

RUTHERFORD LABORATORY

PRESS CONFERENCE

Wednesday, 22nd April, 1964

Lecture Theatre

4 p.m.



LABORATORY FASHION IN BERKS

Nuclear research laboratories have their own range of "fashionable" wear — all strictly utilitarian and all with safety in mind.

Here Mrs. Jill Goodall, of Harwell, wears a fresh air hood, white coat and gloves as she uses a geiger counter to check for radioactivity at the Rutherford Laboratory at Chilton, near Didcot.

The laboratory, covering a 75-acre site adjacent to the Atomic Energy Research Establishment at Harwell, is to be officially opened by Mr. Quintin Hogg, Minister for Education and Science, on Friday.

He will also inaugurate Nimrod, the 7,000m. electron-volt proton synchrotron.

The Rutherford Laboratory is operated by the National Institute for Research in Nuclear Science, set up by the Government in 1957 to provide nuclear research facilities beyond the scope of individual universities and other bodies.

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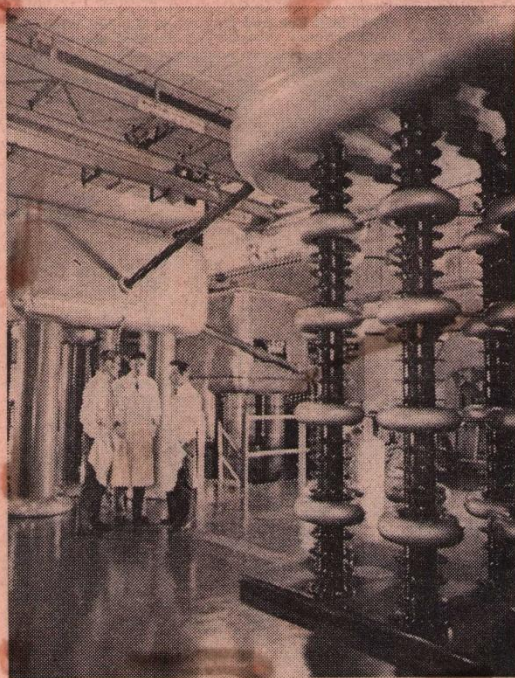
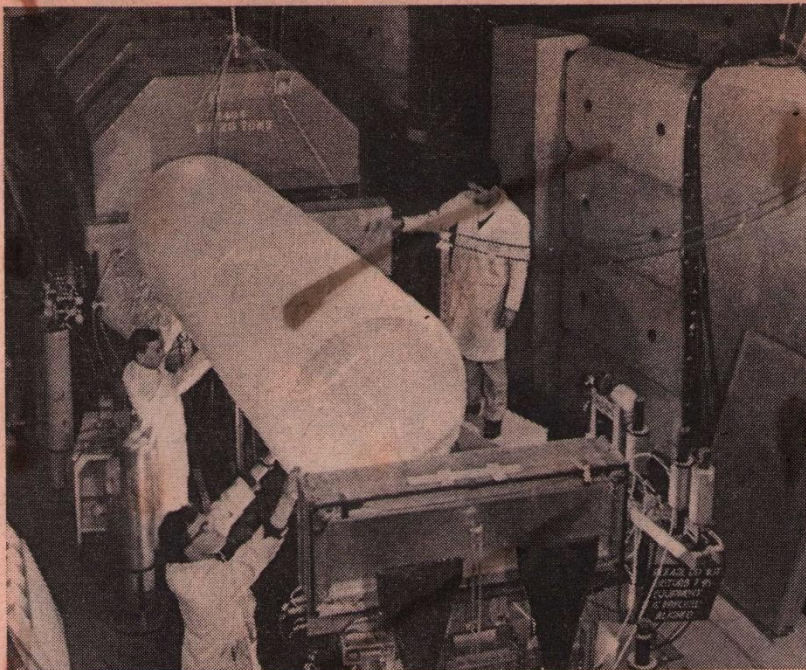
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WEDNESDAY, APRIL 22, 1964

RUTHERFORD LABORATORY PREPARES FOR OFFICIAL OPENING



The Rutherford Laboratory at Chilton, covering a 75-acre site adjacent to the Atomic Energy Research Establishment at Harwell, is to be officially opened by Mr. Quintin Hogg, Minister for Education and Science, on Friday.

He will also inaugurate Nimrod, the 7,000m. electron-volt proton synchrotron. The Rutherford Laboratory is operated by the National Institute for Research in Nuclear Science, set up by the Government in 1957 to provide nuclear research facilities beyond the scope of individual universities and other bodies.

A helium bag (above) being fitted into a beam line in the Nimrod Experimental Hall to reduce the probability of protons being scattered out of the beam by collision with air molecules.

Left: A view of part of the Injector Room, showing from left to right, the EHT platform, the polarized proton source and DC gun and the 500kV filter stack.

Nimrod shows its paces

THE Rutherford High Energy Laboratory, situated on the Berkshire Downs at Chilton, was thrown open to the Press for the first time today.

Developed by the National Institute for Research in Nuclear Science over the past six years, the laboratory concentrates mainly on research in high energy physics. This is the study of the properties and structure of the elementary particles of which the whole universe is made.

Dr. T. G. Pickavance, the director, explained that the aim at the laboratory is to work in such a way that universities can make full use of the facilities.

The programme is based on two particle accelerators — the proton synchrotron Nimrod and the smaller proton linear accelerator.

Research in nuclear and high energy physics is expensive. The laboratory budget for 1963-4 is just over £6m. Of this sum, £2m. is for materials, equipment and services and a further £11m. for completion of the development.

SWINDON, WEDNESDAY, APRIL 22, 1964

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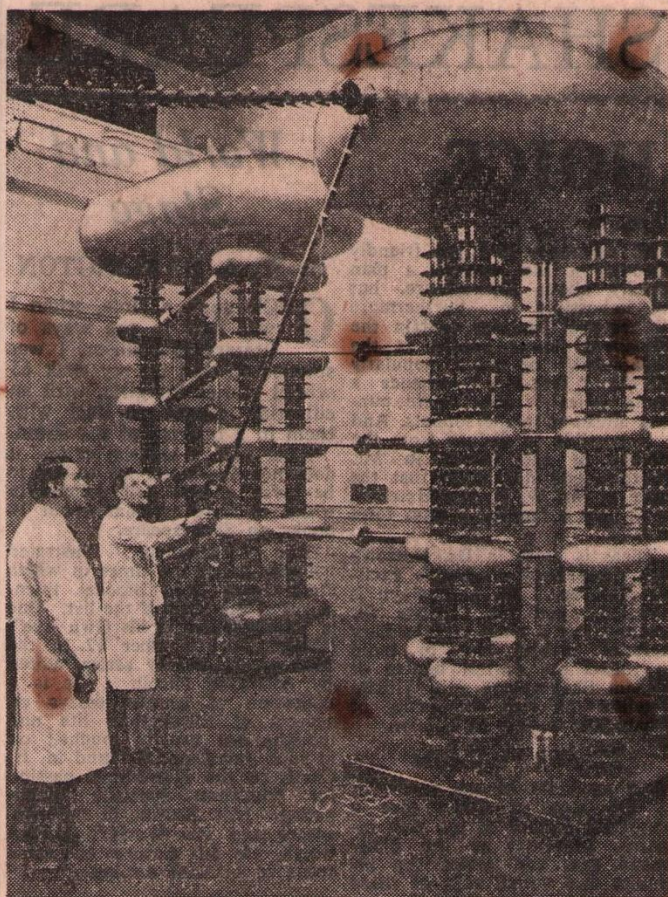


DAILY TELEGRAPH - - - June 29, 1855
 MORNING POST - - - November 2, 1772
 [Amalgamated October 1, 1937]

THURSDAY, APRIL 23, 1964

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INDEPENDENT OF ALL GROUPS



A physicist using an earthing stick on the H.T. terminal in the injector area of Nimrod, Britain's largest nuclear accelerator, at the Rutherford Laboratory, Chilton, Berks. Here protons are accelerated to 500,000 volts before injection into the linear accelerator.

NIMROD IS GIVING RESULTS

BY OUR SCIENCE STAFF

NIMROD, the biggest nuclear accelerator in Britain, is beginning to give results. Experiments in the past few weeks have studied the forces between sub-atomic particles and their structures.

Figures from the experiments have now begun to accumulate.

Nimrod is part of the Rutherford Laboratories of the National Institute for Research in Nuclear Science, at Chilton, Berks. The accelerator was first brought up to full power in August, last year.

Much of the work done on it so far has been to prove and test it for the exact experiments now starting up.

Surprise properties

One of them will study the structure of the proton, one of the two particles that form the nucleus of all atoms. Already, some experiments have shown that the proton has some rather unexpected properties.

By measuring the scattering of a beam of protons accelerated to a high energy in Nimrod, and then made to collide with a target containing more protons, the experimenting physicists hope to learn more about this.

Protons seem to consist of a diffuse cloud surrounding a small hard core. The Nimrod experiment should help to conserve this and perhaps give an idea of the size of the core.

Nimrod is housed at the Rutherford Laboratories in a big round chamber shielded with concrete and earth.

15 year life

The accelerator itself is a ring of electromagnets 155ft in diameter and weighing 7,000 tons. The beam of protons being accelerated runs along a channel in the ring which is kept at a high vacuum.

Nimrod has cost £11 million and according to Dr. T. G. Pickavance, director of the laboratory, it should have a useful life of 15 years. It will be opened formally on Friday by Mr. Quintin Hogg, Secretary for Science.

Nimrod at the 'front line' of physics

From JOHN MADDOX, our Science Correspondent

Chilton, Berkshire
The machine for accelerating atomic particles to the energy they would acquire in 8,000 million volts is now all ready to be opened officially tomorrow by the Secretary for Education and Science, Mr Quinton Hogg.

Striped green awnings and a huge marquee have been erected for the benefit of him who has blessed this laboratory with more than £11 millions to construct the largest machine of its kind in Britain. In fact, Nimrod, as the machine is known, is one of a select company of four in Western Europe which can accelerate atomic particles to energies corresponding to more than a thousand million volts. The largest of these is in Geneva, which produces particles three times as energetic.

Great care

The laboratory here is now a thriving community of close on a thousand people, together with more than a hundred visiting scientists from universities in Britain and even abroad. Roughly four-fifths of the time used for experiments with the large machine is taken up by visitors. Nimrod, it is felt, should be used in common by scientists at British universities.

One obvious feature of the work is its professional character. If a machine costs more than £11 millions, there is no room for string and sealing wax anywhere in the equipment. The result is that all the experiments are engineered as carefully as if they were prototypes for some vast commercial production. Great care is taken that information collected from these experiments is in a form which can be analysed directly by electronic computers.

The machine itself works as well as its designers predicted although necessarily its performance is somewhat overshadowed by that of the larger machines at Geneva and at Brookhaven in the United States. Dr T. G. Pickavance, director of the laboratory, said today that these considerations did not mean that Nimrod would make no contributions to "front line physics."

There were, he said, a great many significant experiments to be carried out in the energy range accessible to his new machine. He quoted as evidence the fact that a machine in California has recently been modified at great cost to give it a comparable performance.

One striking attribute of the work at the laboratory is the way in which new equipment has been designed on the spot. One striking innovation is the use of a device called a "spark cham-

ber" to mark and to record automatically the passage of fast atomic particles between two electrified plates.

That such an event can cause a spark has been exploited for some time, but now the recording of these sparks is being made automatic by installing a material which is sensitive to sound signals around the edges of the chamber. The result is an entirely automatic measurement of the passage of an atomic particle.

Among discussion yesterday of the strategy which has put a large part of British scientific effort into nuclear physics, Dr Pickavance said that the British contribution to the European Organisation for Nuclear Research (CERN) was less than a quarter of the total budget there of £9 millions; that the Department of Scientific and Industrial Research spent roughly £1 million a year on the support of nuclear physics; and that the budget of his own laboratory was likely to be £4.5 millions in the coming year, not counting the £1.5 millions to be spent on construction.

Spent on Nina

At the same time, of course, money is also to be spent on the machine for accelerating electrons (Nina) in Cheshire. Dr Pickavance said he thought these arrangements would satisfy British needs for the immediate future, especially if there were progress towards a collaborative European scheme to build a bigger machine under the umbrella of CERN. Plans for this are well advanced, and the energy of the atomic particles produced would be in the region of 300,000 million volts.

Money is not yet forthcoming, however, and cannot be allocated until studies are completed at the end of this year. Further ahead, there are discussions on a scheme to build a machine more than three times more powerful still on a strictly international basis. There is to be a meeting on this subject next month, but nobody seems very hopeful of the outcome for the time being.



Nuclear age fashion: Mrs Jill Goodall wearing a fresh-air hood, white coat and gloves as she uses a geiger counter to check for radioactivity at the Rutherford Laboratory



THURSDAY APRIL 23 1964

NIMROD IS FULLY OPERATIONAL

USED FOR RESEARCH BY 150 PHYSICISTS

FROM OUR SCIENCE CORRESPONDENT

At the Rutherford High Energy Laboratory, adjoining Harwell, Britain's biggest machine for accelerating nuclear particles to high energies has passed a second critical stage, which means in effect that it is now fully operational.

This stage, the extraction of the main beam from the circular race track round which protons, otherwise hydrogen nuclei, are accelerated to an energy of 7,000 million electron-volts, was first reached on March 24. The announcement was held back for a press visit to the laboratory yesterday in preparation for its official opening by Mr. Hogg, Secretary for Education and Science, tomorrow.

A greater variety of experiments can now be done, and one, using the extracted proton beam, is already at the point when results are beginning to be obtained. Here, as in other work in the laboratory, much trouble is being taken not only to make the taking of observations automatic but also so far as possible to make the working out of the results automatic.

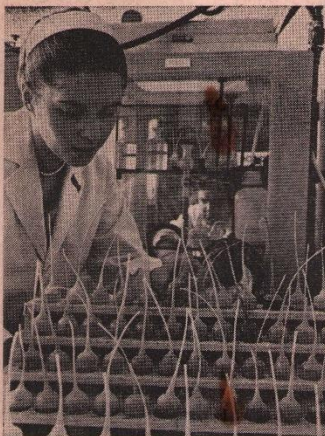
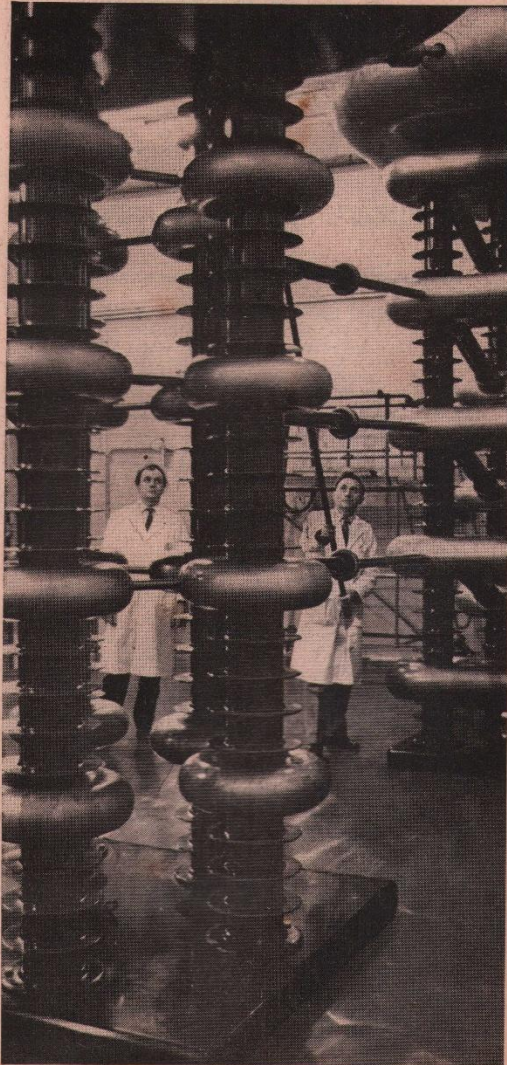
Part of the technique used has been developed for the first time in the laboratory. In all, seven sets of equipment are in use or in course of erection, each for a separate experiment using the big machine known as Nimrod.

