1ST ISSUE JULY 1962

ORBIT

THE JOURNAL OF THE RUTHERFORD HIGH ENERGY LABORATORY

MESSAGE FROM THE DIRECTOR

The Journal of the Rutherford Laboratory, of which this is the first issue, arose from suggestions by members of the staff. It is not an official arm of Management, and will not replace the Bulletin or any of the other documents, official and unofficial, which we all see from time to time.

But the Journal is officially blessed, and the purpose of these remarks is to recommend it to your attention and for your support. Mr. Southworth is a voluntary Editor, and he will need the support of contributors and helpers; I hope that many of you will help him generously. His general aim is to create a lively and interesting Journal, with human as well as scientific interest and for circulation inside and outside the Laboratory. The interpretation of this aim is for him and his associates to determine, and you will see in this first issue something of what they have in mind.

I wish the Journal well, and hope that it will become an important part of the life of the Laboratory.

T. G. Pickavance

REPORT ON NIMROD

The Assistant Director, Mr. Mullett, Presented a progress statement on Nimrod to the Visiting Committee on 13th June, 1962. The bulk of that statement is reproduced here as a comprehensive assessment of the state of the Nimrod Project.

"The present time programme shows August 1963 for 'closing' the machine for commissioning and this date has been held for the last six months. Progress on the machine was, until recently, entirely governed by the supply situation but we have now moved into a period of comparative plenty and can build up and maintain effort and enthusiasm.

Buildings

The magnet room is completely mounded and grassed over so that there will be no more shifts of the magnet foundation due to earth moving. The extension of the main experimental area by roofing over the hardstanding on the west side has started and is programmed for hand-over 31st March 1963. The extension of the Parasitic Area is just starting and is programmed for hand-over 1st April, 1963. This is a very tight programme.

The Heavy Liquid Bubble Chamber Area is handed over. There are some troubles with floor finish to be resolved. The extension of the Control Room Block to the south is handed over.

Work is well in hand on the major extension of the Control Room Block. The three-storey section is programmed for hand-over 31st May, 1963, and the five storey section 30th September, 1963. Unfortunately nothing can be done about these dates and we are clearly going to miss having this building fully occupied before commissioning NIMROD.

Progressive hand-over of the main R.1 block has been recently concluded with the Computer wing.

The Package Job offices and heavy duty laboratory are making excellent progress (Beecham Buildings Limited). The hand-over dates are 8th September, 1962 and 31st December, 1962 for the heavy laboratory and office block respectively.

The site is now much tidier. We have lawns and gardens and the artificial hill has been landscaped.

THE MACHINE

Injector - The injector first worked way back in August of last year and produced 15 MeV protons in identifiable quantity. Unlike other accelerators of this type it immediately got worse rather than better and multipactoring prevented build-up of R.F. field in the tank. After many profitless attempts to clean the vessel and drift tubes the alternative approach of 'dirtying' was tried. The process was described as by 'bell, book and candle' and was literally the latter. The result on a few drift tubes was very encouraging and by more subtle means lampblack was applied to all the drift tubes. Multipactoring has hardly been seen again but voltage breakdown then became the limitation. However it was found that this could be conditioned and in mid-February a beam was again achieved. We have had something like 3 ma of protons at 15 MeV, this without the help of the pre-buncher, and much investigation of the performance and the nature of the beam from the machine has been carried out in this state before adding the complications. Although the X-ray background is now higher, tolerance level is still at a walking distance from the tank. Recently the tank has had to be opened which meant more work on the lampblack. We have had trouble with the main R.F. valve and with insulators. These troubles are being overcome and we have reasonable assurance that the injector will be capable of providing all the protons that NIMROD will accept.

Inflection Systems - The achromatic inflection system of four magnets and a final electrostatic inflector is designed and much of it made and is being tested. The inflector box is in place for magnetic survey.

Magnet and Power Supply - In the same week in mid-February the furious and concentrated efforts of all concerned with the magnet and its power supply achieved the remarkable success of 11,000 amperes. This was with half the magnet

(Cont'd on Page 3)

HOW MAD ARE WE ! ! !

Extract from a recent report concerning a fire in R.20.

'...., the fire was extinguished by the inmates of the building'

Anyone else had similar suspicions concerning R.20 ? ? ?

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and half the power supply working exactly as in final operation. The injection-flat system was found to work and extraction flat-top was also tried.

