing buildings becoming filthy, by being used as thoroughfares,

and allowing unrestricted access. I would not have thought that the present range of notices would deter visitors from finding the office or lab they were looking for.

(6) The decision to use numbers rather than names for the roads was a conscious one taken at the Building Committee.

(7) Yes, there should be a white line to go with the halt sign on Road One near the cooling towers. It will appear soon.

(8) The main gate is the one at the junction of Road Seven and Fermi Avenue. The P.L.A. gate is the 24-hour gate and was chosen as such when the P.L.A. was the centre of most of the activity which went on in silent hours. There may well be a case for reconsidering this decision now and making the main gate also the 24-hour gate.

Letters to the Editor

Letters may be addressed to 'The Editor, ORBIT, Building R.1' Pseudonyms are accepted provided the authors name is known to the Editor.

Sir,

I feel compelled to point out gross errors in the 'Who owns the Zebra?' problem published in your last issue. We have heard much of the cunning attempts of the Americans to lure British Scientists from their Mother Country, but I little expected the 'house organ' of Britain's largest HEP Laboratory to print such propaganda.

Who ever heard of an Englishman living in a RED house, drinking MILK, smoking OLD GOLD cigarettes and keeping SNAILS? The Englishman in fact lives in a BROWN house, drinks BEER, smokes WOODBINES and keeps a WIFE and 2.4 CHILDREN.

John Bull

Sir,

In these days of intensive scientific research, some accidental overlapping of effort is inevitable, but with the distribution of Royal Society Medals and Nobel Prizes so critically dependent on the clear establishment of priority of discovery, I feel it necessary to point of that it was I who first suggested reversing the motion of the revolving doors to prevent the continual influx of cold air into Building R1.

Moreover, the self-styled "Theorists" have not in fact provided the theory; I originally published this on January 2nd, (on the back of an old copy of ORBIT), and showed that the volume V of cold air swept in per second is given by:

$$V = K \frac{d\theta}{dt} \qquad \text{---------- (1)}$$

(neglecting higher order terms, and assuming a door of infinite height)

Not only is it immediately evident that reversing the sign of $d\theta/dt$ causes cold air to be swept out rather than in, but one can also see that V will be completely independent of the position of the "PUSH" sign.

Another feature of this equation, not always appreciated, is that V is zero when $d\theta/dt$ is zero. This simply requires wedging the door and using the old R1 entrance; or, alternatively, that all the occupants of R1 should stay at home on cold days.

I attempted to demonstrate the latter effect experimentally during February, but I am informed that my absence did not noticeably increase the temperature of the building.

P. F. Smith

Sir,

Although you probably hope for no more technicality in your letters than that needed to decide the polarization of revolving doors, perhaps you would allow a comment on Professor Dingle's paradox, described, unhappily without the baby, in the March Orbit. In these days when theories seem proportionately short-lived to the particles they try to explain, the least one can do is to defend special relativity, when it has managed to survive, unsullied, from the beginnings of modern physics.

The crux of the problem lies in the definition of simultaneity in two systems moving uniformly relative to each other. Clocks can be synchronized throughout each system by allowing for the time taken for light signals to pass from point to point. But if the time scales are so arranged that clocks at A and X in the two systems are synchronous as they pass each other, clocks at other coincident points will be out of step; i.e. events which appear simultaneous in one system will not be so in the other.

Thus in the example given by Professor Dingle, at the moment in the A-B system when X passes A, A, B and X all read time zero, while the Lorentz transformation shows that Y already reads 144. When X reaches B, he reads 6 while B reads 30 (as all good pions and physicists know). A also reads 30 but the age of Y has increased by 6 to 150.

When we consider the situation from the XY frame at rest we find that A's clock reads 30 and Y's clock 150 as they pass each other, not 6 and 30 as suggested in the paradox, because the relativistic contraction requires XY = 5AB. Thus the same results are obtained for the ages of A and Y whichever system is assumed to be at rest, as must be expected from the symmetry of the Lorentz transformation. At time 150 in XY, B has long since passed X and has in fact covered 24/25 of the journey to Y. Just as simultaneity is peculiar to each frame, so distances in different frames which appear equal from one of them, appear unequal from the other.