The laboratory is used jointly in research by university scientists and members of its own staff. About 150 physicists, Dr. T. G. Pickavance, the director, stated, are already basing some part of their research on Nimrod or are planning to do so. Of these about 130 are university scientists.

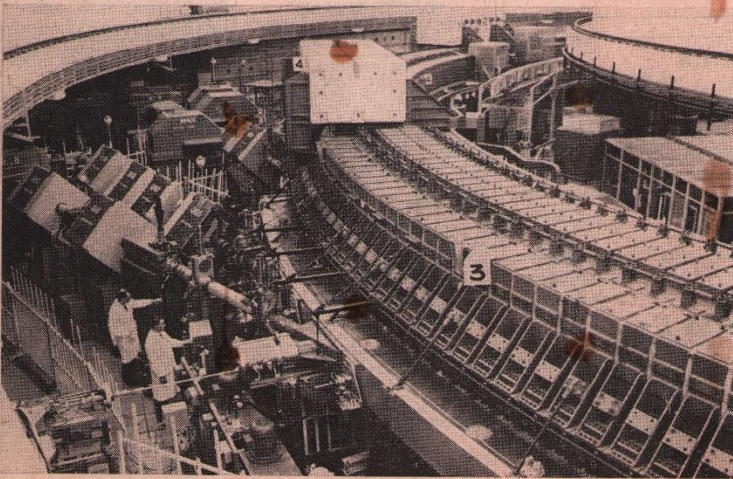
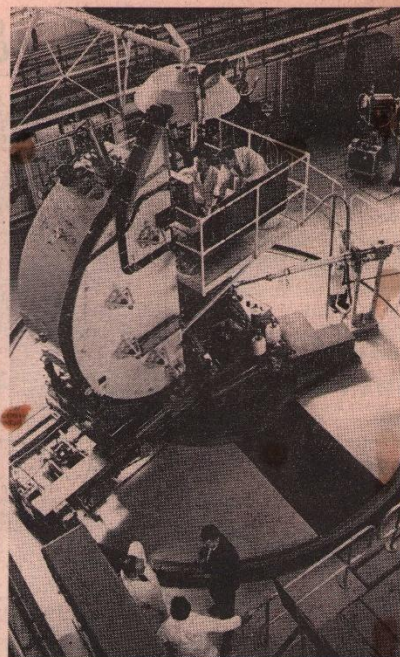
Pictures, page 24.

The Rutherford Laboratory

The Rutherford High Energy Laboratory at Chilton, Berkshire, is to be opened tomorrow by the Minister of Science, one of two large-scale laboratories belonging to the National Institute for Research in Nuclear Science



Above: Working with chemical reagents. A radiochemist is behind. Left: The Cockcroft-Walton high voltage generator. Right: A beam analysing magnet. The laboratory is used jointly by university scientists and members of its own staff



The Nimrod magnet. Nimrod is a proton accelerator used for experimental work. Report page 6



The world this morning

THURSDAY,
APRIL 23, 1964
THREEPENCE
No. 14967 • •

**Voice of
the Herald**



Scientist Jill Goodall puts on 'lightning-proof' boots

Where boffins play with lightning

NIMROD! That's the word which may put Britain well ahead in this modern world.

The name, taken from the Bible, means Mighty One in the Earth.

And Nimrod of the 1960s is a very mighty thing indeed—a giant "ray" gun buried in a mound of earth at the Rutherford laboratory, Didcot, Berks.

It will be unveiled today by Mr. Quintin Hogg, Minister for Science and Education.

Nimrod's job is to shoot out 7,000million-volt particles which are smaller than the atom.

From its 44ft.-long barrel, protons will be ejected into a doughnut-shaped magnet as big as Piccadilly Circus in London.

Inside the magnet, the protons will crackle and flash as if the 150 nuclear scientists in charge were playing with lightning.

Said Dr. John Thresher, one of the scientists: "It is probable that we will discover entirely new particles from which the whole universe is made."

Nimrod is one of the biggest machines of its kind in the world. Running costs are more than £6million a year.

How to smash atoms and still stay chic



IT'S the latest in Atom Age fashions... designed strictly for safety.

The woman wearing the plastic hood, white coat and gloves, is Mrs. Jill Goodall, a nuclear research worker at the Rutherford Laboratory at Chilton, Berks.

She is using a Geiger counter to check part of the laboratory for radioactivity. In an emergency, the hood would enable her to breathe uncontaminated air.

The laboratory will be opened tomorrow by Mr. Quintin Hogg, Secretary of State for Education and Science.

Daily Mirror

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Evening Advertiser

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Experimental Officer High Energy Physics, Mr. Clive Thomas, of 70 Buckingham Road, Swindon, examines the liquid hydrogen target.



Ray Wilson, of 3 Stonehurst Close, Stratton St. Margaret, and Brian Parkinson, of 4 Arundel Close, The Lawns, two Swindon employees, discuss the installation of a beam energy monitor.

Giant nuclear project in Berks is 'vital for human progress'

NOW that the giant £11m. Nimrod project is fully operational, the Rutherford High Energy Laboratory at Chilton has become an important centre for research "which is vital for human progress."

At this 75-acre centre on the windswept Berkshire Downs is some of the finest equipment in the world for experimenting in the field of high energy physics—the study of elementary particles which make up the whole universe.

Besides catering for the country's ablest physicists, the laboratory is helping to produce top calibre men for the future. Its facilities are provided free to university groups interested in this field.

Already there is a big waiting list of such bodies wanting

to make experiments.

The price seems tremendous. The laboratory's budget for the 1963-4 period was more than £6m. Justifying this "large" expenditure, Dr. T. G. Pickavance, the director, said yesterday: "The fundamental point is that science is an essential part of our culture, and therefore it is vitally important to develop the most creative branches of science."

Dr. Pickavance was addressing representatives of the Press and

radio, who, for the first time, had been invited to tour the complete laboratory.

Since the beginning the programme has been based on two particle accelerators—the proton synchrotron Nimrod and the much smaller proton linear accelerator.

"Nimrod now joins the really big machines capable of supporting 'front line' research in high energy physics," said Dr. Pickavance. "There are 12 others now operating in this class—six in the USA, three in Russia and three elsewhere in Western Europe."

Atomic machine on public view

BRTAIN'S biggest research tool, the Nimrod accelerator, or atom-smashing machine which has cost £11m. and is to be inaugurated officially when Mr. Quintin Hogg, Secretary for Education and Science, opens the Rutherford High Energy Laboratory near Harwell to-morrow, was yesterday seen publicly for the first time by the Press.

Already used at week-ends during the past winter, it has shown that it could take a leading place among the world's scientific instruments for investigating what the director of the laboratory, Dr. T. G. Pickavance, called yesterday "one of the most important frontiers of human knowledge."

The heart of Nimrod is a ring-shaped magnet: the familiar doughnut tube of Zeta but on a much bigger scale, 155ft. in diameter.

The tube is used as a gun to fire at atoms, sub-atomic particles of enormous energy, the resulting collisions producing a host of new particles found only extremely rarely in natural conditions.

All-British

Nimrod enables British scientists to use their own machine for the first time, to produce the most recently discovered and most interesting particles. Previously they had to depend on American machines or that of Cern.

In the important scale of the number of particles produced it is already among the leading machines. Soon it should beam a million million sub-atomic particles—protons or the nuclei of hydrogen atoms—28 times a minute.

The machine and its associated laboratory are underground.

Experiments

Its operation starts with a bottle of hydrogen gas (a child's balloon full of which could keep it going for 3,000 hours). Protons made by stripping the electrons from the atoms of hydrogen are injected into the main tube at a sixth of the speed of light.

They travel a million times round the ring, equal to half the distance to the moon, in a seventh of a second, reaching a final speed of about 600m. m.p.h.

They are then channelled off to a number of experiments in which they collide with atoms, and the results are recorded in various ways and examined by computers.

The Birmingham Post

& Birmingham Gazette



The Birmingham Post

Founded by
John Frederick Feeney
December 4, 1857

Birmingham Gazette
November 16, 1741

(Amalgamated November 3, 1956)

THURSDAY, APRIL 23, 1964

DAILY EXPRESS

OPINION

THURSDAY APRIL 23 1964



Atom-smasher starts work

Britain's new £11 million atom-smasher—the Nimrod cyclotron—will be set to work tomorrow at the National Institute for Research in Nuclear Science by Science Minister Mr. Quintin Hogg.

The 7,000-ton machine, shaped like a giant doughnut, will enable physicists to tear the atom apart and analyse the "glue" that holds the various parts together.

The SKETCH says

★★ DAILY SKETCH, Thursday, April 23, 1964 9

'Doughnut' has a key to the world's secret

Sketch Science Reporter

IT looks like a giant doughnut, the size of Piccadilly Circus. It is buried two storeys deep in the Berkshire countryside.

Through its core, tiny particles of matter, too small to see, too light to weigh, are swirled along a channel on a million circuits in less than a second.

It is Nimrod, Britain's biggest atom-smasher, due to be set in action by Science Minister Mr. Quintin Hogg tomorrow.

This £11,000,000 machine, weighing 7,000 tons, could

reveal one of the most exciting secrets challenging the world's nuclear scientists: The key to the very structure of the universe.

Mr. Hogg will press a button to spark particles on a journey equivalent to half the distance to the moon with a kick of 3,000,000 watts, researcher John Thresher told me.

KICKED OUT

"In less than a second they will be kicked out and aimed through pipes at a target to produce millions of tiny particles—the very forces which bind the atom together," he added.

SCIENTISTS 'AT HOME' TO THE PRESS

THE Rutherford High Energy Laboratory, situated on the Berkshire Downs at Chilton, was thrown open to the Press for the first time yesterday.

Developed by the National Institute for Research in Nuclear Science over the past six years, the laboratory concentrates mainly on research in high energy physics. This is the study of the properties and structure of the elementary particles of which the whole universe is made.

Dr. T. G. Pickavance, the director, explained that the aim at the laboratory is to work in such a way that universities can make full use of the facilities. "We want them to make their own research in this field while remaining full members of their academic communities and in particular teaching their students," he said.

The laboratory is now at a crucial stage of development. It grew out of AERE Harwell at the beginning of 1957 and is now starting the work for which it was set up.

£6m. BUDGET

The programme is based on two particle accelerators — the proton synchrotron Nimrod and the smaller proton linear accelerator.

Operations are carried out 24 hours a day. They serve an average of 50 nuclear physicists of whom 40 are visitors from universities; the others are laboratory staff.

Research in nuclear and high energy physics is expensive. The laboratory budget for 1963-4 is just over £6m. Of this sum, £2m. is for materials, equipment and services and a further £1½m for completion of the development.

Justifying this "large expenditure" on one field of pure research, Dr. Pickavance said: "The fundamental point is that science is an essential part of our culture. Therefore, it is vitally important to develop the most creative branches of science."

Safety at the 75-acre laboratory is of prime importance. When experiments were first carried out it was estimated that without cautions people living without about a two mile radius would be in danger of radiation.

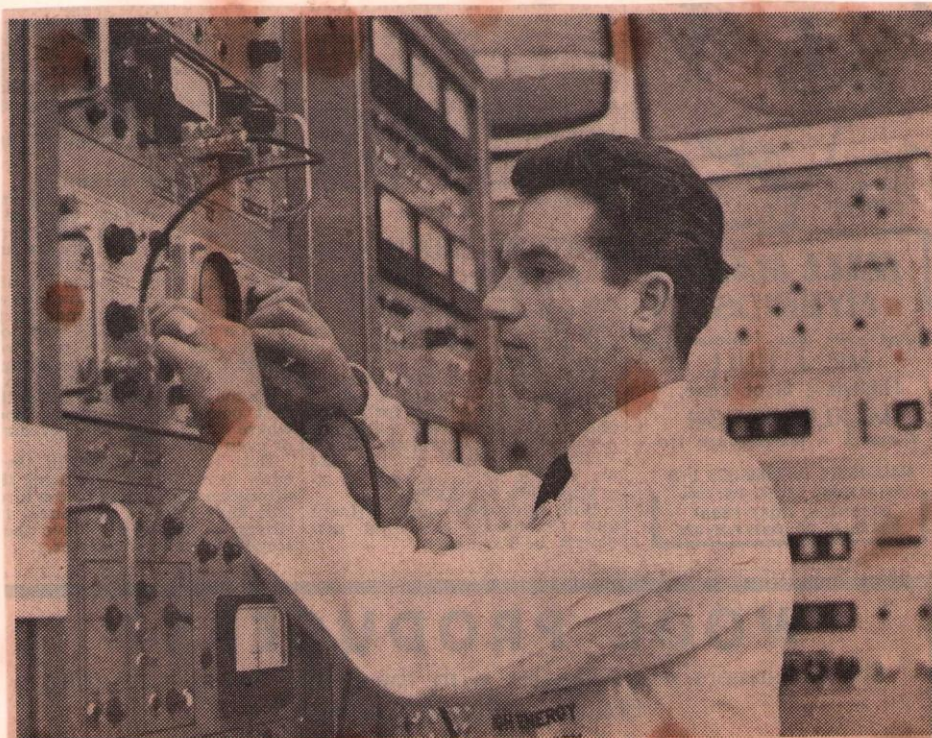
Nimrod for instance is buried under 10ft. of concrete and 20ft. of earth to prevent fall-out. That is how it gets its name—"the mighty one in the earth," Book of Genesis.

At the moment 945 staff are on the laboratory's pay roll. Eventually this number will increase to over 1,000.

Tomorrow the Rt. Hon. Quintin Hogg, Secretary of State for Science and Education will officially open the laboratory and inaugurate Nimrod.



Mr. D. A. Harragan of Sutton Courtenay, manager of the Orion computer, a former Chippenham Grammar School pupil, who enjoyed spending his school holidays helping on a farm at Aldbourne, feeding data into the machine.



