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Cover photograph: From 3-7 October a series of ten seminars were given at CERN on the results of the Berkeley International Conference on High Energy Physics. In the photograph Professor Y. Goldschmidt-Clermont is discussing the latest developments in experiments on mesonic resonances. (Part of this seminar was televised for a Swedish television programme and camera and lights can be seen in the photograph.)
Dr. A. Martin writes in this issue about the theoretical developments reported at the Conference and short accounts of several of the major experiments are also given.

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The European Organization for Nuclear Research, more commonly known as **CERN** (from the initials of the French title of the original body, 'Le Conseil européen pour la Recherche nucléaire', formed by an Agreement dated 15 February 1952), was created when the Convention establishing the permanent Organization came into force on 29 September 1954.

In this Convention, the aims of the Organization are defined as follows:

> **'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'**

Conceived as a co-operative enterprise in order to regain for Europe a first-rank position in fundamental nuclear science, CERN is now one of the world's leading laboratories in this field. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of **high-energy physics,** often known as **sub-nuclear physics** or the **physics of fundamental particles.**

High-energy physics is that front of science which aims directly at the most fundamental questions of the basic laws governing the structure of matter and the universe. It is not directed towards specific applications — in particular, it plays no part in the development of the practical uses of nuclear energy — though it plays an important role in the education of the new generation of scientists. Only the future can show what use may be made of the knowledge now being gained.

The laboratory comprises an area of about 80 ha (200 acres), straddling an international frontier; 41 ha is on Swiss territory in Meyrin, Canton of Geneva (the seat of the Organization), and 39.5 ha on French territory, in the Communes of Prévessin and St.-Genis-Pouilly, Department of the Ain.

Two large particle accelerators form the basis of the experimental equipment:

— a 600 MeV synchro-cyclotron,
— a 28 GeV proton synchrotron,

the latter being one of the two most powerful in the world.

The CERN staff totals about 2300 people.

In addition to the scientists on the staff, there are over 360 Fellows and Visiting Scientists, who stay at CERN, either individually or as members of visiting teams, for periods ranging from two months to two years. Although these Fellows and Visitors come mainly from universities and research institutes in the CERN Member States, they also include scientists from other countries. Furthermore, much of the experimental data obtained with the accelerators is distributed among participating laboratories for evaluation.

Thirteen Member States contribute to the cost of the basic programme of CERN in proportion to their net national income:

Austria (1.90 %)	Italy (11.24 %)
Belgium (3.56 %)	Netherlands (3.88 %)
Denmark (2.05 %)	Norway (1.41 %)
Federal Republic of Germany (23.30 %)	Spain (3.43 %)
	Sweden (4.02 %)
France (19.34 %)	Switzerland (3.11 %)
Greece (0.60 %)	United Kingdom (22.16 %)

Poland, Turkey and Yugoslavia have the status of Observer.

The 1966 budget for the basic programme amounts to 149 670 000 Swiss francs, calling for contributions from Member States totalling 145 860 000 Swiss francs.

Supplementary programmes, financed by twelve states, cover construction of intersecting storage rings for the 28 GeV accelerator at Meyrin and studies for a proposed 300 GeV accelerator that would be built elsewhere.

Albert Picot

With the death on 9 October of Monsieur Albert Picot, CERN has lost one of its greatest friends and Geneva one of its most distinguished citizens.

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Monsieur Picot, speaking to Professor Weisskopf, on his last official visit to CERN in October 1964. The occasion was the 10th anniversary celebration of the signing of the Convention establishing the European Organization for Nuclear Research. M. Picot was then able to see how well his faith in CERN had been justified.

Albert Picot was involved in CERN since its very early days. It was mainly thanks to him that Geneva was put forward as a site for the Laboratory of the new European Organization for Nuclear Research and he played a predominant role in securing the support of the Canton of Geneva which gave CERN its present excellent site.

This is described in Professor Kowarski's *An account of the origin and beginnings of CERN:* 'Councillor A. Picot, then in charge of the Canton's educational and cultural department was a supporter of the CERN idea (and of CERN's coming to Geneva) from the earliest beginnings; as soon as the CERN Council's choice had fallen on Geneva, he initiated — together with Councillor R. Casaï, in charge of public works — all those multiple activities which had to be undertaken in good time in order to prepare the future installation of CERN on the territory of the Canton. In view of the somewhat unusual character of CERN's projected activities, detailed explanations had to be given to the population and — when an adverse trend had appeared on the local political scene — a campaign of persuasion had to be carried through. The invitation to CERN was finally ratified by a popular referendum, with a vote of over 70% in favour of CERN's coming to Geneva.'