11,000 amperes corresponds to roughly 16 kilogauss which is near enough 8 GeV. How far we can accelerate a useful beam beyond 7 GeV depends upon the performance of pole pieces and pole face windings. This part of the programme was completed virtually on schedule with a 24 hour run at over 10,000 amperes and a repetition rate of 20/minute with remarkably few shutdowns. This long run produced significant shakedown of the coils and some pole piece movement, all of which has been dealt with, although it has warned us that we ought to do such a shakedown on every completed octant. Six octants were involved at various times in these tests. We had always planned to have a little in hand on the power supply and it turns out that we have done rather better than we expected all round. The maximum repetition rate at 7 GeV will be at least 30 per min. with the minimum flat top and about 26 with 0.5 sec. flat top. The second half of the Brown Boveri converter equipment has been similarly run up to 11,000 amperes. We now have all the pole pieces, and most of the pole face windings. Straight section boxes are available for magnet survey.

Preliminary magnetic survey hit some troubles with ripple on the magnet power supply where one is effectively measuring $\frac{dB}{dt}$ because this is directly related to applied voltage. We do not yet have the final ripple correction system installed and we tried to adapt the ripple filter transformers, which were already installed as chokes. This was not successful but detailed balancing and filtering of the measuring coils achieved the equivalent result.

Vacuum System - We can dispose of the vacuum plant pumps, pipes etc. as ready at any time they are wanted, except of course for some hard work in installation, and very pleasing progress had been made on the really difficult problems of vacuum vessels.

We were all prepared to spend many weeks in leak hunting and repairing every vessel. The acceptance figure for the outer vessels was set at 150 lusecs. Within two weeks of delivery, again in this week in mid-February, the first production outer was down to a leak rate of 6 lusecs and on its way into the machine ahead of programme.

The number two vessel was even better in time scale for testing and in leak rate (1.8 lusecs). Vessel No. 3 was not so good but is now fixed to a similar leak rate. Vessel No. 4 will be under test shortly; components are made at the factory for several more vessels and we should complete substantially to programme. We have gratefully accepted the opportunity presented by the early availability of Vessel No. 1 to vacuum test a completed octant of the machine as early as possible, that is, before rather than after magnetic survey on octant 5. We want to see whether any further problems appear. This too should be happening by the date of the meeting.

The prototype inner vessel has eventually been repaired to the extent of a leak rate of 0.6 lusecs. The acceptance figure for inner and header together is 1.25 lusecs. The first production vessel immediately showed a leak rate as low as 0.8 lusecs without any leaks. Further vessels are following closely behind. If all continues to go well we should pick up time in production of inners and complete substantially to programme.

The header vessels have naturally been dealt with as the last component and development teams are still engaged but we should get the first one in July/August and have four available by early next year. In parallel we are producing closure plates of thick polythene with tie bolts to take the atmospheric load. At the end of June we shall re-assess the relative number of headers and closure plates. If the desired vacuum can be achieved with less than the full five diffusion pumps per octant then we shall be happy to have more closure plates. They are cheaper and we can get closer to beam in the machine. However, with a leak rate of 0.8 lusecs on inners it looks as though the increased pump capacity of headers is still desirable.

R.F. System - We tend to forget the R.F. system, because it has never looked like being a holding item despite the fact that it too has had troubles. The whole system has been built and operated and is now approaching a Mark II form throughout.

A transistorised Primary Frequency Generator is available.

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A CRY FROM THE HEART ! !

Overheard at the Laboratory on the Open Day, June 16th.

"But Daddy, I thought you said it was a Bubble Gum Chamber".

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Report on NIMROD (Continued)

The cavity has been rebuilt with copper clad steel for magnetic shielding and new R.F. coupling has been built in. This has worked up to full power. A transistorised bias supply will be available soon to replace the silicon, germanium set. The production R.F. drive unit is being tested at Pye. All the original equipment is in place in the magnet room with the cavity in the withdrawn position.

Everything that can be done without having protons to accelerate should be done in plenty of time.

Control System - Steady progress has been made and we are now determining how best to arrange the front row of the control room racks for ease of commissioning. At this stage we shall not be operating with a control desk.