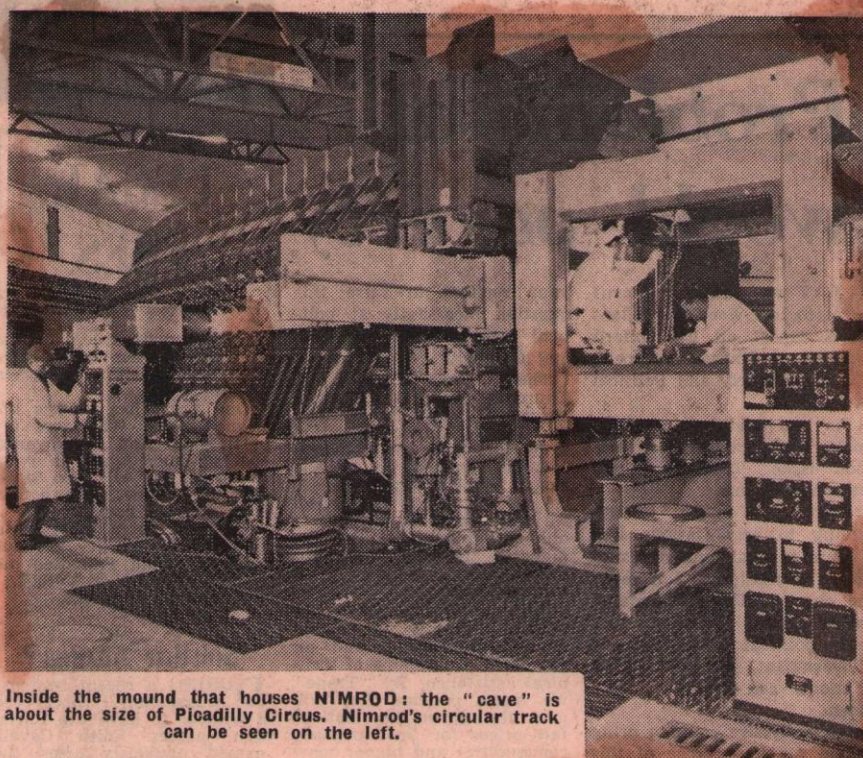
Mr. Leslie Crowther of 37 Paddock Close, Charlton, Wantage, monitoring Nimrod beam current.

Wiltshire Gazette and Herald

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THURSDAY, APRIL 23, 1964

THURSDAY, APRIL 23, 1964



Inside the mound that houses NIMROD: the "cave" is about the size of Piccadilly Circus. Nimrod's circular track can be seen on the left.

NIMROD JOINS THE ATOM SMASHERS

SIX experimental teams, mostly from universities, are already working on Nimrod, the £11m. atom-smashing synchrotron which was commissioned last August at Chilton.

It was Press day yesterday at the Rutherford High Energy Laboratory, where tomorrow Mr. Quintin Hogg, Minister for Education and Science, will press the button to "open" Nimrod officially.

The Director of the Laboratory, Dr. T. G. Pickavance, said Nimrod had now joined the really big machines capable of supporting "front-line" research in nuclear physics.

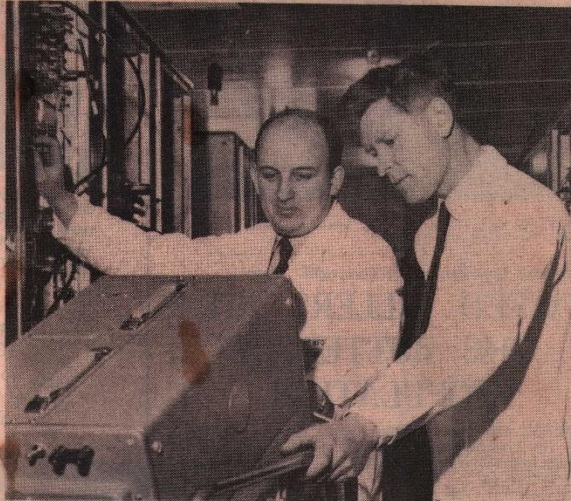
In terms of the energy of the minute particles it accelerates, it is fifth in the world.

week: for the rest of the time it is shut-down for modifications. During the running, nobody can enter the shielded area because of radiation, and an intricate security system ensures that all are out before starting up the machine.

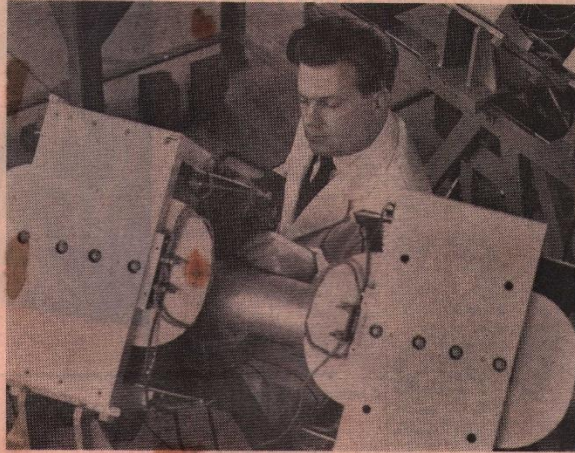
Winter worries

Fears had been expressed that because of the enormous amount of electricity it uses, Nimrod might have to close down during high-demand periods in the winter. Close

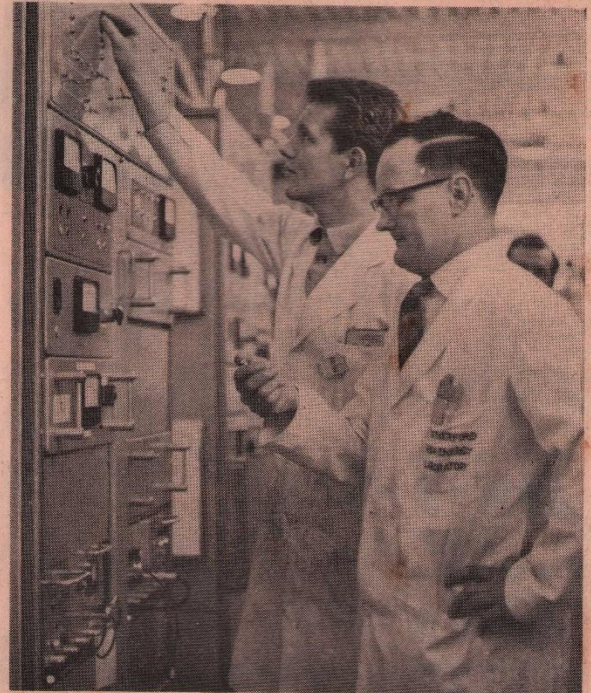
BERKSHIRE MEN WORKING WITH NIMROD



Mr. Terrence Harper of Reading (left), with Mr. Ron Hazell of Courtenay Road, Wantage, using an oscilloscope to monitor wave forms on Nimrod at the Rutherford High Energy Laboratory, Chilton, Berkshire.



Physicist Mr. Anthony Banford of Foliat Drive, Wantage, testing a focussing lens on the proton linear accelerator.



Mr. John Pilcher, of 46 Fyfield Close, Wantage, (left), operating the vacuum control panel for leak rate measurement, while Mr. Laurence Phillips of 34 Foliat Drive, Wantage, takes the leak rate with a stop watch.

**Wiltshire Gazette
and Herald**

THURSDAY, APRIL 23, 1964

Nimrod's programme gathers momentum

Britain's £11 million, 7-GeV particle accelerator will be formally inaugurated by the Secretary of State for Education and Science on 24 April, when he opens the Rutherford High Energy Laboratory. The machine is now operational and its potentialities and some of the current experiments are discussed

by Dr Peter Stubbs

BITAIN'S big proton synchrotron *Nimrod* has been working since August and the first experiments are now starting up. The 7-GeV proton beam which the machine can generate has less than a quarter of the energy of the huge accelerators at the European Organisation for Nuclear Research (CERN) or Brookhaven. Although this means that physicists will be unable to use it for scientific exploration at the extreme frontiers of the subject—such as neutrino research—it is still the first machine in Britain able to produce K-mesons, anti-protons and the so-called hyperons or heavy particles.

With *Nimrod's* particle beams, it will be possible to study in detail the interactions and physical properties of many of the new "resonances" which appear to be very short-lived, excited states of matter rather than fundamental new particles. In this way workers at the Rutherford Laboratory of the National Institute for Research in Nuclear Science should be able to help to fill in the elegant pattern that relates the 100 or so known particles under the so-called Unitary Symmetry theory (see *New Scientist*, Vol. 21, p. 458) with which the existence of the important omega-minus particle, recently discovered at Brookhaven, was predicted.

Nimrod's eight-segment, circular accelerating track is 155 feet in diameter. Protons are accelerated by a radio-frequency electric field in a toroidal-shaped vacuum chamber, made of glass fibre and epoxy resin. This lies

between the pole pieces of the 7000-ton electromagnet which forms the bulk of the machine and accurately controls the path of the particles. Initial pulses of protons are injected (Figure 1) into *Nimrod's* "racetrack" from a 44-foot linear accelerator with an energy of 15 MeV. They reach their maximum energy of around seven GeV after about a million revolutions taking approximately $\frac{1}{3}$ second, and this proton beam can either be extracted from the machine directly, or caused to react with internal targets giving rise to various kinds of secondary beams composed of pi-mesons, K-mesons, neutrons and so on that can be taken out for experiments. The electromagnet requires an increasing current of up to 10 000 amps at some 15 kV during the acceleration pulse. This large amount of power is produced by a motor-alternator system; the current in the magnets decays to zero after the pulse in 0.8 seconds, and the power is stored by the generator system in flywheels as inertial energy which can then be used to supply current for the next pulse.

The accelerator is designed to produce 28 pulses a minute of high-intensity protons, each pulse containing at least a million million particles. In fact, it is already producing pulses of half this intensity regularly and further improvements are expected. At present *Nimrod's* working week is $3\frac{1}{2}$ days and a useful high-energy beam is on tap for rather more than half this scheduled time; during the year the NIRNS workers hope to increase its running

time to 5-6 days a week and to improve its already high reliability. Part of the primary proton beam was first successfully extracted on 24 March this year.

The original intention of *Nimrod's* planners, before its construction began in August 1957, was to build a high-intensity proton machine rather than attempt to compete with the very high-energy accelerators then already being built at CERN and Brookhaven. Both types of machine have their own purposes and it was generally supposed that for very high-energy machines the number of particles in the beam would fall off as the energy increased; however, the yield of secondary particles produced by a collision of each primary accelerated particle rises with the energy, and physicists now recognise that one can get good high-intensity secondary beams from the most powerful synchrotrons. In a sense, therefore, *Nimrod* is not, by present standards, the logical type of machine to build in order to break new ground in high-energy physics. On the other hand, there is a great deal of necessary work that it is competent to do which would not employ the bigger machines to their full advantage.

At the moment, the High Energy Physics Division of the Laboratory, responsible for the organisation and co-ordination of the research programme which works in close collaboration with the visiting teams of workers from a number of universities, has six experiments under way. A further three are planned for inclusion later in 1964. Of the four experiments demonstrated this week, three were concerned with probing the nature of resonances known to occur when pi-mesons of specific energies are scattered by encounters with protons.

In one of these, being performed by Dr P. G. Murphy and Dr J. J. Thresher, of RHEL, a beam of negative "pions" is produced from an internal target in the accelerator and impinges on the protons of a liquid hydrogen target. The pions are selected for charge and energy in the usual way by bending magnets, so that only those with energies between 0.9 and 1.15 GeV are used, enabling a particular resonance occurring at 1.03 GeV to be studied. The pions are scattered by the protons, giving rise to recoil protons; both pions and recoil protons can then be detected by an array of 50 scintillation counters placed in an arc round the target. By electronic techniques it is possible to tell which of the particles have origi-

Nimrod's programme gathers momentum continued

nated by the elastic collision process and hence to find the angular distribution of the particles. The so-called "scattering angles" of the pions and protons tell the physicists more about the resonance process.

A second and a third experiment are, so to speak, "threaded" on the same experimental beam of either positive or negative pions. One, designated pi-2, is the responsibility of Dr F. F. Heymann, of University College, London, and Professor E. H. Bellamy of Westfield College, London. Again the idea is to look more closely at two recently discovered pion-proton resonances—a positive pion one occurring at 2.4 GeV and a negative pion one at 1.95 GeV. The set-up is somewhat similar to that of the previous experiment but the two workers use spark chambers to record scattering events. These are controlled by scintillation counters which switch them on only when there is something significant to record. The sign of the charges on the pions in the beam can be reversed simply by reversing the current through the bending magnets of the beam which has been specially designed to select either negative or positive pions in this way.

Behind pi-2, pi-3 is an experiment that makes use of the pions that have passed right through the pi-2 liquid hydrogen target without encountering protons. It has been designed by Dr A. B. Clegg, of Oxford University, and Dr A. Carroll, of RHEL, to examine another aspect of the pion-proton resonance at 1.95 GeV that occurs with negative pions. The pions are focused to a small spot on another hydrogen target with magnets, and the object is to study the exchange of electrical charge between the negative pion and scattering proton; immediately after the impact, the two particles exchange charges, giving rise to a neutral pion and a neutron. The neutral pion decays almost at once and gives two gamma rays. The target lies inside a rectangle composed of spark chambers and when the gamma rays strike the sides of this they produce pairs of electrons and positrons that can be recorded by the chambers.

The fourth demonstrated experiment, N-1, a joint effort by Dr G. Manning, of the Atomic Energy Research Establishment, Dr H. B. van der Raay, of Birmingham University, Dr J. Malos, of Bristol University, and Dr N. Lipman, of RHEL, is intended to find out more about the interaction of high-energy neutrons colliding with stationary protons. The neutron beam is produced

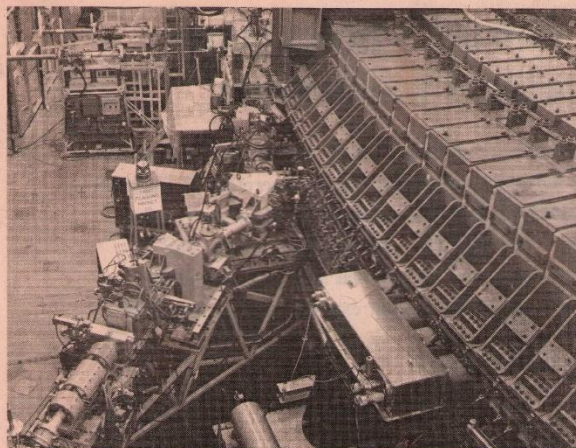


FIGURE 1. Part of *Nimrod's* 7000-ton electro-magnet which guides the protons in their circular vacuum chamber, showing the point where the initial protons with an energy of 15 MeV are injected into the machine. Three of the four wedge-shaped bending magnets, belonging to the so-called "achromatic inflector system" that steers the protons on to the correct path for injection, can be seen.

with an internal target in the accelerator and impinges on yet another liquid hydrogen target. Collisions result in protons which travel in the same direction as the incident neutrons and have almost as much energy. Those protons that have energies and directions within certain limits are detected with scintillation and Cerenkov counters that trigger spark chambers to record their positions to within one hundredth of an inch. This permits the accurate determination of the energies and angles of emission of the protons. An interesting feature of the experiment is the use of sound-ranging devices on the spark chambers. In this comparatively new technique microphones placed around the sparking area pick up the sound of the spark as the particle traverses the chamber; from the time-delay at each the particle's position can be accurately fixed by suitable electronics.

In addition to these experiments, a second proton beam is to be used by Mr A. E. Taylor, of AERE, Dr A. Ashmore, of Queen Mary College, London, and Dr T. G. Walker, of RHEL, to study the scattering of 7-GeV protons by the stationary protons in liquid hydrogen. Part of the team has recently discovered some unexpected effects in

this interaction at CERN and it is hoped to elucidate them further. Another pion beam is being designed by Mr J. A. Newth, of Imperial College, London, and Dr R. J. Ellison, of Manchester University. The later experiments will involve Cambridge and Southampton Universities, University College, London, RHEL, AERE, and also the Centre d'Etude Nucleaire de Saclay. There is little doubt that *Nimrod* is already being treated as a national, if not an international, asset!

Not that research directly connected with the accelerator is by any means the only kind of research which the building of a British synchrotron at the Rutherford Laboratory has stimulated there. Many workers are concerned with subsidiary problems; the design and improvement of detecting apparatus, data processing equipment, engineering, the production of high magnetic fields using superconductors, the construction of heavy liquid and helium bubble chambers to supplement the big British National Bubble Chamber when it returns from CERN, and the design of polarised proton targets in which the protons will all have their "spins" aligned in one direction. Altogether some 80-90 physicists are being kept busy by research on *Nimrod*.