Monsieur Picot led the Swiss delegation to the CERN Council until December 1958. Some extracts from the farewell address by the then President of Council, M. de Rose, will emphasize the special position Albert Picot holds in the history of CERN:

'The Council has benefited from your great experience of public affairs and of men. During the seven years you have been associated with CERN's activities, your interest in the Organization and your enthusiasm for CERN's cause has never flagged for one moment... You are one of the few men who have felt that the opportunity of co-operating with men of science in a great scientific enterprise was indeed an exceptional opportunity in life.

'I regard you as one of the 'founding fathers' of CERN... We are well aware of the influence you have on your compatriots and of the respect and esteem in which you are held by them. I know therefore that in the City of Geneva you will be one of the men who will continue to form public opinion and will not cease in speech and in writing to exert a profound and beneficient influence on the progress of CERN's destinies.

'You leave with the admiration, gratitude and affection of the entire Council.'

Albert Picot was born in Geneva on 2 April 1882. He was educated at the Collège de Genève and the Universities of Geneva, Heidelberg, Berlin and Paris and emerged a man of broad culture and great strength of character. One incident during his University days showed his awareness of the growing trend in human life towards the technical and scientific. He deliberately interrupted his studies to spend some time in Industry as an apprentice mechanic building physics instruments. After University, he began a brilliant career in law until 1931 when he was elected Conseiller d'Etat. He then gave up all his professional activities to devote himself exclusively to Geneva. He led several government departments and served as President of the Council in 1938, 1944 and 1947. Many other important positions in national and local affairs were filled with distinction right up to the time of his death.

CERN pays tribute to one of its most ardent supporters. The many people, from both the CERN Council and the CERN staff, with whom Albert Picot had established close friendships, feel a sense of deep personal loss.

Professor Veksler

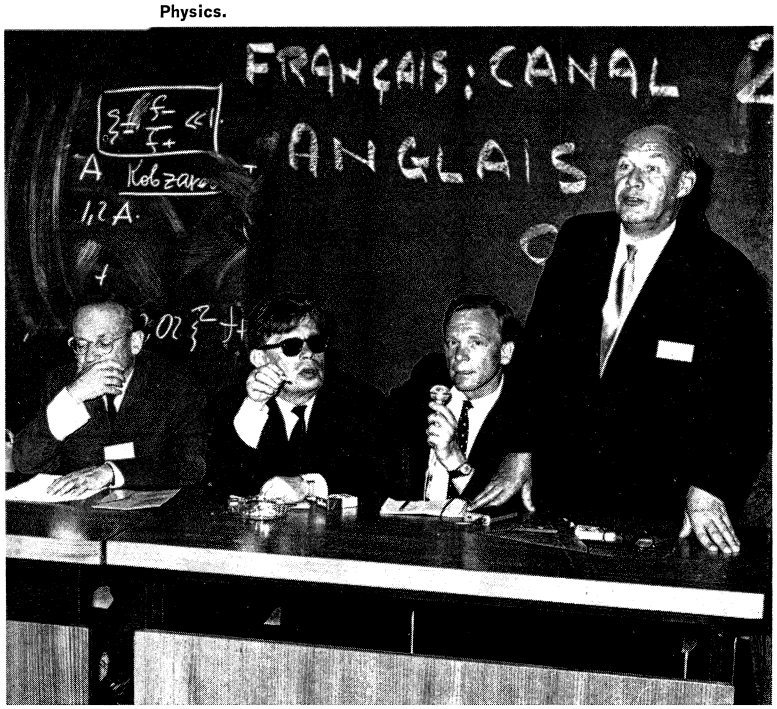
Professor Vladimir Veksler, one of the leading scientists from the USSR, died on 22 September. His outstanding contributions to the theory of particle accelerators won him international fame and respect.

Vladimir Veksler was born on 4 March 1907. In 1931, he graduated from the Moscow Institute of Energetics and began research at the All Union Electrotechnical Institute. He moved in 1936 to the Institute of Physics of the USSR Academy of Sciences until 1956 when he joined the Joint Institute for Nuclear Research (Dubna). He remained there, as Director of the high-energy laboratory over the 10 GeV proton accelerator, until his death. He was made Academician of the USSR Academy of Sciences and eventually became Chairman of the Department of Nuclear Physics in the Academy.