Installation and testing - The present state of the machine is that we are well engaged in magnetic survey. Five periods of four weeks each are involved. In the first period all the techniques had to be proved and certain final shimming experiments made. We lost a little time in this stage. The next four periods are survey proper moving around the machine, powering four octants at a time and changing a pair each month. The physicists normally work from 10 to 12 hours a day which involves two shift operations of the power supply. Night working is being used to catch up when there are things like power supply troubles. During weekends the installation teams move straight section boxes in and out, and do other things required for survey. At the same time many other installation jobs have to be fitted in. The first period of survey proper will, by this meeting, be completed about a week behind programme. We expect that having done everything once we shall pick up lost time before the end of the survey. The results are good. Remanent field is 8 to 12 gauss averaged over 3 sectors. The pulsed 'n' values are now well within the correction limits of the pole face windings and the pulsed median plane is not more than 0.1 inches above the geometrical centre.

Two octants of the machine are now complete with outer vacuum vessels and pole pieces and will enter magnetic survey in this final condition. The other six have pole pieces accurately installed but without vacuum vessels. Immediately after survey these octants will be stripped down for installation of outer vacuum vessels and so much work will be going on in the area that we have to do model exercises to see that no terrible clashes occur.

At this time much work has to be done on the power supply. No. 1 alternator is being rebuilt at English Electric and we should get it here in August. It has to be installed on the foundation block, the whole rotating system has to be aligned with fitted bolts and we have to check that the two halves of the power supply work properly both individually and together.

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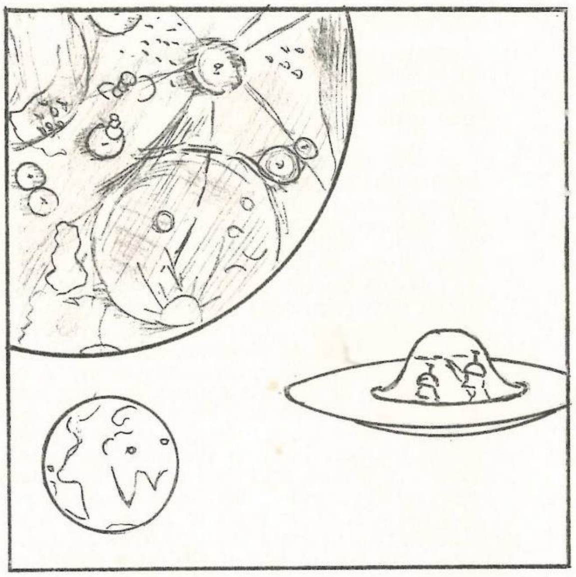

"LOOK! ANOTHER PLANET WHERE THEY BUILD BIG ACCELERATORS".

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We cannot be completely happy about full energy and full repetition rate for the whole machine until we have done this. We also have to commission the ripple filter system, get injection flat and particularly extraction flat to work properly and do odd jobs like ultrasonic surveys of shafts, flywheels and so on. During all this time we also feel the necessity for carrying out 24 hour shakedown runs on completed octants. We need to get closer in time to the problem to see the factors which will emerge to help us to determine the course of things.

The last run of the programme to a working machine may seem to show a generous amount of time, but there is a great deal of progressive installation to be done interspersed with vacuum testing. We shall be looking for any corners which we can cut as we get more experience but cannot as yet commit ourselves to any compression. Our confidence is expressed by the fact that we now have regular meetings of the Commissioning Working Party. Dr. Hobbis runs this working party because he will be in charge of commissioning the machine. In the Commissioning meetings we are educating or re-educating ourselves about the parameters and mode of operation of the machine, determining in the light of our own experience and that of other establishments how best to carry out injection and acceleration studies, making sure that we have the appropriate variables and diagnostic equipment, and finally trying to assess in advance the meaning of certain results and the consequent action required.

E D I T O R I A L

Today marks the birthday of 'ORBIT' the first journal of the Rutherford Laboratory. The idea of a Journal had been with several people for some time and it was Ted Harrison who finally took the initiative to get the project underway. He is featured in PROFILE for his pains.

The Journal will aim to foster a spirit of common interest by helping to create a popular and likely image of the activities and aims of the Rutherford High Energy Laboratory. Since we are all employed by the National Institute, we can assume that we are of use to the Laboratory no matter what our sphere of activity. We are each of us making some contribution to the Laboratory projects and therefore have an interest in the progress of these projects and can rightfully share in their ultimate success.

Monthly progress reports, simple explanations of projects, news from other accelerator laboratories, reports from conferences etc. .... should all help to keep us aware of our immediate state and alive to our position in the world of science.