What an opportunity for Orwellian equalities!

Michael Craddock

Something Odd

"Fss!"
"I beg your pardon?"
"I - er - I see you're looking at this model of the site."
"Yes, there seems to be a lot of building going on."
"Ah, now there you have it! You've put your finger right on it! But there's something else going on that not many people realise - something odd - what do you make of that!"
"You mean that building there, number 29?"
"That's it. Notice anything peculiar about it? About the shape of it? That circular bit with a rectangular bit joining on to it?"
"What's odd about that?"
"Why, can't you see - it's an accelerator!"
"My dear chap, that's the new canteen building."
"Canteen! Ha, Ha, how naive! That's just a cover - it's another accelerator I tell you. Look at the shape of it for a start. Who ever heard of a canteen that shape! Why it's quite unfunctional for a canteen, I mean, how are the tables going to be arranged? Are we all going to sit in concentric circles or along radii? And what happens to the poor chap in the middle - why he won't know whether he's coming or going. But for a cyclotron type accelerator, that shape is absolutely fundamental and impossible to disguise, as this clumsy attempt shows."
"Look everyone knows that's the canteen! You're joking of course, Ha, Ha!"
"I'm not joking at all - you must listen to me. Can't you see the boldness, the audacity of it - to build an accelerator right under our noses without us knowing. But I'm not fooled. Have you seen anybody having a meal in there? Have you seen any fish and chips?"
"But it isn't finished yet!"
"Ah! exactly! so how can you say it is a canteen? We're told it's going to be one, but I say it's going to turn out to be an accelerator. What about those rumours that it was costing too much. Of course it is - for a canteen, but not for an accelerator. And why is it taking so long to build? It seems a particularly simple structure to me, but you see, it's what is being built underneath that's taking the time."
"Look, that shape was a deliberate attempt by the architect to symbolise the work of the Laboratory."
"Double bluff! Can't you see it? First put up a building that must look like an accelerator and then pretend that it's a canteen symbolising an accelerator when all the time it is an accelerator. Doesn't the subtlety of it take your breath away?"
"I have an appointment I'm afraid ...."
"No don't go, look, this isn't the only thing. Look at this building over here."
"Well I'll believe that's an accelerator, it's the Variable Energy Cyclotron isn't it?"
"Ah you've used the new name! They've got at you, you see. It used to be called the Chemists Cyclotron, but that was one of their few mistakes - why what would a chemist want with a cyclotron? They've given it an obscure name now just to fool us."
"But it's an officially approved project - everyone knows about it!"
"There you go again - "Everyone knows" - people only know what they're supposed to know. Look at this model again. First the big one, in the pit, and now these smaller ones springing up all round! Can't you see how they're spreading - reproducing all round, like polination from one fertile centre! We're all in great danger and yet people go about just as usual!"
"My dear fellow, calm down! You're making yourself ill with all this. Now just consider it rationally and answer two questions. Who are these people and why should they perpetrate these things?"
"I'm glad to see you're beginning to take me seriously. Now, I can't tell you who They are - too dangerous - but I'll tell you this much - They're not of this world, old chap - dear me no! As to why they're doing it, I've only theories so far, but this is what I think - we're being taken over, that's what!"
"But how?"
"Why can't you see it? All these machines are very expensive and more and more are being built - all over the world - this is only a small part of it here - even the Russians are going under - it's growing like an epidemic - why it's undermining our whole economy, absorbing all our manpower and brains - we're all involved can't you see!"
"I have to go now ..."
"Look at the moon!"
"Please don't shout!"
"Well don't keep walking away then! I tell you it happened on the moon and it's happening here. All those craters up there. "Were they volcanoes or were they caused by meteorites" - why it's clear as day, they're old accelerator pits! It's all happened before ..."
"Just sit down over there old man while I make a phone call."
"Who are you calling? Hey you're one of Them yourself aren't you? That's it, I should have realised before - take your hands off me - put me down ...."

POLICE NOTICE

A reward is offered for information leading to the arrest of Eddy Current, charged with the induction of an 18 year oil coil, Milli Henry, found half choked and robbed of valuable joules.