His research included experimental techniques in X-ray physics, cosmic rays, isotopes, and counters. But the work which has written Veksler's name in the history books of science is his contribution to the theory of accelerators. In 1944, he published a paper in Doklady Akad. Nauk SSSR on 'phase stability', a principle which is fundamental to the operation of our present day high energy synchro-cyclotrons and synchrotrons. The 'Atoms for Peace' price in 1963 was awarded to Professor Veksler and Professor McMillan of Berkeley, who published his independent work on phase stability at almost the same time, for their contributions to accelerator theory. Professor Veksler also received the 'Lenin Prize', the highest honour in the Soviet Union.

Professor Veksler visited CERN several times and has been a prominent figure among the Soviet scientists at high energy physics and accelerator conferences for many years.

Professor Veksler, on the extreme left, with other scientists from the USSR at CERN in 1962 for the International Conference on High Energy Physics.



CERN/PI 6054

UNESCO celebrates its 20th anniversary

In November 1946, the United Nations Educational, Scientific and Cultural Organization (UNESCO) was established. The Organization played a very important role in setting up CERN and it is therefore a particular pleasure to offer our congratulations to UNESCO on its 20th anniversary.

The purpose of UNESCO is defined as '...to contribute to peace and security by promoting collaboration among the nations through education, science and culture...'. Among its primary tasks is 'to promote the progress and utilization of science for the benefit of all mankind' and it was under this heading that UNESCO was able to help in the birth of CERN.

In June 1950, Professor I. Rabi made a statement to the General Conference of UNESCO, held at Florence, in favour of establishing regional laboratories for scientific co-operation in Europe. The Conference authorized the UNESCO Director General, Mr. Torres-Baudet 'to assist and encourage the formation and organization of regional research centres and laboratories in order to increase and make more fruitful the international collaboration of scientists in the search for new knowledge in fields where the effort of any one country in the region is insufficient for the task; and to this end, to undertake to find out the needs and possibilities for such regional research centres, to make initial surveys of cost estimates and location; and to help in the formulation of programmes, contributing to the cost of construction or of maintenance out of UNESCO's regular budget.'

Professor P. Auger, Director of the Natural Science Department, created a special office at UNESCO and enlisted a number of European physicists as a 'Board of Consultants'. This Board met several times in 1951 at the UNESCO Headquarters in Paris and by the end of that year UNESCO was able to call an intergovernmental Conference of all the European members of UNESCO. A similar meeting, held soon afterwards in Geneva, led to the signature by eleven European nations of an agreement establishing the provisional CERN organization. In May 1952, the CERN Council held its first session at UNESCO. UNESCO also contributed greatly to the preparation of the CERN Convention which was signed in 1954.

CERN was a new concept and to bring it to reality new, unorthodox methods had to be used. Throughout those early days a lot depended on the enthusiasm and imagination of Professor Auger and his associates and on the confidence and practical support of UNESCO.

After the signing of the Convention, CERN began its separate existence and the role of UNESCO was over. However, the close ties of friendship and of work between the two Organizations have remained, and were cemented by the signature of an agreement between the two Organizations.

The Berkeley Conference

The 13th International Conference on High-Energy Physics was held at the Lawrence Radiation Laboratory, Berkeley, California, USA from 31 August to 7 September. More than 100 European physicists took part in the Conference and the quality of their contribution (especially that coming from CERN) to the Conference was generally recognized to be outstanding. We present here a discussion by a CERN theoretician of the latest developments in the theory of particle physics which were presented at the Conference.

Developments in the Theory of Particle Physics

by **A. Martin**
Theory Division

The subjects discussed at the Conference covered both 'classical' topics (quantum electrodynamics, axiomatic field theory and its Californian substitute, S-matrix theory) and new, more fashionable topics (current algebra, the eternally young subject of weak interactions — where each time a question seems to be settled, Nature introduces new complications — and the resuscitated 'Regge-poles' which again appear as a major tool to study high-energy collisions together with the quark model).