The second aim of the Journal will be to provide a platform for a broad range of topics related to work at the Laboratory. This should cover the full spectrum of human interest ranging from serious articles on general themes related to some aspect of Laboratory life, through humour, intended and unintended, to Births, Marriages and Deaths .... If something of interest has happened or you have something interesting to say - get it into ORBIT! All personnel may contribute to our pages in this field with articles, news or letters.

Here then, is our first issue. Like all new born creatures, ORBIT will need close attention and careful nourishment in its early days and its success will depend largely on the extent of enthusiasm for its aims. We will attempt to provide something of interest for everyone which is a tall order in itself for all types of people are involved with a wide range of interests. However, let us hope that as the Journal grows up from this modest beginning, it will take a stimulating and popular part in the life of the Rutherfore High Energy Laboratory.

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LETTERS TO THE EDITOR ....

Pseudonyms may be accepted provided the author is known to the Editor.

Dear Sir,

Your Journal provides me with a long awaited opportunity to ventilate my feelings on the subject of footpaths and sidewalks in and around the Rutherford High Energy Laboratory. On two recent occasions I have narrowly escaped being run-over whilst walking from one building to another. For some reason quite beyond my comprehension pedestrians are expected to walk in the roads and take their chance with the traffic. Why are there no side-walks?

Yours respectfully,

SPIN ORBIT.

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Dear Sir,

Can you provide any information on the N.I.R.N.S. Restaurant? Surely time is wasted and considerable inconvenience caused by the trek to the A.E.R.E. Canteens or liquid haunts still further away. I feel that when we have a local eating house the laboratory productivity, however this is measured, will rise sharply.

Yours faithfully,

GOURMAND.

The following is an extract from the Whitley Council Meeting Minutes on 2nd April -

\- 'The Chairman said that after work had been started on the restaurant the Management had been told that the estimate of the cost had arisen above the amount approved. Work on the restaurant was suspended and an investigation had been made to discover the reasons for the increase in the estimate. The results of this investigation were still under consideration, and an application to the Treasury for additional funds was likely to be necessary. The Staff Side were concerned to see that attempts to reduce the cost to the original estimate did not lead to a reduction of standards in facilities or decoration. They would also like to draw the attention of the management to the present unsatisfactory arrangements at lunch time. The buses to the canteen arrived at the peak period, with the result that a large part of the midday break was spent in queuing.

The Chairman assured the Staff Side that the restaurant would be of satisfactory standard and estimated that the work should be finished within twelve months of the restarting of building operations. In the meantime he appreciated that there might be some inconvenience to the staff of the Rutherford Laboratory, but hoped that this could be kept to a minimum, and the management would welcome suggestions to improve the present arrangements.'

EDITOR.

PROFILE ... E. R. HARRISON

Science is not what it was. Fifty years ago if you swung a cat around in a laboratory you would hit a scientist; today you would hit an engineer or an administrator. If you asked the injured person where the nearest scientist was he might not know for they are rare birds. In the Rutherford Laboratory, for instance, those who would call themselves scientists body and soul are a very small number, but without any doubt they must include Ted Harrison.

In his own words Ted Harrison is a buccaneer of science, by which he means that at any moment he may seize upon a subject quietly minding its own business and so impose his will on it that it is never quite the same again. This was so with his Hypothesis of the Origin of the Pacific Basin published in "Nature" last year. Recently he has been thinking about "perception" i.e. just what do we mean when we say we see something. This has little to do with superficialities such as lenses and optic nerves. He is after something deeper, and if the search makes common sense stand on its head he considersit looks better that way up.

This hankering after philosophy recalls a time when an unwitting British Army finances him as a philosopher. He disappeared into the desert to think and his thoughts on paper added up to half a million words. The upshot was the realisation that he knew too little about the way the world was made so be became a scientist in order to find out. Fifteen years later he feels fit for another grapple with philosophy.

Talking to Ted Harrison is no game for the chicken-hearted; even talking about the weather may be unsafe. His hesitant "I don't understand what you said" is the signal to take cover or gather your courage to face the thunderbolts manufactured behind the imposing dome of his forehead. He is not so quick at thinking or talking but both thought and words possess enormous momentum. He has been compared with the legendary rugger hero who always scores carrying his opponents across the line. This forcefulness ignores fine distinctions of status and inevitably he drops many bricks. He can nevertheless be checked. The smooth carpets of status are made for brick-dropping but Ted Harrison is easily touched by remorse if he realises he has hurt needlessly.