MR. HOGG STARTS £11m. DEVICE AT CHILTON

The Minister for Science and Education, Mr. Quintin Hogg (far left) speaks with some of the staff members at the Rutherford High Energy Laboratory, Chilton today, before he inaugurated the £11m. Nimrod proton synchrotron.

He was welcomed at the laboratory by Dr. T. G. Pickavance, its Director. Before lunch Mr. Hogg saw a film of the laboratory's work and met members of the staff and trades union leaders. Among the guests were Mr. Airey Neave, M.P. for North Berks, and Ald. J. H. Stanley, Mayor of Abingdon.

Speakers at the lunch, apart from the Director and Mr. Hogg, were Lord Bridges, chairman of the National Institute for Research in Nuclear Science, and Sir John Cockcroft, Master of Churchill College, Cambridge.

Guests lunching in the new Nimrod-shaped restaurant were able to see on closed television circuit screens the state of the machine; over the loud speakers came the other Nimrod, from Elgar's Enigma Variations.



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FRIDAY, APRIL 24, 1964

£11 m NUCLEAR PLANT WILL PAVE THE WAY

WHEN Mr. Quintin Hogg, Secretary of State for Science and Education, presses a red button today another nuclear establishment will be added to Berkshire's list.

Today it is the turn of NIRNS, the National Institute for Research in Nuclear Science, at Chilton, where Mr. Hogg will officially open the Rutherford High Energy Laboratory, which covers 75 acres next to the AWRE, Harwell.

The Minister will set in motion Nimrod, an £11 million piece of

equipment the size of Piccadilly Circus, which has taken six years to build.

Nimrod is the heart of NIRNS and, on Wednesday, newspapermen were given a preview of the Rutherford laboratory including a visit inside Nimrod.

It is a gigantic 7,000-ton ring of electro-magnets, 200ft in diameter with 60ft of earth around the side, and 8ft of reinforced concrete and 10ft of earth on top. Without this shield, people for several miles would be in grave danger from radiation.

Nimrod, which has been running since last August, is used to

accelerate protons to very near the speed of light. The minute particles are shot into the machine at one-sixth the speed of light and are then spun round in a vacuum inside the magnet.

The protons leave the machine with the power of 7,000 million volts, and scientists "shoot" them at other protons to see what happens when they collide.

The most popular way of watching these collision is to fire the protons from Nimrod into a "heavy" liquid in a tank. They leave a path of bubbles which can be photographed and studied in detail.

The scientists at the laboratory do not yet know to what discoveries this work might lead. NIRNS has been set up for pure research and will cost the taxpayer about £5 million a year.

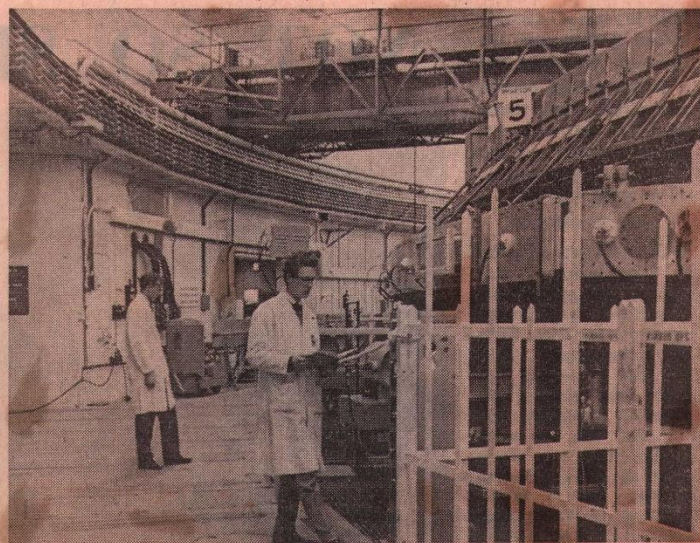
In an address to journalists on Wednesday, Dr. T. G. Pickavance, the director of the Rutherford Laboratory, explained the reason for such high expenditure.

"The fundamental point is that science is an essential part of our culture, and therefore it is vitally important to develop the most creative branches of science," he said.

Evening Advertiser

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SWINDON, FRIDAY, APRIL 24, 1964



Neil Cumming, of Faringdon (above, foreground) at work in the giant Nimrod Magnel Hall at the Rutherford High Energy Laboratory at Chilton, which was officially opened today by Mr. Quintin Hogg, Minister for Education and Science. Below: The clerical officer in the travel section is Mrs. Patricia Rossiter of 29 Okus Grove, Upper Stratton, who has worked at the laboratory for almost three years.



THE GUARDIAN

London

Saturday April 25, 1964

Nimrod in brain-drain variation

Nimrod, Britain's latest and largest scientific instrument, and its associated laboratory were playing an important part in reversing the "brain-drain," said Mr Quintin Hogg yesterday.

The Minister was speaking at the Rutherford high-energy laboratory, adjoining Harwell Atomic Centre, where he started up the £11 millions atomic particle accelerator. Nimrod is named after the Biblical character who was a "mighty hunter." The music at the inauguration ceremony, appropriately enough, included Elgar's "Enigma variation, Nimrod."

The laboratory has been set up to provide facilities in atomic research which no university could support by itself, said Mr Hogg. It was intended that universities should continue to have fullest access to its facilities.

On the question of housing even larger machines, Mr Hogg said that the governments in Euratom had called for a design study for a large machine but none had committed themselves to building it. Such a machine would cost at least £75 millions and must inevitably be a co-operative enterprise.

He described Nimrod's only purpose as to "accelerate approximately to the speed of light a stream of almost inconceivably small particles." This was with the object of creating even smaller particles whose length of life after they had been created could only be measured in minute fractions of a millionth of a second.

"In any generation before the present we should have been considered mad." Even today many of those who had actually paid for the machine had not the remotest conception of what it was about.

But the acquisition of knowledge for its own sake was essential to the wellbeing of a civilised country.

Mr Hogg, speaking later at a meeting of scientists at Guild Hall, Abingdon, said that national expenditure on research and development may well be 3 per cent of the gross national product. This was better than any other Western country except America. But as regards civil research and development this figure might beat that of the US.

He believed that a revolution had been achieved in the scale of the national scientific effort, in the relationship between Government and science, and in the education and training of scientists.

DAILY MAIL, Saturday, April 25, 1964

PAGE 4 | Diary, Crosswords, Stars

CHARLES GREVILLE

PEOPLE

 **NAMING** a new sauce after a nuclear machine at Harwell yesterday—caterer **Mr. William Burroughes**. This raisin and rum mixture was called "Nimrod Sauce" after the machine set in motion

by **Mr. Quintin Hogg**. "If he'd kept his peerage, it would have been Hailsham Sauce, but I drew the line at having Hogg Sauce on the menu," said Mr. Burroughes.



SATURDAY APRIL 25 1964

"NIMROD REVERSING BRAIN DRAIN"

Mr. Hogg, Secretary of State for Education and Science, yesterday claimed that Nimrod, the proton synchrotron at the Rutherford High Energy Laboratory at Chilton, Berkshire, and the laboratory itself were playing a part in reversing the "brain-drain". The facilities they made available had already begun attracting nuclear physicists back to Britain, he said.

The laboratory has been set up to provide facilities in atomic research which no university could support by itself, and Mr. Hogg said it was intended that universities should continue to have fullest access to its facilities. Mr. Hogg was touring the laboratory after inaugurating Nimrod.

MINISTER AT NIMROD INAUGURATION



The Minister of Education and Science, Mr. Quintin Hogg, taking the weight off his feet during his tour of the Rutherford Laboratories at Chilton yesterday. He is chatting with Dr. N. Lipman (left), Mr. Airey Neave, M.P. for North Berkshire, and Dr. G. H. Stafford.

Mr. Hogg 'looks round corner' of science

NEED FOR CLOSER UNIVERSITY LINKS

MR. Quintin Hogg, Secretary of State for Education and Science, "looked round the corner" of science when he spoke at the inauguration lunch of NIMROD — the £11m. National Institute for Research in Nuclear Science atom-smashing machine at Chilton—yesterday afternoon.

He spoke of demands for machines of 300 GeV and even 1,000 GeV in the future — NIMROD is a 7 GeV accelerator — which, Mr. Hogg said, would "only be sensible to build on a world scale."

Mr. Hogg continued: "Not even the combined nations of a continent can afford indefinitely nuclear science on that scale."

"And, of course, to the cost of the accelerators has to be added the cost of the giant computers like ATLAS and other accessories which were necessary to their proper working."

Many physicists

This, of course, was the explanation of NIRS itself. "No one nation can be self-supporting, no one university can justify facilities on this scale. They must be provided for a consortium of university scientists," Mr. Hogg said.

Mr. Hogg, who was speaking in the new NIRS canteen, said the experiments on this machine already absorbed the energy of nine university groups, two Atomic Energy Authority groups, and the Rutherford group, representing in all about 100 physicists and forming eight teams, each proposing one or two experiments depending on the electronic technique of particle detection.

Seven other university groups and the Rutherford group were now participating in bubble chamber experiments.

After his speech Mr. Hogg called the main NIMROD con-

QUESTION OF COST

The first accelerator used for research in nuclear physics cost "about £1,000," Sir John Cockcroft said at Chilton yesterday.

This compared with the £11m. cost of NIMROD, the atom smashing machine which was inaugurated yesterday.

Mr. Hogg then pressed a green button to inaugurate the machine and a change in the picture on closed circuit television screens in the dining room showed that NIMROD had started to operate satisfactorily.

Lord Bridges, chairman of NIRS, said that the laboratory wanted university staffs coming to it to feel that they were in an extension to their own and other universities. Guests heard the signal siren and then an urgent call for anyone in the area to use the emergency exit.

Essential links

The laboratory, he said, would not only contribute to the growth of nuclear physics but would also help to keep alive the essential links between advanced teaching in the universities and fundamental research.

Dr. Pickavance, director of the laboratory, said: "We are very pleased with NIMROD. In spite of its complication, it is reasonably docile."

A good start had been made on the research programme and there was no shortage of research projects or physicists anxious to carry them out.

Sir John Cockcroft, a founder member of the National Institute, said that the ultimate objective of high energy nuclear physics was to understand the relationships between four basic forces of the universe.

"But before we reach this very distant goal it is likely that many other now unpredictable discoveries will be made with this our powerful new instrument."

MR. Quintin Hogg, Secretary of State for Education and Science, said at Abingdon last night that he sympathised with a questioner who complained of a dissociation between scientific teaching and research.

Mr. Hogg was following his engagement at the Rutherford Laboratories at Chilton with a talk to an audience of more than 200, mostly scientists from North Berkshire establishments, at Abingdon Guildhall. The questioner said the dissociation was marked "in this part of the world," and added: "We are not even allowed to supervise our own students for higher degrees."

No compulsion

Mr. Hogg replied: "I have been trying to encourage universities to allow people to study for Ph.D. in a Government laboratory, but they need a great deal of persuading."

"I have no power of compulsion, and the general view is that I should not have powers of compulsion."

In his address Mr. Hogg said that dissociation between teaching and industry is dangerous at technician level and could be catastrophic at university and college of advanced technology level.

He added: "This I believe, is one of the greatest errors committed by the Soviet bloc powers—the concentration of the highest levels of research in institutions away from the university and industry."

Pressure groups

A questioner said that in large technological decisions, the Government seemed to be "bobbing on a sea of private interests, pressure groups and so on."

Mr. Hogg agreed that it was buffeted by pressure groups but said: "Whether or not it is bobbing is open to question."

Deviations in policy over a land reactor were not based on a choice of reactor but calculations of the size of the Government programme. Another questioner asked how much Government research institutions were tied to the profit motive in determining the work they do.

In a detailed reply, Mr. Hogg said: "Not very much." He added amid laughter and applause: "No one could say that the Atomic Energy Authority was dominated by the profit motive."

Mr. Quintin Hogg sets NIMROD to work

MR. QUINTIN HOGG inaugurated NIMROD yesterday (Friday) by pressing a button linking a luncheon assembly with the Rutherford Laboratory. The occasion was also the formal opening of the laboratory at Chilton, adjoining A.E.R.E., Harwell. A distinguished gathering of 250 people included international scientists and representatives of all sections of public life.

Before the inaugural luncheon, Mr. Hogg chatted with five trade unionists, Mr. W. Boyd, Mr. A. H. Spurway, Mr. J. P. Bishop, Mr. W. M. Bray and Mr. J. Short.

Mr. Hogg said: "In any generation before the present we should have been considered mad to spend £11,000,000 of the taxpayers' money on a machine the only purpose of which is to accelerate approximately to the speed of light a stream of almost inconceivably small particles, with the object of creating other particles even smaller.

"We are engaged today on what is essentially an act of faith. It is as much an act of faith as Ely Cathedral, and in the end faith of this kind is the sort that moves mountains. If this country can no longer emulate the power of imperial Rome, as we have done until recently, we can at least aspire to the intellectual eminence of an Athens in the modern world.

"May NIMROD be a magnet to attract to this country brains and talent and imagination that would shed lustre on those who use its facilities, and not least on the poor British taxpayer who has to pay for it."

Built at cost of £11 million

THE Rutherford High Energy Laboratory at Chilton, which has been built on a 75-acre site adjoining the Atomic Energy Research Establishment in the neighbouring parish of Harwell, on Wednesday received its first visit by the Press.

The laboratory is the first to be sponsored by the National Institute for Research in Nuclear Science, which was set up in 1957 by the Government to provide for common use by universities and others, facilities which are beyond the scope of individual universities and institutions carrying out research in the nuclear field.

The laboratory grew out of the accelerator division and part of the engineering division of the Harwell establishment, some 300 of the latter staff being transferred in 1961. The present payroll is 945, and the research programme is currently cost-

ing £6 million a year, of which £1½ million goes on salaries.

The work of the laboratory is mainly research in high energy physics—the study of the properties and structure of the elementary particles of which the whole universe is made.

The main programme of the laboratory is based on two particle accelerators—the 7 GeV (seven thousand million electron volts) proton synchrotron NIMROD, and a much smaller proton linear accelerator. The latter is in daily use by university research teams as well as staff of the Rutherford Laboratory.

NIMROD, which produces its first high energy particles in August last year, and was officially inaugurated yesterday (Friday) by Mr. Quintin Hogg, Secretary of State for Education and Science, now joins the really big machines capable of supporting "front line" research in high energy physics. It represents Britain's entry into a very competitive field. There are 12 others now operating in this class—six in the United States, three in Russia, and three elsewhere in Western Europe.

The machine, built at a cost of just under £11 million, is named after the mighty hunter NIMROD, who is described in Genesis as "a mighty one in the earth." It is contained in an underground circular building whose diameter is as big as Piccadilly Circus, and which is heavily shielded by concrete and earth. NIMROD's main physical feature is a large ring-shaped electro-magnet, 155 ft. in diameter, which weighs 7,000 tons. Protons are accelerated to a very high velocity whilst constrained to a circular path by means of a magnetic field.



MR. QUINTIN HOGG, seen here at an informal gathering with Trades Union representatives prior to the opening of the Rutherford Laboratory.