Quantum electrodynamics

Here, the role of theoreticians consists mainly of registering satisfaction or worry over the agreement or disagreement of experiment with theory. For instance, we were extremely happy to learn that pair-production at high energies, examined in an experiment at DESY by a Columbia-DESY collaboration[1], agrees perfectly well with the old Bethe-Heitler formula. On the other hand, we are worried by a new measurement of the Lamb shift[2] which deviates by 0.3 MHz from the theoretical prediction. This is a deviation of 3 parts in 10 000 and should not normally worry a high-energy physicist who is happy to predict things to 10 % accuracy. But if the measurement is taken seriously, it is an important deviation, too large to be accounted for by strong interaction effects, or by a readjustment of basic physical constants.

Fundamental questions (Axiomatic field theory and S-matrix theory)

These theoretical topics are seldom discussed at Conferences because of their somewhat abstract character. They provide useful general information, but do not make, up to now at least, precise predictions which can be tested by experiment. They provide, however, a framework into which any more detailed theory should fit.

Axiomatic field theory is the mathematical expression of a few basic postulates:

i) that the theory should still be applicable when the reference frames are changed

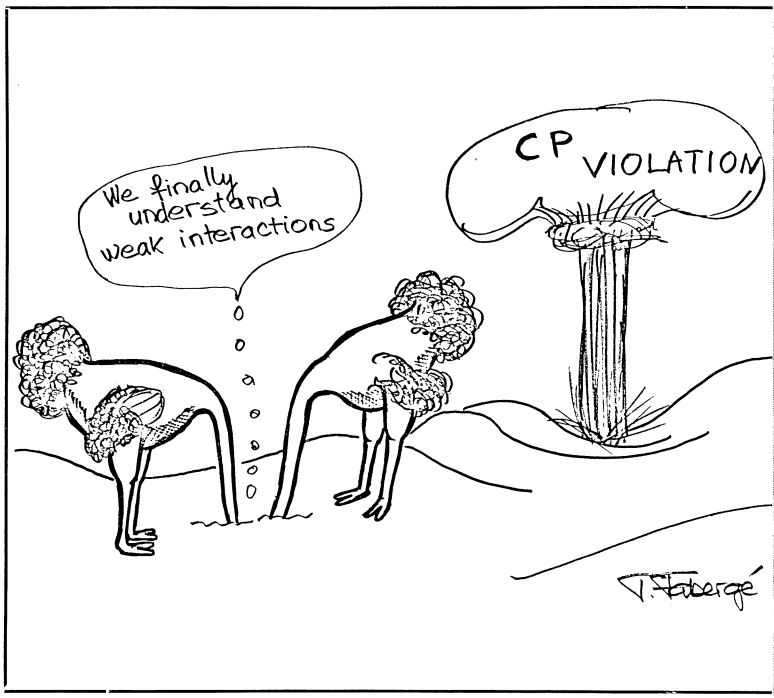
ii) causality — that the effect comes after the cause (to be useful, causality has to be more strict than what is observed for particles; it has to hold on a microscopic scale, and is then called 'locality')

iii) that there is a lowest mass in the spectrum of all existing particles.

Until recently, the main success of field theory has been to establish forward dispersion relations for pion-nucleon scattering (which have been tested experimentally and are still being tested at higher energies) and the famous CPT theorem, which shows that particles and antiparticles have the same mass, spin, lifetime, etc., and connected particle spin and statistics.

The difference between S-matrix theory and field theory is that in S-matrix theory, the structure of the scattering amplitude is somehow postulated and then confronted with the powerful requirement of unitarity, i.e. conservation of probability.

In field theory, two contributions came from CERN. One concerned the general character of the 'crossing property', which answers the question, 'If the proton-



proton scattering cross-section is known with great accuracy, can we obtain the proton-antiproton scattering cross-section?' J. Bros, H. Epstein and V. Glaser showed that this is possible. The second contribution, which I presented, is half way between the two theories; it uses the existing results of field theory and adds the requirement of unitarity to extend these results further. It is then possible to establish that total cross-sections increase with energy at a rate which is at most the square of the logarithm of the energy.

In S-matrix theory one of the most interesting results was obtained by M. Froissart who established a connection between spin and statistics. We heard also an interesting talk by J. C. Polkinghorne who showed that the structure of reaction amplitudes predicted by S-matrix theory coincide with that obtained by looking at a series expansion of the reaction amplitude (at least in some special cases).