Relaxation is as energetic as work. He and his wife Photeni have many parties to their credit, memorable both for their great hospitality and his determination to let his hair down.

He is one of the most outspoken men you will meet but those who know him realise both the accomplishment and the integrity from which this stems. Spare time artist, voracious reader, uproarious laugher, but above all devoted scientist, Ted Harrison is a distinctive character.

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'There were now 750 employees at the Rutherford Laboratory; this figure might be expected to rise to about 850 by the latter half of this year and more slowly thereafter (this figure of 850 excludes the provision for about 50 craftsmen to replace contract labour on the site)'

Whitley Council, April 1962

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'With reference to N.I.R.N.S. house building the chairman said that the Treasury Approval had recently been given for the purchase of land for a further 50 houses. Approval of funds for the actual building was still awaited.'

Whitley Council, April 1962

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'The Council agreed to adopt the following resolution:- "that the Committee of Management of the U.K.A.E.A. Benevolent Fund should be formally asked through the Atomic Energy Authority if they will provide for the admission of past, present and future members of the Non-Industrial staff of the Institute equally with such members of the staff of the Authority to the U.K.A.E.A. Benevolent Fund Scheme." '

Whitley Council, April 1962.

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STILL WAITING ?

"President Kennedy yesterday opened the World's Fair at Seattle, Washington State, by remote control from Palm Beach, Florida, where he pressed a telegraph key which "bounced" a radio signal off the star Cassiopeia A, 10,000 light years from the earth" ....

The Times, April 23rd, 1962.

THE ACCELERATOR WORLD

We aim to contact some of the leading accelerator laboratories in an attempt to establish a reciprocal news service with them at journal level. This should help us to see ourselves in the broad context of accelerator physics throughout the world and to keep us abreast of progress elsewhere. News of important developments or achievements anywhere in the world of accelerators will be published if it comes our way.

A few details on some of the important laboratories are given below and others will follow in later issues:-

Brookhaven National Laboratory - The Laboratory at Long Island, New York houses two big accelerators - a 30 GeV alternating gradient synchrotron and a 3 GeV constant gradient synchrotron. The 3 GeV machine has been in operation since 1952 and is known as the Cosmotron since it was the first proton machine in the world to reach energies comparable with the energies of cosmic ray particles. The 30 GeV machine operated at full energy for the first time in the autumn of 1960 and provides over 10" particles per pulse. It is the highest energy proton machine now working with a maximum available energy of 33 GeV.

European Organisation for Nuclear Research (CERN) - The laboratory at Geneva in Switzerland is probably the best known of all the other accelerator laboratories to people with N.I.R.N.S. It is a joint European project to which the British contribution has been about 25%. The accelerator is a 25 to 28 GeV proton synchrotron which first operated in November 1959 while under the Directorship of J.B. Adams who is now in charge of the Culham Laboratory. Its performance exceeded all expectations, yielding an output pulse of over 10" particles.

Argonne National Laboratory - The Argonne project is a 12.5 GeV zero gradient proton synchrotron (often called simple the GZS) and is situated in Illinois, U.S.A. They hope for well over 10^{12} protons per pulse output at a rate of 15 per minute (this compares with our estimated 10^{12} protons at 25 to 30 per minute) and their scheduled completion date is in 1963.

Lawrence Radiation Laboratory - This is the University of California accelerator laboratory at Berkeley. They have a 6.3 GeV proton synchrotron (the energy specifically chosen for the creation of anti-protons) operating since February 1954, which is called the Bevatron. (In America and France a 'billion' is a thousand million not, as in England, a million million. We call a thousand million a giga. The American BeV is therefore our GeV - hence Bevatron). The machine is now undergoing major modification and overhaul to increase the output beam intensity and they hope to be on the air again next year.

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At 20 GeV the electrons will be travelling at 0.9999999997 of the velocity of light and the electron mass will be 40,000 times the rest mass.

Commissariat A L'Energie Atomique - The French proton synchrotron at Saclay is known as 'Saturne' (the planet Saturn has a broad flat ring of orbiting particles around it). It was completed in August 1956 and has an output pulse of 5×10^{10} protons at an energy of 3 GeV.