The rectified criminal armed with a carbon rod escaped from Weston primary cell where he had been clapped in ions. The escape was planned in three phases. First he refused the electrolytes and climbed through a grid, despite the impedance of warders and finally went to earth in a magnetic field. It seems likely that he stole an AC Motor. This is of low capacity and he is expected to try to change it for a megacycle and return ohm by a short circuit. He may offer series resistance and is a potential killer.

Personnel News

Suggestion Awards

Awards totalling £24 were made at the seventh meeting of the Rutherford Laboratory Suggestions Awards Committee held on Monday, 22nd April, 1963.

Some suggestions, although they may not be adopted in their present form, were considered to merit recognition and Encouragement Awards were made in this respect to the following:-

Mr. E. B. Iberson - £1
Mr. P. Seager - £1
Mr. J. McHugh - £1
Mr. J. E. Vanstone - £1

The Suggestions Awards Committee recommended the adoption of suggestions submitted by the personnel named below and Awards were made as shown:-

Mr. C. D. Moreton - £2
Mr. E. B. Iberson - £2
Mr. T. B. Stewart - £10
Mr. F. S. Whear - £2
Mr. R. A. Kimber - £2
Mr. J. C. V. Clarke - £2

D. Rose, Secretary,
Suggestions Awards Committee

Comings and Goings

J. E. Hailstone, R. M. Nelson, Mrs. J. M Stammers, Mrs. P. Bridgeman, H. W. Harris, Mrs. J. Gilmartin, Mrs. W. D. Phelps, N. K. Roberts, D. N. Bennett and Mrs. D. E. Baston join Atlas Laboratory.

W. M. Evans joins Electronics; M. E. Sproul joins PLA Nuclear Physics.

D. R. Perry, Miss S. Norcliffe and W. B. E. Marsh join Radiation Protection.

A. G. Morley joins Theoretical Physics; Mrs. L. M. Goward joins Finance and Accounts; A. E. Ball joins High Magnetic Fields.

V. J. Rohatgi and Mrs. M. Rohatgi have concluded their fixed term appointments.

D. C. Clifford, Mrs. J. F. Craig, A. Morgan and E. M. Dickins have left us.

H. Hall has retired.

Congratulations to -

Gilbert Payne of Electrical Design Group and his wife Lorna on the birth of a son, Andrew John, on the 13th April.

Who Owns the Zebra ?

The complete solution of the problem is as follows:

HOUSES	Yellow	Blue	Red	Ivory	Green
INHABITANTS	Norwegian	Ukranian	Englishman	Spaniard	Japanese
PETS	Fox	Horse	Snails	Dog	ZEBRA
DRINKS	WATER	Tea	Milk	Orange Juice	Coffee
CIGARETTES	Kools	Chesterfield	Old Gold	Lucky Strike	Parliaments

The first correct solution to reach the Editor's Office was handed in by David Price from the R.9 Workshop. He received the prize of a zebra (inanimate, shelf mounting type) and a glass of water.

Many correct solutions were received including those from P. Gill, P. Smith, Mrs. L. B. Mullett, S. H. Spanner, C. G. Bonfield, C. Gascoigne, G. Arnison, M. Craddock (who was worried by the projection of the 'soft' image of a milk drinking, snail rearing Englishman), A. Pitkethly, D. Rose, D. W. Galbraith, H. E. Morgan, R. E. Worsham, G. M. McPherson, Mrs. C. Pickles, C. A. Baker, L. Denton (who used an ingenious method of cutouts to reach the solution), Miss F. Slade and R. Q. Apsey. Others checked that they had the correct solution without recording their names.

'Life' magazine itself - the source of the problem, have received about a thousand solutions and they continue to arrive. In their issue of March 25th the Editor's Note concentrates on this high response and uses it to proclaim 'For years we have taken it for granted that our readers were above average in education and professional attainment ... One of the many requests for permission to re-publish the problem, for example, came from the editor of the house organ of Britain's National Institute for Research in Nuclear Sciences'.

... and as I tapped the ash from my Havana cigar into the gold plated NIRNS ashtray on the polished teak desk I smiled quietly to myself, raising my eyes to the Picasso reproduction marked out so cleanly from the oak panelled walls of my office and thought, 'Very true .... very true'.