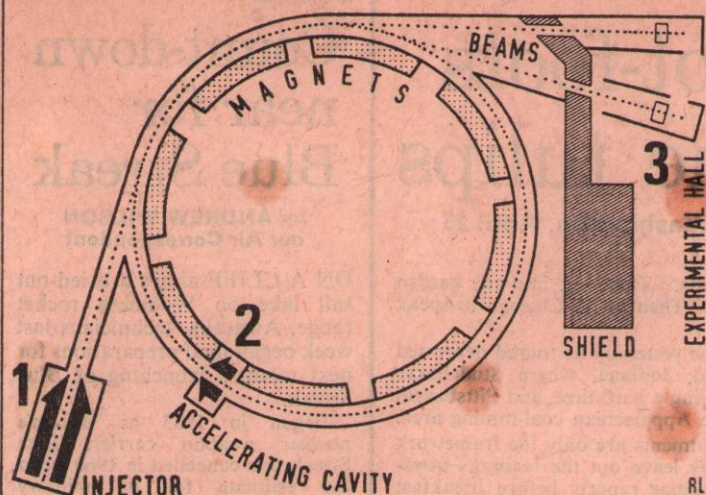
Photo: Alfred F. Carpenter.

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READING SATURDAY APRIL 25th 1964

NUCLEAR SCIENCE



SEQUENCE OF EVENTS IN NIMROD.

1. Injector fires bunch of protons into circular vacuum tube 465 feet in circumference. Over 7,000 tons of magnets hold protons in circular path.
2. Powerful electric field in accelerating cavity gives protons a mighty kick each time round. In seven tenths of a second they circle a million times, covering 100,000 miles, reaching 99 per cent of the speed of light.
3. Magnet deflects protons on to targets in heavily shielded experimental hall. Nimrod can produce 28 pulses of a billion protons each per minute.

Smashing—but very expensive

by JOHN DAVY, our Science Correspondent

THE COST of smashing atoms is rapidly becoming a highly controversial subject. Nimrod, Britain's latest atom-smashing machine, which was officially inaugurated last week by Mr Quinton Hogg, Minister for Science, has cost £11 million to build.

The Rutherford Laboratory of the National Institute for Research in Nuclear Science, which has grown up round Nimrod on a stretch of old airfield just outside Harwell's security fence, costs over £4 million a year to run. High energy physics is easily the most expensive research activity outside space exploration. It is certain to become more expensive still. Nimrod men are nervously aware that Mr Hogg's Advisory Council on Scientific Policy recently recommended that no more should be spent on high-energy physics until the needs of other sciences had been met. Mr Hogg's visit last week was thus a somewhat tense occasion—especially as he was accompanied by hawk-eyed Treasury men. Nimrod is undoubtedly a superb research instrument—the largest national machine outside America and Russia, and fifth in the world league table. It is some 12 million times more powerful than the world's first atom smasher built at the Cavendish Laboratory, Cambridge, by Cockcroft (now Sir John) and Walton in 1932 at a cost of about £1,000.

Russia is currently building a machine 10 times more powerful than Nimrod, and six times more powerful than the 12,000 million electron volt machines at Brookhaven, United States, and CERN, the European Centre for Nuclear Research near Geneva.

Machines three to four times more powerful still are being intensively studied at Cern and Brookhaven. And there is already serious discussion of an ultimate monster, for use in the 1980s, a one billion electron volt machine which would be about seven miles in diameter. (A Rutherford Laboratory scientist said cautiously last week: "There might be a possible site in Austria.")

Faster yet

The reason why physicists want these machines is simple: the ultimate constituents of matter are still highly mysterious, and they want to explore further.

The technique is to fire atomic particles—protons or electrons—at other particles or whole atoms, and see what happens. Atom smashers are machines for accelerating these nuclear projectiles. To penetrate more deeply into the atomic nucleus, the bullets must travel faster. This calls for bigger accelerators.

This situation has led to detailed studies at Cern and in America of the future of the atom-smashing industry. Nimrod is at present the pinnacle of Britain's nuclear physics effort. But the Cern study implies that it will be merely at the base of a European scale "pyramid."

Collision course

The Cern study draws up a shopping list of roughly Nimrod-sized machines which might be needed to support a "summit programme" of giant machines. This "base-of-pyramid" list includes:—

1. A "meson factory" producing a particular class of nuclear particle in far greater quantities than yet available.
2. A "Kaon factory" producing very intense beams of another class of particles.
3. A really powerful machine for accelerating electrons (rather than protons). The world's largest electron accelerator is currently under construction at Stanford University, California, and is two miles long.

The Cern summit programme calls for two projects. First, the attachment of storage rings to the existing Cern accelerator. Pulses of particles would be stored in these rings, travelling in opposite directions. Then a magnet would deflect the pulses into a head-on collision. This would give impacts 30 times more powerful than the accelerator can achieve on its own.

Second, the construction of a machine 10 times more powerful than Cern's present accelerator. It would be a mile and three-quarters in diameter, contain 27,000 tons of steel and 2,500 tons of copper, and cost about £120 million spread over 11 years.

Giant machines

The whole programme would be completed in 1977. By then, to use their equipment effectively, the Cern member States (which include Britain, who contributes 25 per cent of Cern's costs) would be spending about £130 million a year on high-energy physics, employing 2,500 physicists and 1,500 professional engineers. This effort, Cern estimates, would represent 0.072 per cent of the member States' gross national product. Britain currently spends 0.3 per cent of her G.N.P. on fundamental research, so that high-energy physics would be taking no more than one fifth of the whole. This, atom-smashers believe, is reasonable.

Cern argues, too, that there will be little choice if Europe wishes to keep a serious stake in the work, since both America and Russia are going ahead with giant machines. American expenditure on high-energy physics is currently double that of Cern States, and if the programme recently recommended by a panel of U.S. scientists is adopted, atom smashing will be costing America £200 million a year in 1977, or one and half times the sum recommended by Cern for Europe.

The uses of NIMROD

BY JOHN MADDUX

THE inauguration at the Rutherford High Energy Laboratory, Chilton, of the machine called NIMROD, which can accelerate the atomic particles called protons to energies corresponding to 7,000 million volts, is a landmark in the post-war history of British science. There are those who think that it may even do a great deal to take the edge off the emigration of scientists to the United States. Certainly there is no question that the lack of really advanced machines of this kind in the years immediately after the war, and their ostentatious presence in the US, was one of the reasons for the westward drift of scientists that started two decades ago.

Others may think of NIMROD as a way of recapturing old prestige. Until the end of the twenties British laboratories—staffed largely but not exclusively by British scientists—had been in the forefront of the great wave of research which showed that atoms were not after all indivisible, and that even the nuclei of atoms could be fragmented by suitably drastic treatment. In the early thirties, however, the tide began to run the other way. Though it was then that Cockcroft and Walton first split atomic nuclei into pieces by deliberate external influence, though Chadwick discovered the atomic particle called the neutron, and in spite of the genius of Rutherford which brooded over this one laboratory, the initiative in this esoteric branch of physics passed to the Americans.

It is tempting to think that the reasons are those which allowed Henry Ford to be such a success, but that is a drastic oversimplification, and even a falsehood. To be sure, American leadership in this field has been based, before and since the war, on the construction of very large machines for accelerating atomic particles to very great speeds (which is the same as saying that individual atomic particles are endowed with comparatively very large amounts of energy). But if at the beginning it took men like Anderson to realise how much might be done by the construction of machines, and even though the tradition died hard in Britain that string and sealing-wax were not merely best but also virtuous, the building of accelerating machines soon became a matter of resources and money. Now £20 millions is not enough to provide the most modern piece of equipment of this kind. NIMROD cost more than £11 millions to build, and will cost at least £4.5 millions each year to run. And already there are those who talk of spending £100 millions on a single piece of equipment for accelerating atomic particles.

THESE sums are so large that it is inevitable that their spending should be regarded as evidence of national prestige. In reality, however, people come and go between the different machines as if these were the property of the United Nations and not of the Governments which built them. This is splendidly illustrated in the present state of affairs by the way in which the instrument known by the ponderous title of the British National Hydrogen Bubble Chamber is now on extended service at the Geneva laboratory of CERN (where British scientists are using it in an international programme of research). Though it had been originally intended that this device should be returned to Britain when NIMROD was ready, it now seems probable that a similar (though smaller) device will be transferred to NIMROD from the French laboratory at Saclay. In other words, high-energy physics (as the speciality is called) is not nearly as chauvinistic as it seems. There is hardly anywhere as cosmopolitan as the coffee room of a high-energy physics laboratory.

But what is it all meant to accomplish? As things are, nobody suggests that there will be any practical benefit. Atomic energy is the offspring of the work in the early thirties, when it was recognised how the nuclei of atoms might be disrupted by suitable collisions with other atomic particles. All the high-energy physics since carried out has served only to make people wiser.

But to what end? What nuggets of wisdom can there be worth hundreds of millions of pounds spent on elaborate equipment, and the efforts of tens of thousands of skilled people all over the world? Nine hundred people dance attendance on NIMROD. It would take the population of a small town to run the machines now being planned. But the enthusiasts are in no doubt of what the answer should be. One of these days, the argument goes, some series of experiments in high energy physics will explain why the universe is as it is; why electrons and protons and the other particles of which matter is made have the particular properties which can be measured in the laboratory; why the speed of light is what it is; why there is light at all for that matter. Surely, the enthusiasts say, that is a prize worth any money?

BUT this is still a distant goal. At present the high-energy physicists are concerned with the immediate task of learning as much as possible about the tiny atomic particles which can be made from atomic nuclei and from the collisions of pairs of familiar

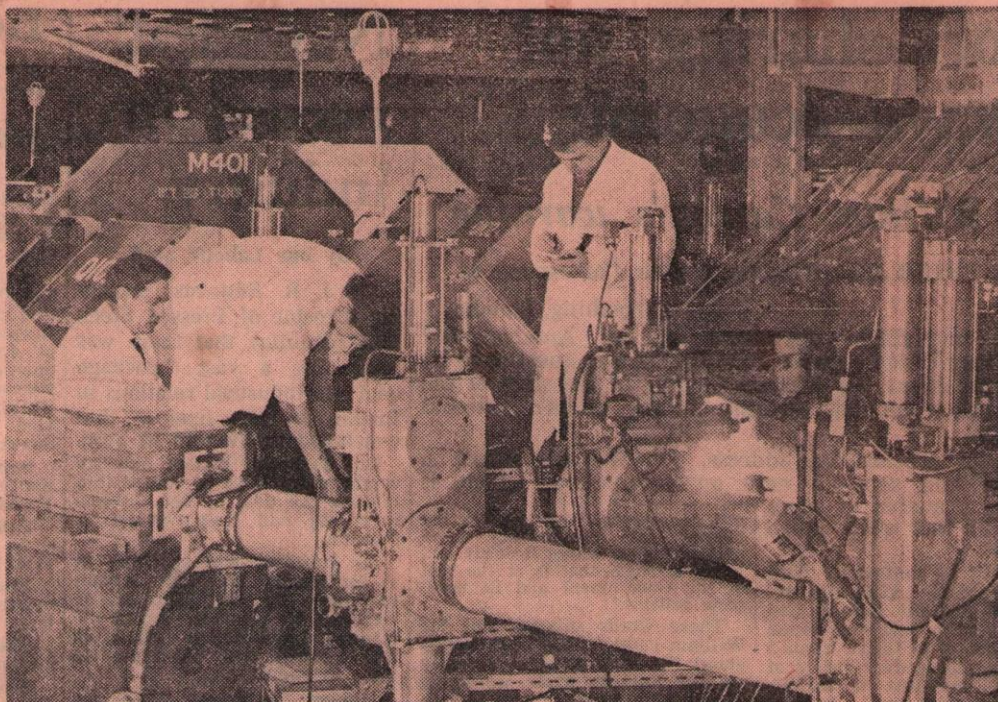
atomic particles. The most recent memorable success in this field was the discovery of the omega-minus particle at Brookhaven earlier this year. That confirmed a comforting theoretical prediction that the great number of the atomic particles discovered in recent years is not, after all, a proof that the natural world is absurdly complicated. There is a great deal of regularity. There is also a great vogue for experiments with the atomic particles called neutrinos—atomic particles which possess neither mass nor electrical charge. The proof, last year, at Geneva that there are really two kinds of these particles bears directly on a characteristic of the natural world every bit as important to the full understanding of it as Newton's laws of motion. It goes without saying that NIMROD will be able to make a valuable contribution to this kind of work even though, by the nature of things, it will not be able to reveal those phenomena which lie beyond the reach of the most powerful machines yet built.

What will these machines look like? As it happens, things have changed a great deal since the early thirties, when the first cyclotron went into service in Berkeley, California. The principle of that device was to use magnetic forces

as means of restricting the movement of atomic particles while these are accelerated to great velocities. In the simplest cyclotrons, this is done by embedding a squat cheese-shaped chamber (rigorously evacuated of gas) between the poles of a magnet. In these circumstances atomic particles carrying electrical charge can be made to move round in circles, at least if their speed is not too great for them to escape the confines of the magnetic forces. But then, the argument goes, particles like this can be accelerated by means of electrical forces supplied, as it happens, by suitable radio waves.

By making magnets that were large enough, instruments like this were able to produce streams of the atomic particles whose energies could only otherwise have been obtained with electrical forces of 500 million volts or so. This is a thousand times greater than the energy of the protons which Cockcroft and Walton had used in their experiments in the early thirties. After the war, however, even this performance was quickly outdone. One of the limitations with the cyclotron device is that atomic particles move in larger circles as they accelerate, so that they move outwards in a spiral path and eventually escape altogether from the machine. Even if there were no other difficulties (which is not the case), making magnets big

John Maddox describes
Nimrod, the new British
linear accelerator at the
Rutherford high energy
laboratory 8



The beam-line emerging from Octant 3 of the NIMROD magnet ring

enough to attain much higher energies would be extremely difficult. So there were evolved the machines in which atomic particles are constrained to move in a fixed circular track during the process of accelerating them. This can only be done by means of magnetic forces which march in step with the accumulation of speed.

THE precision with which this is done is one of the engineering triumphs of the construction of the large machines for accelerating atomic particles now in service. NIMROD and the machine at CERN are of this type. Some, however, accelerate the atomic particles called electrons, which is more difficult than that of protons if the measure of success is the energy with which each particle is finally endowed. Still other machines are long, straight, tunnel-like structures, in which atomic particles are accelerated steadily as they move along the length of the accelerating machine. The most spectacular of these is the device now being built at Stanford, California. Work has begun on a mile of it. Eventually the machine may be twice as long.

Great size is also the most obvious characteristic of the circular machines, all of which have evolved by one means or another from the cyclotron. By now a great many different names are in use, corresponding to the large number of changes which may be rung on the principle that atomic particles can be

kept moving in a circular track while their speed is rapidly increased.

In NIMROD this circular track is 155 feet in diameter. Atomic particles have to travel a million times around this circuit before they acquire their full energy of something like 7,000 million volts. For most of this time they travel with a speed virtually indistinguishable from that of light. The whole process takes a mere two thirds of a second.

The machine at CERN is larger still, and correspondingly more spectacular. Yet even this will be dwarfed by some of those for which plans are now being laid, however optimistically. There is, for example, a proposal for a 200,000 million volt machine at Berkeley, California, whose diameter would be 1,600 metres. At CERN, the visionaries would like to see built a machine producing particles whose energy would be half as great again, which would be 2,400 metres in diameter, whose magnet would contain 27,000 tons of steel, and which would consume 20,000kw. of electrical power. At Brookhaven, in the United States, ambition has soared even higher, for there sights have been fixed on an accelerating machine capable of producing protons at an energy corresponding to 1,000,000 million volts. This would be some 11,000 metres in diameter. Russian plans are less well advertised, though a machine for particles with an energy of 70,000 million volts has been under construction for some time. There are also plans for machines with energies of 500,000 million and 1,000,000 million volts.