Current algebra and higher symmetries

Two years ago, after the famous paper on SU_6 by F. Gürsey and G. Radicati, higher symmetries began to flourish. By higher symmetry, we mean a symmetry which involves not only the internal quantum numbers such as isospin and strangeness (as in SU_3 symmetry) but also spatial properties of particles such as spin. For instance, according to the SU_6 scheme we can put in the same basket the nucleon and the meson-nucleon resonance with spin $^3/_2$ and isospin $^3/_2$. Now serious difficulties have arisen in attempts to make these symmetries consistent with i) Lorentz invariance (i.e. the independence of the laws of physics of the particular reference frame in which they are expressed) ii) locality, iii) unitarity. In particular, D. Amati and W. Alles at CERN exhibited a basic inconsistency.

Later, M. Gell-Mann and B. W. Lee tried to derive essentially the same results (but without the ambition of achieving 'exact' results) from current algebra. One cannot say that this new attempt was really successful and in particular the Amati-Alles argument still applies. However, the commutation relations of the currents survived and so far they do not seem to violate any basic requirement. It was shown first by S. Adler and W. Weissberger that when these commutation relations are supplemented with the requirement that the divergence of the axial current is proportional to the pion field (a fact which has to be at least partly true by the very existence of the pion decay), they lead to extremely interesting sum rules connecting weak and strong interactions, which are in very good agreement with experiment. And so, during last year, most of the activity of theoreticians was spent in this field. Multitudes of sum rules have been obtained and were reported at the Conference.

One of the newest was obtained by D. Amati showing that nucleon form-factors have to decrease rapidly with momentum transfer if one wants to have an overall consistent picture. Another form of these results is low-energy theorems (valid in a strict sense for zero mass particles). In particular, they give a remarkable prediction of the pion-nucleon scattering lengths, and also of pion-pion scattering lengths (but here there is no experiment for comparison). Remarkable agreement with experiment has also been achieved in the field of leptonic and non-leptonic decays of K mesons.

Experiments mentioned in the article:

(1) The experiment done at the DESY electron synchrotron in the Federal Republic of Germany was a collaboration between DESY and Columbia University, USA. They used a photon beam from the synchrotron and observed the production of electron — anti-electron (positron) pairs by directing the photons onto a carbon target. Using a magnet and counter system, measuring the angle between the electron and positron and the momenta of the particles, they could record the production of pairs of a certain 'mass' over a range of values for the mass.

From basic quantum electrodynamics the 'Bethe-Heitler formula' predicts the probabilities of pairs of different mass being produced. Over a year ago, an experiment at CEA (the Cambridge electron accelerator in the USA) cast doubt on the formula, and thus on quantum electrodynamics, by the apparent observation of high mass pairs in greater profusion than the formula predicted.

The DESY experiment was performed with carefully controlled experimental conditions and did not show any deviation from the theory.

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(2) The photon emitted when an electron 'in orbit' around the nucleus of an atom falls from a higher to a lower energy level has a characteristic frequency which is determined by the difference in energy of the two levels. Investigation of the energy levels has been one of the most fruitful sources of knowledge about particles, especially early in this century. The latest refinement came from very accurate measurements in 1947 on the spectral lines of hydrogen by W. E. Lamb and R. C. Retherford. They found that two levels, which were then theoretically predicted to have precisely the same energy, actually differed in energy by a small amount (about one thousand MHz).

This difference became known as the 'Lamb-shift' and its origin lies in the fact that the electron sets up its own electromagnetic field which then acts back on the electron itself. (A fuller description of this effect is given in the article on the present g-2 experiment at CERN, in CERN COURIER, vol. 6, no. 8 (August 1966) p. 153.) The development of quantum electrodynamics explained the effect and brought the Lamb-shift observation back into line with theory.

Two groups at Yale University, USA, are continuing precision measurements on the Lamb-shift. One group, led by Professor Lamb himself, is using microwave techniques. The other group, R. T. Robiscoe and B. L. Cosens, is using a technique known as 'level-crossing' and it is their value which is significantly higher than the prediction of quantum electrodynamics. They reported their work at the Conference and in Physics Review Letters, 11 July.

(3) The two experiments at CERN are looking at the 'interference' between K^0_S and K^0_L mesons. They are directed towards understanding the mechanism at work in the observed decay of the K^0_L meson into two pions (first seen two years ago in an experiment at Brookhaven, USA) which violates charge-parity (CP) symmetry, previously presumed to hold in weak interactions.

A 'stable' beam of neutral kaons is prepared by setting detection equipment sufficiently far from the accelerator. Shortlived K^0_S mesons have all decayed and the 'stable' beam contains only K^0_L. K^0_S mesons are then 'regenerated' by passing the K^0_L mesons through matter (such as a block of carbon).