Editor

SAFETY on our Roads

While travelling to the Laboratory from Abingdon I have seen more accidents in three years than in the rest of my life. This is supported by the National Safety League Chart for 1962 reproduced below- Oxfordshire has the poorest record in Great Britain and Berkshire is little better. Because of this we deviate slightly from usual ORBIT material in reproducing this article. -

Editor

ROSPA (The Royal Society for the Prevention of Accidents) launched a 'Get fit for the Road' campaign on 8th April. Paul Haile, Head of their Road Safety Division describes a game with a safety slant which might prove interesting and useful.

'The game demands a good knowledge of the Highway Code and a measure of self criticism on the part of the driver. It should not distract the driver's attention from the job in hand. On the contrary, it should improve his ability to drive defensively.

One mark is scored for every breach of a Highway Code regulation noted by the observer. If there is more than one participant, the observers compete against each other. If there is only one, he or she sees whether a stated total can be reached before the end of the journey. A mark is deducted for every breach noted by the driver but not by the competitors.

If a breach on the part of the driver is seen, two marks are awarded to the observer. Similarly, two marks are deducted if the driver confesses to a fault not seen by his passengers. This is of course where self-criticism by the driver is needed. It's funny how often in such circumstances an excuse is immediately forthcoming from the driver, at least it would be funny if ordinary breaches of the principles of the Highway Code did not so often have tragic results.

Where the points pile up is in restricted areas, one point for every car overtaking the driver who is doing his steady 30. Incidentally, I wonder if drivers who habitually exceed the speed limit ever seriously work out how much time they save by so doing. It's astonishing how often I catch up drivers when we all stop for the next lot of traffic lights. Or there are those who rush past at about 45 m.p.h. to turn left across one's bows into a side road, or even into a garage or private drive only 100 yards ahead.

Foggy weather, particularly daylight fog, is another time when the points are rapidly increased. It amazes me to see the number of people who drive on side-lights only when visibility is no more than 20 yards. They see similar offenders coming towards them, at least one assumes they do, but they still do not seem to realise how difficult it is to be seen in conditions like this. They almost certainly don't realise that at only 20 m.p.h. those 20 yards of visibility are covered in under two seconds, not long for an elderly pedestrian to get out of the way.

Travelling too close behind the vehicle in front is another source of plenty of points. One car's length for every 10 m.p.h. in good conditions - more during bad weather - is the ideal. But if these people do use their mirror, they are always the first to complain if they happen to notice that somebody else is about to drive up their exhaust pipe. More often than not they are the ones who think that that little mirror is there mainly for the (female) passenger's face-saving activities.

Lane straddling and lane weaving, bad positioning and turning without signals all deserve a mark. And then there's the fellow, usually to be found in country districts, who drives a small-powered vehicle 10 years' old or more, does a steady 25, hugs the middle of the road and refuses to let others pass him.

These are but a few of the obvious offences. After a little experience you should be able to spot the not quite so obvious offences, but those more liable to result in accidents such as bad overtaking, cutting in, poor cornering and so on, not only on the part of the other fellow, but also on one's own part. But it's not only the car drivers who can increase the points. Lorry drivers, motor-cyclists, pedal cyclists and pedestrians can all add their quota. I wonder how many pedestrians are aware that the first 15 paragraphs of the Highway Code refer to them, let alone know the advice given.

Admittedly this game is based on entirely the wrong premise in that one should not try to get a high total of points for bad behaviour on the roads. The rules assume that bad and selfish actions on our roads are common. But this unfortunately is the fact that has to be faced and is the factor which is one of the primary causes of an average of 19 people being killed and 940 being injured on our roads EVERY DAY.

The game I have outlined can teach correct road behaviour in the young and it's good for the driver too. This year we are asking everyone to "Get Fit for the Road". This is one small way of doing it.'

NATIONAL SAFETY LEAGUE, 1962

COUNTY	One person dead or injured to number of persons
Essex	250
Durham	249
Lanarkshire	214
:	:
Cheshire	173
Yorkshire	170
Lancashire	168
:	:
Berkshire	137
Devon	136
Suffolk	120
Cambridgeshire	119
Oxfordshire	118

(The national average for 1962 was one person dead or injured in road accidents in every 145).