WHO can afford to build these gigantic pieces of machinery? By now it seems to be recognised that countries such as Britain and France will not be able independently to go beyond equipment on the NIMROD scale. Both the United States and the Soviet Union, however, seem determined to build a larger machine for themselves. This means that European collaboration will be necessary, presumably on the same basis as that at CERN, if Western Europe is to stay in this curious race. Preparatory work has already begun on the design of such an instrument.

For the next generation but one it is plain that nothing less than thoroughly world-wide collaboration will justify the enormous effort needed to build a machine capable of producing protons at an energy of 1,000,000 million volts of energy. Desultory talks between the interested countries have been under way for some years. There is no prospect yet of agreement to collaborate, though it seems also to be understood that the time has not come when the foundations of such a gigantic instrument should be laid. But before this decade is over the chances are that some scheme on these lines will have come to seem a matter of the greatest urgency to the physicists.

WORLD COLLABORATION NEEDED FOR NIMROD'S SUCCESSORS

Quintin Hogg at N.I.R.N.S., Chilton

Mr. Quintin Hogg, Secretary of State for Education and Science, "looked round the corner" of science when he spoke at the inauguration lunch of Nimrod—the £11,000,000 National Institute for Research in Nuclear Science atom-smashing machine at Chilton—on Friday afternoon.

What he saw there was a future demand for machines of 300 GeV and even 1,000 GeV.—Nimrod is a 7 GeV accelerator—which, said Mr. Hogg, would "only be sensible to build on a world scale."

GeV stands for Giga electron Volt, and is a measure of the energy possessed by an electron accelerated by a pressure of 1,000,000,000 volts.

Mr. Hogg declared: "Not even the combined nations of a continent can afford indefinitely nuclear science on that scale."

And, of course, to the cost of the accelerators had to be added the cost of the giant computers like Atlas and other accessories which were necessary to their proper working.

Consortium

This, of course, was the explanation of N.I.R.N.S. itself. The Minister went on: "No one nation can be self-supporting, no one university can justify facilities on this scale. They must be provided for a consortium of university scientists."

Mr. Hogg, who was speaking in the new Nimrod-shaped N.I.R.N.S. canteen, said the experiments on this machine already absorbed the energy of nine university groups, two Atomic Energy Authority groups, and the Rutherford group, representing in all about 100 physicists, and forming eight teams each proposing one or two experiments depending on the electronic technique of particle detection. Seven other university groups and the Rutherford group were now participating in bubble chamber experiments.

Message four

After his speech Mr. Hogg called the main Nimrod control room and asked for "message four"—the final signal to clear the Nimrod area before the machine became operational.

Guests heard the signal siren and then an urgent call for anyone in the area to use the emergency exit. Mr. Hogg then pressed a green button to inaugurate the machine and a change in the picture on closed circuit television screens in the dining room showed that Nimrod had started to operate satisfactorily.

Lord Bridges, chairman of N.I.R.N.S., said in his speech that the laboratory wanted university staffs coming to it to feel that they were in an extension

to their own and other universities.

The laboratory, he said, would not only contribute to the growth of nuclear physics but would also help to keep alive the essential links between advanced teaching in the universities and fundamental research.

Dr. Pickavance, director of the laboratory, said: "We are very pleased with Nimrod. In spite of its complication it is reasonably docile."

A good start had been made on the research programme and there was no shortage of research projects or physicists anxious to carry them out.

Sir John Cockcroft, a founder member of the National Institute, said that the ultimate objective of high energy nuclear physics was to understand the relationships between four basic forces of the universe.

"But before we reach this very distant goal it is likely that many other now unpredictable discoveries will be made with this our powerful new instrument."

Dissociation

In the evening Mr. Hogg gave a talk to an audience of over 200, most of them scientists, in the Guildhall, Abingdon.

He said, he sympathised with a questioner who complained of a dissociation between scientific teaching and research.

The questioner said that the



Mr. Quintin Hogg performing the opening ceremony of Nimrod at the Rutherford Laboratory on Friday. Also in the picture, left to right, front row: Dr. T. G. Pickavance and Lord Bridges.

dissociation was marked "in this part of the world" and added: "We are not even allowed to supervise our own students for higher degrees."

Mr. Hogg replied: "I have been trying to encourage universities to allow people to study for Ph.D. in a Government laboratory, but they need a great deal of persuading."

In his main address, Mr. Hogg said that dissociation be-

tween teaching and industry is dangerous at technician level and could be catastrophic at University and College of Advanced Technology level.

He added: "This, I believe, is one of the greatest errors committed by the Soviet bloc powers—the concentration of the highest levels of research in institutions away from the university and industry."

Another questioner said that

in large technological decisions, the Government seemed to be "bobbing on a sea of private interests, pressure groups and so on."

Size of programme

Mr. Hogg agreed that it was buffeted by pressure groups but said: "Whether or not it is bobbing is open to question." Deviations in policy over a land reactor were not based on a choice of reactor but calculations of the size of the Government programme.

North Berks Herald

41 Sturt Street, Abingdon
Tel: ABINGDON 106

THURSDAY, APRIL 30, 1964

THURSDAY, APRIL 30, 1964

EXTENDING THE LIMITS OF HUMAN KNOWLEDGE

Particles near speed of light

With the massive Nimrod project now fully operational the Rutherford High Energy Laboratory at Chilton is equipped to extend the frontiers of human knowledge.

The Rutherford Laboratory, which has a budget of £6m this year, is able to attract the world's ablest scientists. Universities make free use of the facilities and there is a considerable "waiting list" for such bodies wanting to carry out experiments.

Last Wednesday the national and local Press and B.B.C. representatives were able to have their first really close look at the National Institute for Research in Nuclear Science, which includes Nimrod (it takes its name from Genesis, "the mighty one in the earth") and the Proton Linear Accelerator.

An address was given by the director, Dr. T. G. Pickavance, who said that there was justification for the enormous amount of money which was spent purely on research.

Elementary?

He pointed out that the study of the properties and structure of elementary particles of which the whole universe is made, had expanded so rapidly in the past few years that physicists had begun to wonder, which if any, of the particles deserved to be called "elementary."

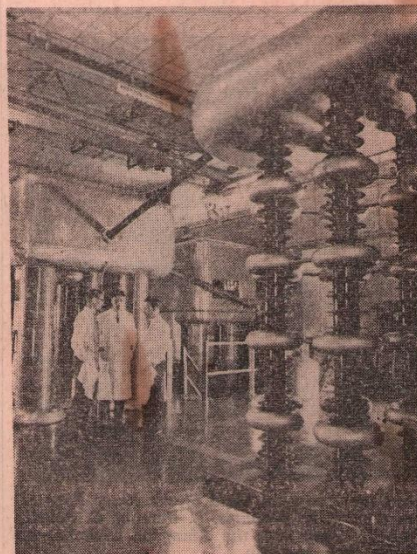
"Science is an essential part of our culture, and therefore it is vitally important to develop the most creative branches of science."

"Few would challenge the statement that the allocation of support for pure research should follow the directions which the leading minds find most challenging."

No quick return

"A central and particularly challenging field such as high energy physics should certainly be supported, even though it is expensive and give no guarantee of direct returns beyond its shore of the output of trained minds from the educational process which, at its most advanced level, must be coupled with research."

Dr. Pickavance said that science was a complex structure which could be seriously



Part of the injector room of the 50 Mega electron Volt proton linear accelerator, showing (left to right) the E.H.T. platform, the polarised proton source and D.C. gun and the 500 kilovolt filter stack.

harmful if the criterion for getting a grant bigger than some chosen sum were to be a promise of quick economic returns.

The Rutherford Laboratory grew out of the Accelerator Division, and a part of the Engineering Division of A.E.R.E. Harwell, beginning in mid 1957. It was not until January, 1961, that almost all of A.E.R.E. staff working on Rutherford Laboratory projects — then some 300 strong — transferred to NIRS employment. The present pay roll numbers 945.

The Proton Linear Accelerator was first operated in 1959 and it has been used for research since the beginning of

1960. Nimrod produced its first high energy particles in August, 1963.

Dr. Pickavance said: "These two machines are extremely powerful research instruments. The P.L.A. fills an important gap by operating in a relatively neglected energy range. We believe that, with its ancillary facilities, it is at present the most powerful machine in the world in this energy region."

It was operated for four 24 hour days each week. An average of 50 nuclear physicists, of whom 40 were from universities, used it. Seven university physics departments, including Oxford, were regularly involved.

Nimrod has joined the really big machines capable of supporting "front line" research in high energy physics. There are 12 others now operating in this class. In terms of particle energy, Nimrod is fifth from the top, but in terms of beam intensity it is already among the leaders.

13 Megawatts

Nimrod running at full power takes 13 megawatts from the national grid. This will increase to 20 megawatts in time.

Fears had been expressed that because of its enormous power consumption, Nimrod might have to close down during high demand periods in the winter. Close contact was kept with the local electricity board throughout the winter, but in fact the laboratory never had to shed load, said Dr. Pickavance.

The centre ring of Nimrod is as large as Piccadilly Circus. Protons are shot from their source through a linear accelerator into this ring, and then whirled round it accelerating all the time until they achieve 99.9 per cent of the speed of light.

Radiation hazards — which would spread over a two mile area if released — are eliminated by a defensive mound of concrete and earth. There is lateral shielding 60ft. thick.

HARWELL'S FRENCH VISITORS

A.E.R.E. Harwell gave a practical demonstration of the entente cordiale at the weekend when they entertained 35 guests from the Centre d'Etudes Nucleaires de Saclay.

This was a return visit after last year's first inter-change when Harwell went to Saclay. So successful have been the visits that it is certain that a tradition has been established.

The Saclay centre is the French counterpart of the Atomic Energy Research Establishment, Harwell.

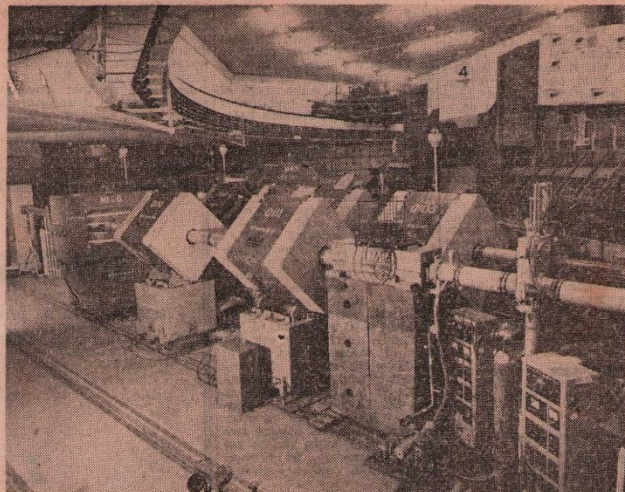
A reception was held in their honour in the new A.E.R.E. restaurant on Saturday night, at which Dr. R. Spence, Director of the Establishment, welcomed the visitors.

In reply, the president of the Saclay Rugby Club, M. Daughreilh, said: "Until today I thought to receive his friends thus was a Frenchman's speciality. In this way and also playing good Rugby we have much to learn from you."

On Sunday morning the French party visited Oxford. After lunch at Harwell, the business of the weekend — a Rugby match — was played.

Saclay fielding a team which included Mommejat, a brother of the famous international, won by eight points to five after a fast, hard and exciting game. Harwell drew 3-3 last year.

A most successful weekend was rounded off at the Fox public house, Stevenon, before the guests were taken by coach to London airport and thus by air to Paris.



A general view of various beam lines in the Nimrod magnet room leaving the magnet ring and passing through the main shield wall into the experimental area.

CCTV systems monitor Nimrod operations

CLOSED circuit television is extensively used for the setting up and operation of Nimrod, the 7 GeV proton synchrotron at the Rutherford Laboratory, of the National Institute for Research in Nuclear Science, at Harwell, which was officially opened by Mr Quintin Hogg last week.

There are three main CCTV systems, the largest of which is a 405-line general surveillance and security network by Rank Telecommunications. This has 13 cameras, eight on fixed mounts and five with zoom lenses and remote control of pan and tilt. The system is expandable to 30 channels, and is one of the largest of its kind in the UK.

A Pye mark IV 625-line system is used for experimental beam focusing. Originally used at the proton injector only, it is now being extended to the main control room.

The injector system is particu-

larly dependent upon CCTV, due to the very high energies involved giving rise to radiation hazards (e.g. observation of the beam striking targets).

A 625-line AIDS system is used for observing grids and scintillators in the main control room.

For setting of the beam as it travels round the synchrotron fine wire grids, coated with a fluorescent material, are swung into the path of the beam.

Scintillation occurs where the beam strikes, and the cameras are used to observe this from the main control room.

It seems to me

by Geminus

BIGGER THINGS could well follow the tacit agreement of the United States and the Soviet Union that the production of fissile material should be sharply reduced. In the United States, where fairly complete information on the subject is available, it is plain that within a few years the annual output of fissile uranium will be only half of what it was two years ago. There will also be a reduction of plutonium production, though its extent is more difficult to estimate. In the Soviet Union, no doubt, reductions of comparable extent are to be expected, though just what these are there is nobody to say. But as a crude generalisation it would seem reasonable to suppose that the two largest nuclear powers will, in future, only produce half as much nuclear explosive as they used to do.

But is it not then reasonable to ask whether the trend towards unilateral disarmament might not go much further still? Why shouldn't the nuclear powers—Britain included—now go the whole hog, and abandon the production of nuclear explosives altogether? Supplies of these materials must be adequate to meet all foreseeable needs. With the equivalent of more than 25 tons of TNT for every inhabitant of the earth, the continued manufacture of fissile material must seem extravagantly wasteful, even to the most hardened exponents of deterrence.

An end to production would have enormous advantages. As things are, there is nothing to prevent one country or another increasing the scale of its production again, without quite knowing what it is doing, if the political climate should deteriorate. But a halt to production would also be compatible with some kind of inspection or verification. The major nuclear powers could declare which plants had been used for making nuclear explosives, and could hand over the keys to the other side. Clandestine plants might still exist, or might still be built, but the risk of evasion would be small. For the plain truth is that both founder members of the nuclear club now recognise they have too much fissile material. It is in everybody's interest to see that they now recognise that the best way of dealing with a glut is to avoid adding to it in any way.

* * *

IT HAS BEEN a cheerful week at the Rutherford Laboratory. *Nimrod* seems to have been working splendidly. All the worry about the electricity bills has been banished, at least until the winter (as defined by the Central Electricity Generating Board) returns. Mr

Quintin Hogg was successfully protected from the showers which spattered his visit by a handsome green-and-white-striped awning between his car and the laboratory's restaurant—a structure which has more in common with an antique bird cage than its designers can have intended. So it may seem indecently quizzical to ask what should come after *Nimrod* and its sister *Nina*, on which construction has already begun in Cheshire.

The first essential is that full use should be made of the equipment which exists. Having spent more than £11 million on *Nimrod*, it would be folly for the government to cramp the Rutherford Laboratory by needless cheeseparing. Using *Nimrod* is more important than finishing *Nina* on time, but, of course, there is no reason why both things should not be done.

And that, it seems to me, should be the end of Britain's independent contribution to the machinery of high-energy physics. As with the nuclear strategy, so with high-energy machines, interdependence should become the order of the day. CERN is a proof that it can work, at least so far as science is concerned. But it would now be helpful if the government in the person of Mr Hogg would publicly declare *Nimrod* and *Nina* to be the last in the line of accelerating machines begun by that with which Cockcroft graced the Cavendish in the early 1930s. In future, it should be said, Britain will build big accelerating machines only in collaboration with other countries.