The decay law of this mixture has been investigated experimentally for the decay into positive and negative pions, which has definite CP symmetry properties. An oscillatory interference term between K^0_S and K^0_L has been detected in this law, corresponding to the 'beating' between the two waves. The beat frequency is related to the small mass difference between K^0_S and K^0_L (about 3.5×10^{-6} eV or 1 part in 10^{-14} of the total K^0 mass) and has been measured with very high accuracy. The phase difference between the two waves has also been measured with great accuracy. Part of this phase difference is introduced by the regeneration of the K^0_S, the remaining part is connected with the way in which CP symmetry is broken in the decay of the K^0_L into two pions.

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(4) The CERN experiment on the decay of the eta meson into three pions was discussed in detail in the main article of the last issue of CERN COURIER (p. 171). With three times as many observations as in all the other published experiments combined, it showed no evidence for the violation of charge symmetry (C) in the eta meson decay.

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(5) The experiment by a Saclay-Orsay collaboration was carried out at the CERN proton synchrotron in 1964. Negative pion beams with energies from 3 to 18 GeV were directed onto a hydrogen target and the resulting charge exchange process (where the charges of the negative pion and positive proton are exchanged resulting in a neutral pion and a neutron) was observed by optical spark chambers. Analysis of the pictures continued throughout 1965, and the complete results were reported in Physics Letters on 15 January 1966. The whole of the data gave strong support to the Regge pole model of the interaction where the rho meson is the intermediary in the charge exchange.

The experiment has now been carried a stage further by a Saclay-Orsay-Pisa collaboration using a polarized proton target, instead of the conventional hydrogen target. This makes it possible to measure the polarization of the recoil neutron, which should be zero to fit the strict Regge pole model. Preliminary results from the experiment were presented at the Berkeley Conference. They indicate a polarization of about 16 % quite independent of energy. More detailed analysis is now under way.

To the non-specialist in this field, like myself, these results are rather impressive in spite of the many uncertain steps between the initial assumptions and the output.

Weak interactions

The situation in weak interactions seems to have improved quite a lot, except for the mystery of the decay of the long-lived K^0 meson into two pions, which violates time-reversal invariance. If one ignores this particular phenomenon, everything seems fine. (See the drawing on page 193.) The Cabbibo theory, which connects strange and non-strange particle decays is fully satisfactory. The non-leptonic decays begin to be understood with the help of current algebra as mentioned above.

So, the only black spot is the decay of the long-lived K^0 into two pions. Two experimental groups from CERN[3] (K. Winter et al. and J. Steinberger, C. Rubbia et al.) have shown that the long-lived and short-lived decays into two pions interfere, which kills practically any theory trying to save time-reversal invariance.

The problem is to find the origin of the time-reversal violation. A very audacious theory had been proposed by T. D. Lee according to which the origin of the violation is electromagnetic. With G. Feinberg and J. Bernstein, he had noticed that, while electromagnetic interactions seem to preserve parity, there is no evidence of invariance by time-reversal or charge-conjugation. This theory would have been definitely confirmed if an asymmetry had been observed in the decay of the eta meson into three pions (as appeared to be the case in an experiment of P. Franzini et al.). However, the CERN experiment[4] by G. Finocchiaro et al. showed, after many more observations of the decay, that the asymmetry was less than 1 %, and this result apparently convinced everybody at the Conference.

Therefore, one can conclude that it is not proved that the origin of the anomalous K^0 decay is electromagnetic. However, as was stressed by T. D. Lee, it is not proved either that the basic mechanism is not electromagnetic. In fact it would be tempting, from the phase measurement of K^0 long versus K^0 short into two pions, to prefer the so-called 'super-weak' interaction of L. Wolfenstein, but many other theories predict the same phase.

New measurements are needed, in particular the study of the eta decay into two pions and gamma which will be done at CERN, but which may not achieve sufficient accuracy. Paradoxically, the answer might come from a completely different field of physics, namely, the measurement of the electric dipole moment of the neutron which can be done with very great accuracy.