Oak Ridge National Laboratory - The American Laboratory at Oak Ridge, Tennessee has a 12 GeV proton synchrotron project. They use a condenser-choke bank as the energy storage system, as opposed to our flywheel, and a fixed frequency proton cyclotron as the injector.

Joint Nuclear Research Institute - High - The Russian Institute have their laboratory at Dubna near Moscow, where a 10 GeV synchrophasotron has been in operation since 1957. The number of particles per pulse is 10^9 to 10^{10} with 5 pulses per minute. An interesting technical point is that 36,000 tons of iron are used in the magnet compared with the 7,000 tons for Nimrod.

University of Minnesota, School of Physics - The accelerator laboratory at Minneapolis U.S.A. is a leading proton linear accelerator centre. Beam exit ports are provided on their machine at 10, 40 and 68 MeV with average outputs of 0.2, 0.04 and 0.02 microamps respectively. The 68 MeV beam is the highest energy proton linear accelerator in the world and was completed late 1955.

Deutsches Electronen Synchrotron (DESY) - At Hamburg in Germany the highest energy electron synchrotron laboratory in the world is located. The output energy is 7.5 GeV with 10^{11} particles per pulse. Their completion date is 1963.

Stanford University - In 1961 the American Congress approved funds for a 20 GeV electron linear accelerator to be built at Stanford University in California. The accelerator will be by far the largest of its type in the world and will ultimately be capable of 40 to 50 GeV with a linear length of two miles. A linear machine is necessary to avoid the energy losses by X-ray production which are prohibitive for orbiting electrons of these energies.

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WHY BUILD NIMROD?

Mr. Southworth sketches historically the developments in the sphere of elementary particle physics from the beginning of this century and brings out the position of high energy accelerators in this new field.

The idea that all matter is built up from a few fundamental units has been with man for centuries. Perhaps the oldest record is in the writings of Democritus in 400 B.C. where the name atom, which is Greek for indivisible, was first applied to the unit. Scientific evidence to support this idea was collected by the 19th Century Chemists who, led by Dalton in 1803, compiled a list of separate types of atom - 92 were eventually recognised from hydrogen to uranium - from which all known chemical compounds are composed. When Mendeleef assembled the elements in the orderly array of the periodic table in 1869, it seemed as if one of man's first theories about nature had been proved very satisfactorily.

The Breakdown of the Atom

This orderly state of affairs was shortlived, for at the end of the 19th Century, when several physicists were engaged in investigating the nature of the cathode ray, the electron was discovered. J.J. Thomson expressed the results of his experiments in 1897 as follows:- "we have in cathode rays, matter in a new state, a state in which the subdivision of matter is carried much further" and he ends with the then revolutionary conclusion, "atoms are not indivisible for negatively charged particles can be torn from them by the action of electrical forces." This negative particle, the electron, it was proved, exists in all the atoms and is some 2000 times lighter than the hydrogen atom, the lightest of the atoms. The "indivisible" atom had been split and the search for the fundamental building blocks of matter began all over again.

The Beginning of Nuclear Physics

The next big advance in thought about the nature of matter was the result of Rutherfords experiment in 1911. Thomson, having shown the existence of negative electrons in the atom, assumed that they were dotted about in a sphere of positive charge to give a neutral atom.

Rutherford fires a beam of alpha particles emmitted by radioactive radium at the atoms in a gold foil. The alphas were quite energetic positively charged particles which were expected to plough through the spheres of positive charge with little deviation from their original paths. In fact, a small number were actually reflected back in the direction of their source. Rutherford's surprise at this observation can be judged from his remark "It was as incredible as if you had fired a 15 inch shell at a piece of tissue paper and it had bounced back and hit you!"

To explain the results of his experiment, he suggested that the atom consisted of a tiny concentrated core of positive charge, the nucleus, with a cloud of electrons around it. The positive alpha particles, which would generally pass almost straight through the electron cloud, would occasionally be aiming for the nucleus. Then they would be reflected back by the 'Coulomb force', which means that the positive charge on the particle and the positive charge on the nucleus repel one another.

One of the chief reasons why the idea of a tiny core in the atom seemed so fantastic to scientists at the time was precisely this Coulomb force which says that positive charges repel one another and that the force of repulsion increases as the charges get closer together according to the inverse square law. Rutherford's theory indicated that in a uranium atom, for example, 92 positive charges are packed in a nucleus with a diameter of about a millionth of a millionth of a centimetre. The force tending to push the particles apart when they are brought so close together is enormous. It was obvious that a force, to overcome the Coulomb force, must exist within the nucleus to keep the positive particles together. Many years passed before this mystery was explained.