But what should follow on the 25-GeV machine at CERN? At Geneva they seem to be agreed that an energy of 300 GeV is the next to aim for. At this stage there is little hope of a wider basis for collaboration than Western Europe, which suggests it would be reasonable to create Dr Weisskopf's dream in something like a decade from now. But before the money is committed, care should be taken to see that the group at Berkeley which wishes to build a 120-GeV machine is given the chance to do so, and there should also be some assurance of restraint by those at Brookhaven who would leap straight to a 1000-GeV machine. Until there can be a United Nations machine, agreement on seemingly leapfrogging is the only way of making sure that, in high-energy physics, competition is not as embittered as it is in the Olympic Games.

* * *

MY BELIEF THAT Battersea power station should now be evacuated will, I am sure, be shared by the moguls of television, not to mention

Nimrod joins the hunt

by C. C. BUTLER

C. C. Butler is Professor of Physics at Imperial College, London University

DURING THE LAST few years striking progress has been made in our understanding of the nuclear particles of which the world is made up. While thirty years ago we only knew about electrons, protons, and neutrons, some eighty different types have now been recognized in experiments, using large accelerating machines of which Nimrod is the latest example in this country. Most of these new developments have taken place in the last two years. Basically, many of the new particles are produced when two protons, the nuclei of hydrogen atoms, are made to collide violently. We call them particles but they are ephemeral entities with life-spans that may be as long as a millionth of a second, but which are often much shorter. After these extraordinary short lives they break up into lighter particles which may, in turn, break up again or, as we say, decay. Although short-lived, they have speeds approaching the velocity of light, so some of these particles can travel long distances

before they decay. In fact, streams, or beams of them, can be produced and shot into tanks of liquid hydrogen, and by doing this it is possible to study what happens when collisions take place. Usually the beams consist of particles called pi-mesons which have 270 times the mass of an electron, or the more exotic K-mesons with about 1,000 electron masses. K-meson beams have been particularly valuable recently in the production of further new particles.

Many scientists have expressed alarm at these discoveries; it was disconcerting to find that the collisions of apparently simple particles should produce such complicated results. Fortunately, however, a pattern is beginning to emerge which enables the physicist to recognize relationships and symmetries among many of these particles. Already the new theory has made one striking prediction which was subsequently found to be correct: the observation of the negatively charged Omega particle which is produced by high-energy K-mesons.

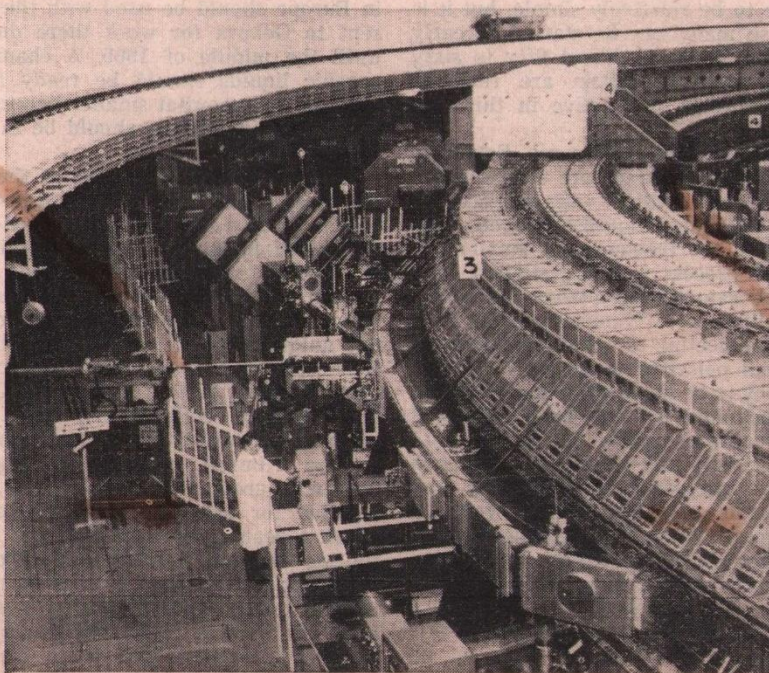
Most of the recent developments in particle physics have taken place in the U.S.A., and in Geneva at the European laboratory called Cern. Large, powerful machines are needed to accelerate protons almost up to the velocity of light before they are allowed to collide violently with other essentially stationary protons. The nuclear physicist measures the energies of his particles in units of electron volts; that is, the energy acquired by a particle when passing through a

potential difference of one volt. During the last few years energies of up to 30,000 million volts have been available at Brookhaven in the U.S.A. and at Cern. But in this country until recently we have had no machine capable of producing K-mesons, which needs at least 3,000 million electron volts, so many of our experimental physicists have had to go to Cern, or may have chosen to emigrate to the United States. Fortunately, this situation is now changing since the new

and powerful accelerator called Nimrod became operational at Harwell.

The history of Nimrod is as follows. In 1957 a national programme was approved for the construction of a large accelerator in a new laboratory, now known as the Rutherford Laboratory, adjacent to the Atomic Energy Establishment at Harwell. This new laboratory is a joint venture between the Atomic Energy Authority and the universities. Nimrod worked for the first time on August 6 last year. Now physicists from the universities are the main users of Nimrod.

Basically, the machine consists of a large ring-shaped electro-magnet 155 feet in diameter, housed in an underground building



The proton accelerator, Nimrod, at the new Rutherford High Energy Laboratory in Berkshire

of reinforced concrete. In a preliminary accelerator protons are accelerated to energies of 15 million electron volts and are then allowed to enter the annular gap between the poles of the big electro-magnet. This gap is enclosed by a vacuum vessel and, under the influence of the magnetic field, the injected protons revolve in circular orbits within the vacuum. Each time they go round the machine a radio-frequency accelerating device increases their velocity. During this acceleration process the magnetic field strength and the frequency of the electric accelerating field both have to be increased in order to confine the protons to the ring of the magnet. Eventually when the magnetic field reaches its maximum value they reach full energy.

By the end of August last year protons were being accelerated to the maximum value of 8,000 million electron volts. The protons reach this energy in groups or bursts thirty times every minute. At first the number of protons in each burst was small, but, after a relatively short period of tuning up a good intensity of 500,000 million per burst has been achieved during long periods of operation, and it is certain that the expected intensities of 1,000,000 million per burst will be achieved. I have the personal impression that Nimrod is well-engineered, and consequently the long-term prospects for development are bright. The energy of Nimrod is less than that of the machine at Cern, which usually operates at about 20,000 million volts, but

nevertheless its intensity per burst of protons is high and there are many important experiments that can be done well with Nimrod which may not be tackled by people using the Cern machine. With careful planning the two machines can be complementary rather than competitive, so Nimrod forms a valuable addition to the existing European facilities for nuclear research.

It is not surprising that the physicists at present setting up experiments to use Nimrod are the people employing electronic techniques who, during recent years in this country, have been severely starved of facilities. Between the approval of the programme to build Nimrod and March of last year, it became apparent that ten groups were anxious to do electronic experiments with Nimrod and, in various combinations, they submitted proposals. These experiments were widely discussed and finally scrutinized by independent assessors. Eventually, it was decided to start work on six experiments during the first half of 1964. The first experiments have to be relatively simple, but it is certainly impressive that so many can be started so early in the working life of Nimrod. In all, about fifty to sixty nuclear physicists, twenty-seven of whom are research students preparing for doctorates, are active in this programme.

Physicists from the Atomic Energy Research Establishment and Queen Mary College, London, are studying the way in which protons of 7,000 million volts energy are deflected, or scattered, by a target of liquid hydrogen. They are particularly interested in the frequency of small-angle scatters. A similar kind of process is being studied by a group at the Rutherford Laboratory using a beam of unstable pi-mesons produced in collisions of Nimrod protons in a stationary target. They are deflecting the beam of pi-mesons by free protons in a special polarized target in which the proton spins have a tendency to be lined up in one direction. This sophisticated target technique has only been attempted on one or two previous occasions in other laboratories.

A third group, from University and Westfield Colleges in London, are studying the interaction of positively and negatively charged pi-mesons of 2,000 million volts in hydrogen. A further group, from the Atomic Energy Research Establishment, the Rutherford Laboratory, and Bristol and Birmingham Universities, have built a 7,000-million-volt neutron beam and are studying the deflections produced when these particles collide with protons. In this experiment the charge of the stationary proton can be transferred to the incident neutron; in other words the electric charge is transferred from the target to the projec-

tile. An additional pi-meson experiment is being set up by Oxford University physicists, and a collaboration between Imperial College, London, and Manchester University physicists is preparing a beam for K-meson physics.

There is every reason to believe that valuable new results will be produced before the end of this year, and that much more elaborate and exciting electronic experiments will be possible next year. By then it should be possible to couple the experiments directly to the Orion computer in the laboratory in order to achieve rapid reduction of the data from the experiments. In this way it will be possible for the experimenter to see clearly how his experiment is progressing from hour to hour.

Three large bubble chambers are being built for use with Nimrod. These are devices which enable the collisions occurring in a target to be photographed. A sixty-inch liquid hydrogen chamber was completed in this country last year, and because it is sensible that the largest chamber available in Europe should be used with the largest machine, it was sent to Geneva for work there during 1964 and possibly until the middle of 1965. A chamber of similar size for organic liquids should be ready for Nimrod in the late autumn. A somewhat smaller helium chamber, the only one of its kind in Europe, should be in operation in the spring of next year.

Recently French physicists at the high-energy laboratory at Saclay, near Paris, have suggested that they might be able to bring a thirty-inch hydrogen and deuterium chamber to Nimrod during the summer of this year; and this proposal is strongly supported by bubble chamber physicists in Britain. A 2,000-million volt beam of K-mesons can be built which should enable British and French physicists to carry out unique experiments in deuterium during the autumn. It is certainly a good thing that European physicists should wish to come to the Rutherford Laboratory and that the fine spirit of collaboration that exists round the Cern machine at Geneva will be extended, if on a modest scale, to the Nimrod machine in England. Finally, several university groups—Bristol, Durham, and University College, London, for example, plan to expose emulsion stacks to Nimrod beams, so extending still further the diversity of the experimental programme centred on it.

We can look forward to exciting results in the future, and without doubt our high-energy experimental physicists now have, for the first time in their own country, useful facilities for both pi-meson and K-meson physics as well as the more usual protons and neutrons.

— *Science Survey* (Third Network)

Hogg foresees 1,000 GeV accelerator

WORLD EFFORT NEEDED FOR ATOM PROBE

INTERCONTINENTAL co-operation in atomic energy research, surpassing the limited joint European venture, has been forecast by Quintin Hogg, Minister for Education and Science.

Beyond the 30GeV accelerator at CERN, Switzerland, paid for by 12 nations, Mr Hogg foresaw demands for the 300GeV machine and the 1,000GeV accelerator.

Whether Britain decides for international co-operation on these high energy installations or opts for going it alone, possibly towards a 100 GeV unit, will be strongly influenced by talks, between those concerned with the work, which begin next month.

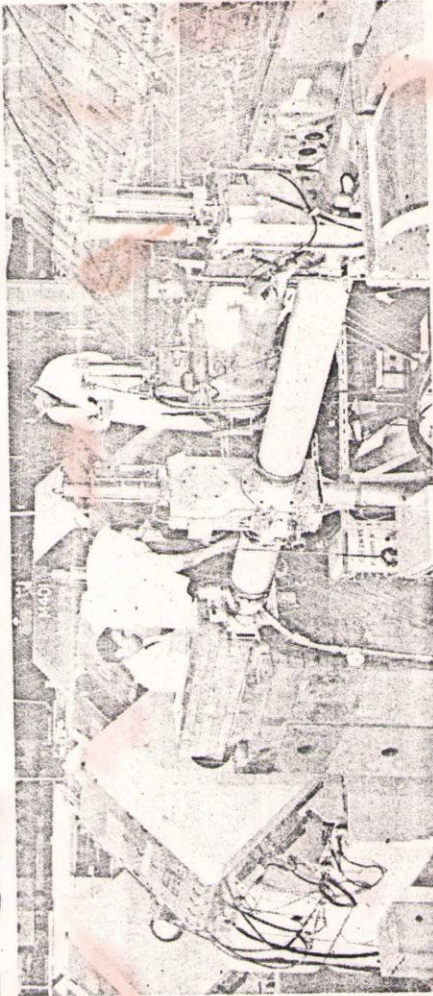
Important gap

Mr Hogg was speaking at the commissioning of the high energy proton synchrotron Nimrod at the Rutherford High Energy Laboratory, Didcot, Berkshire, last week.

The proton synchrotron and the linear accelerator are intended to fill an important gap by operating in a relatively neglected energy range.

Of the three large bubble chambers on the programme, two are still being built and the one which has been completed is being used at CERN.

By an arrangement whereby the largest bubble chamber in Europe is to be coupled to the largest accelerator, this will not



View of the T12 beam line emerging from Octant 3 of the Nimrod magnet ring, the 7GeV synchrotron accelerator, used for fundamental studies of nuclear and sub-nuclear phenomena.

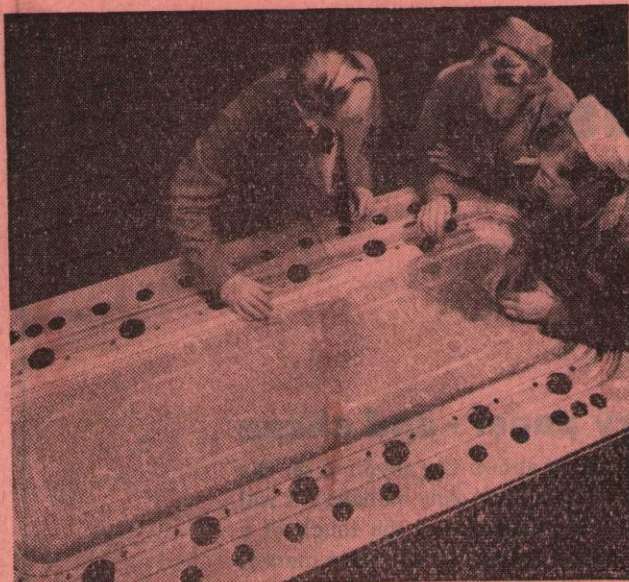
be available in England until next year when an even bigger collision chamber should be ready for CERN.

The number of sub-atomic particles discovered has grown in the last five years from 30 to over 100. The investigation of which of these, if any, deserve to be called elementary is considered one of the most important frontiers of knowledge.

ENGINEERING NEWS, APRIL 30, 1964

VICKERS REVIEW

MAY 1964



Mr. H. S. Tomlinson and the drillers examining their work.

Tracking Atomic Particles

BUBBLES SHOW THE WAY

A new heavy liquid bubble chamber, made at Elswick, is about to be finally tested and delivered to the Rutherford Laboratory, Chilton. Assembly and testing, it is expected, will be completed by this summer.

The new chamber will enable nuclear scientists to detect visually the passage of ionising radiation, by means of strings of vapour bubbles so formed which will be photographed inside it by special cameras.

This is not the first association of the Vickers Group with the nuclear research programme. Three years ago, it supplied the University consortia with the major equipment for the national liquid hydrogen bubble chamber.

This chamber was initially intended for use on experimental work in connection with NIMROD at Chilton. It is now on loan to CERN, the European Centre for Nuclear Research, at Geneva.