High energy collisions: Regge-poles and quarks

At the 1962 Conference, held at CERN, there was great enthusiasm for the Regge-pole description of high energy scattering. Unfortunately, one of the predictions of the theory was not confirmed by experiment (this said that, at high energies, the target nucleon seems to increase in size and become more transparent). As a result, during the following two years, the shares of the Regge Theory went down fast, as often happens in modern physics, which in some respects resembles Wall

Street. Then W. Rarita and R. J. N. Phillips insisted that the increase in size of the nucleon with energy might be very slow and showed that all the existing data could fit the Regge Theory. At the time, this was not very convincing because we could also fit the data without Regge-poles. However, experimental evidence has accumulated; in particular, the Saclay-Orsay experiment on pion-nucleon charge-exchange[5] established that the rho meson was on a Regge-pole trajectory.

Two contributions to the Conference confirmed the resurrection of Regge-poles. One was the analysis of pion-nucleon backward scattering by V. Barger and D. Kline which works only if the background term is of Regge character and if the nucleon excited-states lie on Regge trajectories. The other, from the L. Dick group at CERN[6], measured polarizations in pion-proton scattering. One basic Regge prediction was checked: the positive pion-proton and the negative pion-proton polarizations are opposite. More detailed predictions are not so well checked and depending on precision measurements, Regge-poles might still be very much alive at the next Conference two years from now, or might be dead for good. On the theoretical side, one thing emerged: if Regge-poles do exist, they are more complicated objects than it was first thought.

On the other hand, the quark model, in which the nucleon is made of three quarks and the mesons of two quarks, makes impressive predictions, in particular that the ratio of the proton-proton to the meson-nucleon cross-section should be $^3/_2$ at high energies. It was stressed by all speakers, in particular M. Gell-Mann and L. Van Hove, that this is no evidence that real quarks exist. As Van Hove remarked, a very convenient description of crystals can be made in terms of collective excitation modes called phonons, but if you tear a crystal to pieces you will not find any phonon. The same could happen with the nucleon when you try to split it into quarks.

(6) This experiment used a polarized proton target and beams of negative and positive pions of energy 6, 8, 10 and 12 GeV/c from the CERN proton synchrotron. In the polarized target, special techniques are used to line up the spins of the protons predominantly in one direction. In the experiment, the direction of the proton spins in the target could be reversed by a small change of a microwave frequence.

When a pion is scattered from a proton, the spin direction of the proton has an influence on the interaction, affecting the likelihood of the pion being scattered at a particular angle to its incident direction. The numbers of pions scattered at different angles were measured by a counter hodoscope system while the direction of the target polarization was reversed approximately every $2^1/_2$ hours. The experiment showed that the polarizations of the recoil protons are opposite for the positive and negative pions, which agrees with the prediction of the Regge-pole model of the interaction. More detailed measurements, including also measurements on proton-proton scattering, finished on 11 September and are now being analysed.

So quarks might just be convenient mathematical objects for the description of elementary particles. Let me say, however, that a serious difficulty might arise if it turns out that the peaks observed in positive kaon-nucleon cross-sections can be interpreted as resonances. One of them (the positive kaon-proton peak) has been analysed by the G. Goldhaber group from Berkeley[7] and might be due simply to a rise of inelastic cross-sections.

In the meantime, the search for real quarks goes on, so far with negative results. We would certainly feel happier if quarks were seen, but we should be ready to accept the verdict of Nature, whatever it is.

General impressions

A great deal of time was allocated to theory. Some experimentalists complained about this as it appeared to them that the success achieved by theoreticians since the last Conference was not so marked. This might be partly true, but this was one of the few Conferences where some aspects of theory (for instance the so-called 'fundamental questions') were discussed and I, personally, was extremely happy that such discussions could take place.

The second impression concerns the importance of the European contribution and in particular of the CERN contribution, not only in experimental fields, but also in theory. All the American physicists with whom I spoke at the end of the Conference stressed this point. It was probably more obvious in the experimental field, but it was also largely true in theoretical work. To be fair, I should say that to my knowledge it is the first time that this has occurred. Most of the previous Conferences were dominated by American experimentalists and theoreticians, or Russian theoreticians. But the impact of the European physicists at the Berkeley Conference was most gratifying and encouraging.

(7) An earlier experiment at Brookhaven, using counters, detected 'peaks' in the positive kaon-proton and positive kaon-neutron cross-sections. These peaks are of the kind which are generally interpreted as resonances. However, these particular resonances cannot be built up from a model which uses only three quarks; more quarks would have to be introduced to explain them. Also, it was the first time that any resonances had been observed in a positive kaon-nucleon system and it was important to look at the effects again.