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NOTHING IS SURPIRISING THESE DAYS

Let us suppose that a notice is posted:- "THE CANTEEN WILL BE BLOWN UP SOMEDAY DURING THE COMING WEEK. THE CHOSEN DAY WILL BE A SURPRISE - ANY DAY FROM MONDAY TO FRIDAY."

Would it in fact be a surprise? It cannot be left until Friday for then it would have to be blown up on Friday and would not be a surprise. Also it cannot be left till Thursday because, since we know it cannot be left till Friday, it would then have to be blown up on Thursday and would not be a surprise.

Also it cannot be left till Wednesday .... and so on.

How can it be a surprise?

Why Build Nimrod (Continued)

Protons, neutrons and mesons

Meanwhile the breakdown of the atom into its constituent parts continued. The positive particle in the nucleus was separately identified and called the proton. Its mass was measured to be 1840 times the mass of the electron.

In 1932 Chadwick demonstrated experimentally the existence of a particle postulated by Rutherford some twelve years earlier. This was called the neutron, carrying no charge and being almost equal in mass to the proton. The neutrons were shown to share the nucleus with the protons in approximately equal numbers and both inhabitants of the nucleus were given the name nucleons.

Then in 1934, Yukawa, a Japanese theoretical physicist, published his theory of the nuclear binding force. He used Einstein's famous relationship, $E = mc^2$, which states that mass and energy are convertible one into the other, to explain the energy which binds the nucleons together in terms of a particle which is exchanged between them. The mass of this particle was calculated as some 200 times the mass of the electron.

The particle was later given the name 'meson' and for a year after Yukawa's theory was published scientists searched for experimental evidence of its existence. Then in 1936 Anderson and Neddermeyer recognised a particle from tracks on cloud chamber photographs of cosmis radiation which was thought to be the Yukawa particle. We shall see later that this was not so.

This was the state of affairs just before the second world war. The separate parts of the atom - electron, proton and neutron - had been identified and the existence of the meson, which carries the energy of the nuclear field, apparently expermentally verified. If we add to these the photon, the weightless particle or 'quantum' in light rays, which carried the energy of the electromagnetic field, we have a small group of fundamental units. We seemed to be in a much more satisfying position than even the chemists with their 92 types of atom.

Antiparticles and Decay

We must now turn to two developments which have been omitted so far, simply to keep the picture up to the 1940's as clear as possible. The first is the concept of antiparticles which originated in Dirac's theory of the electron in 1934. Dirac developed an equation to represent the motion of a free electron or proton and noted that both a positive and a negative solution existed. The negative solution implied particles of negative energy - antiparticles - . The implication which interests us is that for every charged particle we can describe an antiparticle with the same mass, but opposite charge. Anderson and Blacket had actually already detected an electron - antielectron (called a positron) pair in 1932. The anti-proton had to wait until 1955 to be identified on the Bevatron accelerator.

The second development was the observation of the 'decay' of particles. Electrons were observed to be emitted from a radioactive nucleus with a range of energies and their origin was explained as the breakdown or 'decay' of a neutron into a proton and an electron. Since the energy released in the decay must always be the same, the fact that the electrons were emitted with a range of energies posed a problem. Pauli and Fermi resolved the problem by suggesting a new particle, the neutrino, which carries off some of the energy so that the energy of the electron plus that of the neutrino is always the same. The neutrino has no mass and no charge which made detection difficult and it was 1956 before a conclusive experiment to demonstrate its existence was carried out by Cowan and Reines. It seems a very mysterious particle in terms of our normal ideas about particles but it is now as well established in nuclear physics as any other.

We must now revise our approach for we have developed our story so far on the line of a search for the fundamental units of matter. If we are to retain the neutron in our sphere of interest we must drop the search for indivisible units for we have seen that neutrons decay into lesser units. Instead we use the term 'elementary particles' to cover all the new particles discovered since the beginning of nuclear physics.

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ISSUE 2, AUGUST 1962 will include:-

'The Royal Charter of the National Institute' an article by Dr. Willis, Head of Administration.