This project was very much a combined operation. English Steel supplied the main magnets, weighing some 450 tons; and with Firth Vickers, the 30 ton heavy stainless steel plates. At Elswick, the major light alloy components were machined, and the main stainless steel vacuum vessel fabricated and machined.

South Marston were responsible for co-ordination and for manufacturing the camera and light side hydrogen shields.

11,000 HOLES

The new chamber likewise involves many Vickers factories. The chamber with its two magnetic poles weighing about 40 tons is being made at Elswick. The expansion plate illustrated above is made from Firth Vickers molybdenum steel.

This plate contains over 11,000 holes, each 1/8th inch in diameter,

for the passage of the gas pressure cycling the radiation sensitive liquid in the chamber.

DIFFICULT TASK

The holes were drilled with extreme precision and to very close limits by a team of two girls and two men at Elswick. Despite the extreme difficulty of the task, only three drills were broken out of two dozen drills issued.

A combined team of physicists and engineers at University College, London and the Rutherford Laboratory, Chilton, headed by Mr. H. S. Tomlinson designed the equipment. The National Institute for Research in Nuclear Science, Chilton will assume responsibility for the bubble chamber and its ancillary equipment.

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SCIENCE REVIEW

QUARTERLY—No. 52
SUMMER 1964SALUTE TO
NIMROD

The first reaction to the full commissioning of Britain's biggest machine for the acceleration of protons to the high energies needed for research on elementary particles must be one of pleasure and congratulation. In Nimrod, at the Rutherford High Energy Laboratory adjoining Harwell, physicists at British universities have access once again to a machine capable of research close to the front line of physics. The fact that six experiments are already in progress and that about 150 physicists, more than 120 of them at universities, are planning to base some part of their research on Nimrod tells its own story. So also, but more vividly to the eye, does the large quantity of new and efficient equipment that the laboratory already houses. It is deplorable, but true, that this had become a rare sight in Britain. Moreover, there is an evident enthusiasm and pleasure in devising improvements in methods. The occasion of these comments is the fact that Nimrod, a month or so back, passed its final examination. There is, for all such machines, a two-stage process of qualification, analogous to the two-part examination favoured by certain universities, followed in each case by the beginning of associated experiments. Stage one consists in attaining the full energy for which the machine has been designed, but without extracting the main beam of particles from the machine. This stage was passed by Nimrod in late August of last year. It is customarily followed by a period in which the number of particles accelerated in each pulse is increased; and then by the beginning of experiments using secondary beams of particles. These are obtained by arranging for the main beam to hit a target inserted for the purpose into the vacuum chamber. Stage two is the deflection of the main beam from the machine. Its effect is to increase the range of experiments that can be done. It is this stage that has lately been celebrated by the formal, if belated, opening of the laboratory by the Minister of Science and the holding of two open days.

The second reaction to these events involves an element of questioning. Nimrod, as a tool of research, cannot be considered in isolation. It has to be viewed in the context of both smaller and bigger equipment: the smaller equipment, that at universities; the bigger, that operated near Geneva by the European Organization for Nuclear Research (Cern), in which the United Kingdom is one partner. There has always been an element of doubt lest the provision of equipment for individual universities might suffer because of the better facilities made available through the National Institute for Research in Nuclear Science—of which the Rutherford High Energy Laboratory is the first instalment. In the present mood of support for research, doubts on this score should be less than formerly. Moreover, the inauguration of one important piece of university equipment—at Oxford—should follow Nimrod after not too long an interval. In addition, there have been others, not academic physicists, who have suggested that the National Institute for Research in Nuclear Science, so far from contributing to training, would act as a sink in which physicists, already trained, would be swallowed up. The answer appears to lie in experience with the laboratory's smaller machine—a proton linear accelerator—which has been in regular use for more than four years. Research on it has already provided university physicists with more than a dozen higher degrees, with a much larger number in the pipeline. The later careers of these men will be in part a test of the National

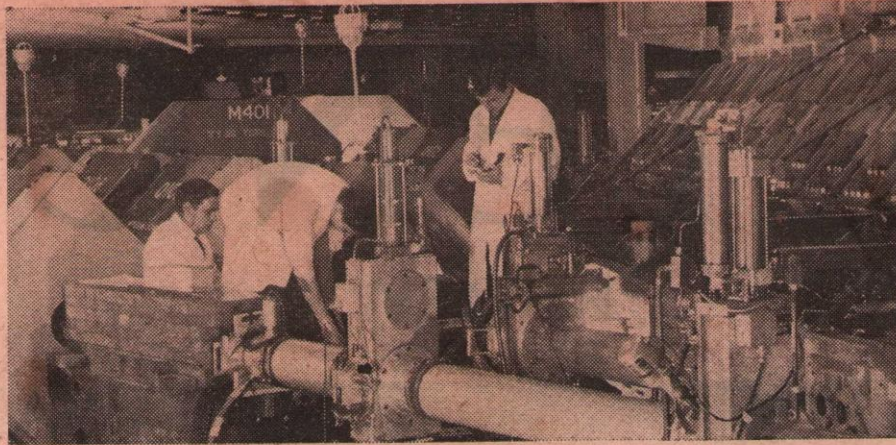
Institute. Just as the dividing line between research at universities and at the National Institute is determined by size and cost of equipment, so, too, is that between the institute and international forms of research. At the present time, Britain, through grants from the Department of Scientific and Industrial Research, is spending around £1m. on research in nuclear physics at universities; £6m. on the National Institute; and contributing just over £2m. to Cern. In return for the latter, British physicists have access at Geneva to a machine four times as big—in circumference and energy reached—as Nimrod. The question then is, what next? The view of the director of the institute, Dr. T. G. Pickavance, as an individual, is that the next major step should be "a really large machine in the European context". This is a reasonable view, provided that other forms of research are not penalized. If the promises made by political parties are fulfilled, the qualification need not be an obstacle.

Order Among Particles

The last number of this *Review* was published too early by a fortnight for comment on the confirmation by the Brookhaven Laboratory—the American counterpart of Cern—of one of the most remarkable predictions made in nuclear physics for many years. This has a double significance. It shows first that the mathematical apparatus employed—that of group theory—is relevant in some way to the world of particles. Having predicted an observed result once, it is expected to do so also on future occasions. This does not mean that unexpected discoveries are therefore at an end: it does mean that when any new particle is discovered, physicists will be able to say at once what further particles should exist and so be looked for. Also, the fact that a pattern exists encourages the hope that a physical theory will be found to account for it.

The second point is qualitative. Although the procedure leading to the prediction was formal, its use depended on a physical idea: that there is no distinction in kind between nuclear particles proper and the still increasing number of highly unstable but also strongly reacting particles to which the generalization applies. A suspicion which had been dawning for some years—that far too many particles were being discovered for all of them to be regarded as fundamentally independent—has been shown to be correct. In other words, the game of using group theory to arrange particles in multiplets—at first of 8, and later of 8 or 10—is not purely a game in mathematics but a game based on a physical assumption, which has therefore been confirmed.

The prediction was threefold, and the confirmation exact within the limits of accuracy of the Brookhaven experiment. The only reservation is one common to all experiments in which the properties of a new unstable particle are deduced from the behaviour of less massive particles formed during its breakdown: i.e., that the secondary particles have been correctly identified by a process of deduction, in which possible alternatives are thought of and, one by one, are

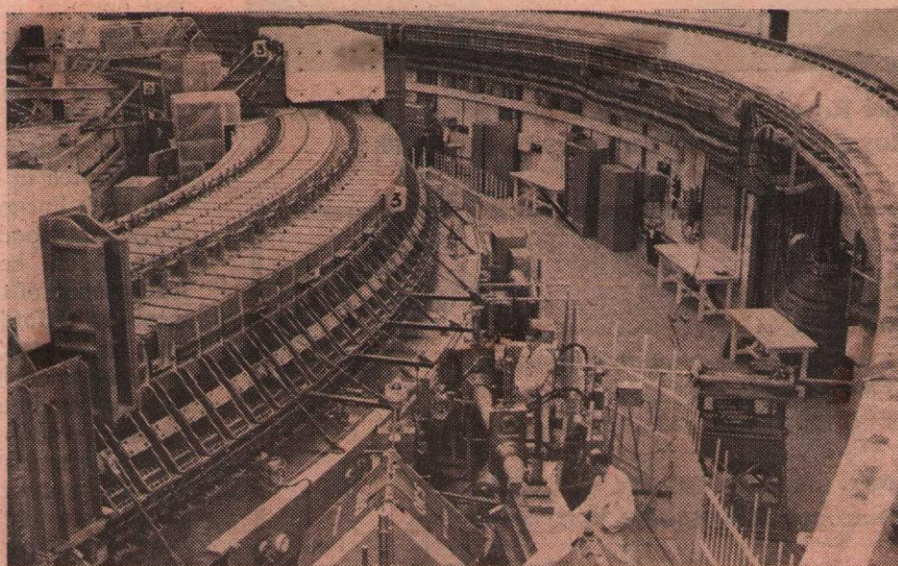


Proton beam line emerging from the magnet ring of Nimrod at the Rutherford High Energy Laboratory of the National Institute for Research in Nuclear Science. While being accelerated to an energy of 7,000 million electron volts, the protons in each pulse travel roughly half the distance to the moon in about seven tenths of a second. They can then be deflected out of the ring for use in experiments.

eliminated. The two simplest elements in the prediction were that there should exist a negatively charged particle, the omega minus, with a mass at rest in the range from 3,280 to 3,288 electron masses. What was found was a negatively charged particle with a mass in the range from 3,276 to 3,322 electron masses, that is, within the limits of the prediction. As to the third prediction, it will be said here only that this, too, was fulfilled.

Credits for this result are distributed widely. The experiments and their interpretation were reported beneath no fewer than 33 names—which must surely be a record in team work. Those chiefly concerned were R. P. Shutt, who was generally responsible, and N. P. Samios, who was in immediate charge of the experiment. On the theoretical side, the sequence of ideas began with three

Japanese physicists—Y. Ohnuki, Ikada, and Ogawa—and passed next to Professor A. Salam and J. C. Ward at the Imperial College of Science, London. There entered next on the scene Y. Ne'eman, an Israeli who came as a student to Professor Salam, and the much more experienced Professor Murray Gell-Mann of the California Institute of Technology. Of these two, Gell-Mann carried prediction a stage further. This is as far as is relevant to the omega minus prediction. Beyond this, the approach which has thus far been vindicated has been further elaborated with what results in successful prediction remain to be seen. The mood is one of optimism and, whatever else may happen, a fillip to experiment can be predicted.



Proton beam line at the Rutherford High Energy Laboratory seen from above. The vacuum chamber round which pulses of protons are accelerated is between the pole pieces of the magnet. The magnet is built in octants and between these there are straight sections. There are 28 pulses a minute, with a million million protons in each pulse.

Last word on *Nimrod*

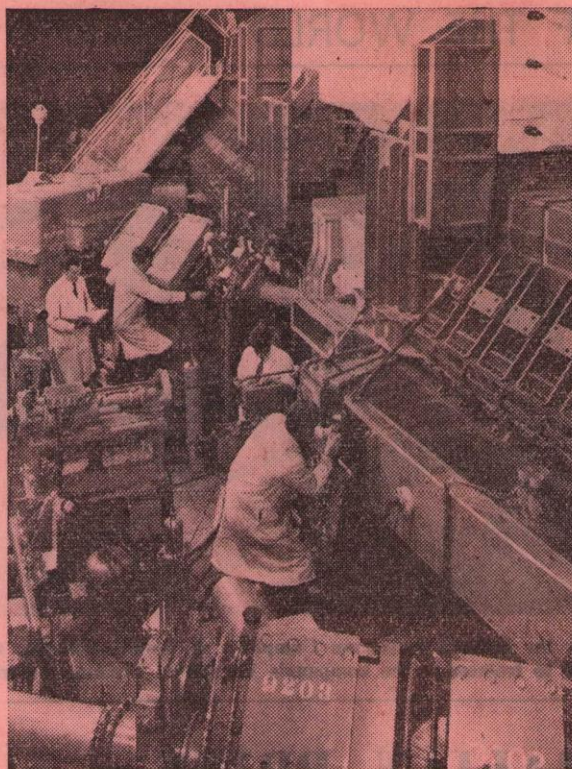
ALTHOUGH the official explanation is that *Nimrod* commemorates the mighty hunter before the Lord, one might have thought, from the welter of popular publicity attending his recent meeting with Mr Quintin Hogg, that he was christened to recall his namesake's foundation of the Kingdom of Babel. And the occasion produced (in one newspaper) the patriotic claim that *Nimrod* is "the largest national machine outside America and Russia, and fifth in the world league table".

Nationalism, these days, gets in everywhere. Breathes there a man with soul so dead who never to himself has said, this is simply deplorable. My own, my native land sunk to fifth place in the World League Table of Proton Synchrotrons? What chance do we stand of regaining the Ashes if true-born Britishers sit back content with a 7-GeV atom-smasher only 155 feet in diameter when the Americans already have one giving 30-GeV, the Russians are supposed to be building a 70-GeV model, and CERN at Geneva are studying the possibility of a 300-GeV job, $1\frac{1}{2}$ miles across?

Of course, the first thing we must do as a nation is to exorcise that subconscious feeling that *Nimrod* is somehow basically funny, in common with all things that proceed in continuous circles, such as mice on tread-wheels, Fabre's revolving caterpillars, people on the Inner Circle, or "The Music Goes Round and Around". We must rid our minds of the nagging refrain that you push the injector valve down, the protons go round and around, yoo-hoo-hoo-hoo, and they come out in the experimental chamber here.

Atom-smashers have now taken their place as national virility-symbols alongside shrunken heads, Sabine women and independent nuclear deterrents. Any day now, de Gaulle, Nasser and Mao-Tse-Tung will be proclaiming that they can no longer go naked into the negotiating chamber without even a *Nimrod* to their names. The competition will daily be getting fiercer.

With the old country already wallowing in fifth place, there is only one sure way we can leap to the top of the table. We must beat the Americans and Russians to the draw and build the ultimate monster of which they are now only dreaming—the 1000-GeV machine of about seven miles in diameter. Heaven knows where we'll put it or what on earth we'll do in the middle of it when we've got it, but at least we'll be able to hold up our heads on foreign coach tours when the conversation gets round to the World League of Proton Synchrotrons and how's everybody getting along with their neutrino research?



Part of the *Nimrod* magnet ring, where powerful beams of atomic particles are extracted for experiments.

NUCLEAR LABORATORY OPENING TO-MORROW

By Our Scientific Correspondent

To-morrow, the Rutherford High Energy Laboratory at Chilton (Berks.), with its major piece of research equipment—the giant atom-smasher called *Nimrod*—is being officially opened by Mr. Quintin Hogg, Secretary of State for Education and Science.

The laboratory is operated by the National Institute for Research in Nuclear Sciences, set up by the Government in 1957 to provide a common research centre for university use. But it is equipped with facilities beyond the financial scope of universities and other institutions working on basic nuclear physics. Scientists and engineers are trained.

Nimrod, a £11m. machine, is the third largest of its kind in the world. It ranks after the U.S. and Swiss accelerators, but differs from them in that it delivers a high intensity of particles, although at lower energies. It is complementary to the Swiss CERN machine, to which British physicists have access.

Nimrod has already been operated at week-ends during the past winter and has shown that it would take a leading place among the world's scientific instruments in investigating what the director of the laboratory, Dr. T. G. Pickavance, called to-day "one of the most important frontiers of human knowledge."

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