'Safety at the Rutherford Laboratory' an article by Mr. Myers.

Information on 1000 GeV proton machine under study in Russia.

'What's on at the P.L.A.'. Some of the experiments currently running on the Proton Linear Accelerator.

News from the America visit of Mr. Bowles and Mr. Simmonds.

Cosmic Rays

After the war, investigation of cosmic rays became more intense. Primary cosmic rays are known to consist mainly of protons with small percentages of alpha particles and other heavier nuclei sometimes with fantastically high energies (greater than a million GeV), showering into our atmosphere from outer space. Their origin and the source of their high energies is still not clear but they provided, until the 1950's, the major source of high energy particles. The creation of new particles can only occur when the necessary energy is available for conversion into mass in accordance with Einstein's relationship, which explains the concentration of interest on cosmic rays. They were investigated using cloud chambers and later photographic emulsions in both of which they leave tracks from which such information can be obtained, and very surprising information it proved to be.

The first development around 1947 was the realisation that the meson detected by Anderson was not the one which had the mass to fit the Yukawa theory. Powell working at Bristol on cosmic rays identified the true Yukawa meson and called it the pimeson (273 times the mass of the electron), the Anderson meson became known as the mu meson (207 times the mass of the electron). All the particles so far discovered could be explained but why the mu meson should exist and why it should have its own particular mass is still a complete mystery.

Further unexpected particles were discovered following the work of Rochester and Butler at Manchester who found two neutral particles, (later called the K meson, with a mass around 1000 electron masses and the hyperon, with a mass greater than that of the proton) in cloud chamber photographs of cosmic rays. This was the first indication of a complex pattern of new particles the so-called "strange" particles many heavier than the proton, which have now been identified. The list of elementary particles and antiparticles has now been extended to over thirty and most of the newcomers are quite inexplicable.

High Energy Accelerators

Cosmic rays are not a controllable source of particles and the incidence of the strange particles in particular is very rare. Thousands of photographs may reveal the interesting particles only once, thus the possibility of producing the particles virtually to order in the laboratory is invaluable. Therefore the development of the techniques to build high energy machines was a great breakthrough for the nuclear physicist. Cyclotrons with energy ranges below 1 GeV were first developed and used chiefly for pi meson physics. The proton synchrotrons followed from 1953 onwards, producing the strange particles for investigation.

Experimental results from accelerators are now being accumulated at an unprecedented rate. The observed phenomena are described as yet in terms of the only suitable theory available (quantised field theory) and a general scheme of the known particles has been assembled as the new equivalent to the periodic table of the chemists. But a general theory of elementary particles still seems far from being evolved. Some most obvious questions, such as why the mu meson and other particles have their particular masses, why the proton does not decay to a positron and a photon when decay is universal among other heavy particles etc. .. still defy answer. We obviously need much more basic knowledge to develop a satisfactory theory and there is no telling when a sudden flash of insight may dispel mysteries of long standing. It is to provide this basic knowledge that accelerators are being built.

The Advent of Nimrod

It is in this new world of physics that the proton synchrotron 'Nimrod' takes its place. Britain, up to the 1950's, has always been at the forefront of nuclear science ever since the days of Thomson and Rutherford and it would seem justifiable if only on the grounds of tradition to establish the necessary tools, high energy machines, in this country to recover this position. The spearhead of the attack in this new science has moved to the big accelerator laboratories and Nimrod should bring us back into line in work of tremendous fascination and importance.

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AVE ET VALE

Dr. J.J. Thresher joined the Nimrod Nuclear Physics team. He was previously attached from A.E.R.E. and worked with the P.L.A. He is now at the Berkeley Laboratory in America until November of this year.

Mr. Wicks and Mr. Short took up posts in Supply and Safety Section respectively.

Industrial Employees joining us in May were Mr. Edwards, Mr. Hall, Mr. Hester, Mr. Joslin, Mr. Pinkney, Mr. Raisbeck and Mr. West.

Mr. Nichols has joined Administration and is located in the R.1 Admin. Office.

Two Machine Operators were appointed to the Atlas Laboratory - Mr. Hardie and Miss Harte.

Mr. Petts joined the Central Engineering Services Sect.

Mr. Bill Brown left the Laboratory after several years with Injector Group.

Mr. Barret from the P.L.A. Engineers returned to AERE.

Among Industrial employees, Mr. Bennet and Mr. Lightfoot left us.