The Goldhaber group at Berkeley, had bubble chamber pictures of positive kaons on hydrogen and deuterium covering the energy range where the 'resonances' were seen, though not in fine detail. But there was sufficient information on the positive kaon-proton photographs to indicate that practically all of the observed peak in this cross-section could be due to production of other particles — an 'inelastic' effect as opposed to a true resonance. Thus, it seems possible that this peak can be explained away without invoking a resonance, and thus without changing the three quark model. As yet, there is insufficient data on the positive kaon-neutron system to put forward any such alternative explanation, but more detailed investigation is going ahead for both interactions.

Elementary Particles in the Service of Man

This article was prepared by the Atomic Energy Research Establishment, Harwell, and the Rutherford Laboratory in the U.K., for a Physics Exhibition in March of this year and is reproduced here with acknowledgement. It is an account of how some of the knowledge gained in the previous generation of our research has already been applied 'in the service of man'.

The fundamental building bricks of the universe have from time immemorial provided a fruitful field for speculation and, since the beginning of experimental science, for research. At the present time, research into the structure of the atomic nucleus and of the forces that hold it together constitute a major activity of 'big science' and employ a substantial proportion, in man-power and equipment, of the world's research effort in the whole field of physics. This is a far cry from the situation only a few decades ago when the efforts of individuals, often working in primitive conditions and on a shoe-string budget, pioneered the field with the establishment first of the existence of the electron as a constituent of all matter, and later of the fact that atoms have nuclei and that these nuclei consist of protons and neutrons. Now some of the world's most expensive research tools are being used in establishing order amid the apparent welter of so-called 'elementary' particles.

Some of the practical developments in technology and medicine which have resulted from, or have been notably aided by, our understanding of these matters are outlined. Most of the material will be familiar, and much has inevitably been left out — photons, for example, are entirely omitted for lack of adequate space in which to do them justice.

Useful particles

Of all the elementary particles so far discovered and classified only a very few have hitherto found any practical use outside their natural role as basic constituents of matter, or in fields other than scientific research: these are the electron, its opposite number the positron, the proton and the neutron; one other, the negative pion, shows promise of joining this small band of 'useful' particles. There is little doubt however that practical developments will arise which will make use of other particles besides these. If photons of electromagnetic radiation are to be regarded as particles — as certain of their characteristics qualify them to be, especially in the higher energy ranges — then practically the whole spectrum from gamma rays to the longest radio waves could be included.

The electron

Overwhelmingly the most important and versatile of the elementary particles from the point of view of practical applications is of course the electron. It is convenient to classify its role in practical affairs according to its origin — orbital or nuclear — and to the environment in which it is used.

Electrons in orbit

In the conditions which obtain at the earth's surface nearly all atoms carry sufficient orbital electrons of their own, or shared with other atoms, to balance the positive charge due to the protons on their nuclei. All chemical properties and changes depend upon the numbers and arrangement of electrons in their orbits, and the formation or breakage of the chemical links between atoms involve the redistribution of these orbital electrons. The formulation and development of the ionic theory and the electronic theory of valency, and concepts such as free radicals and electron density, have brought about a far clearer understanding of the nature of chemical structure and change than had previously been possible. With this understanding have come many of the major advances in chemical research and technology, ranging from commercial developments in the electro-chemical and plastics industries to the spectacular rise of the whole new science of molecular biology.

Electrons in conducting solids

Current electricity was already being used commercially on a grand scale well before Thompson's discovery of the electron; nevertheless, its visualization as a shunting movement of loosely bound electrons in a conductor has helped considerably in the theoretical and practical development of current electricity and electromagnetism. The discovery and development of superconductivity is perhaps the most promising outcome in recent years of this concept of the electric current.

Electrons in semi-conducting solids

Certain substances or assemblies allow the passage of electrons in one direction more readily than in another. These include particularly some of the elements (and their compounds) whose orbital electron structures put them in the middle groups of the periodic table — between the obviously metallic and the obviously non-metallic elements. If the regular crystal structure of one of these materials is thrown out of step, as it were, by the introduction of 'impurity' atoms, and if another material is placed in contact with it, electrons will flow across the boundary more readily in one direction than in the other. Such devices form the basis of solid-state diodes or rectifiers which are used both in low-current electronic devices (of which the crystal and cat's whisker was an early example) and increasingly, for handling large amounts of electricity in a.c./d.c. power rectifiers. The transistor is another solid-state semi-conductor device in which a potential difference along one axis

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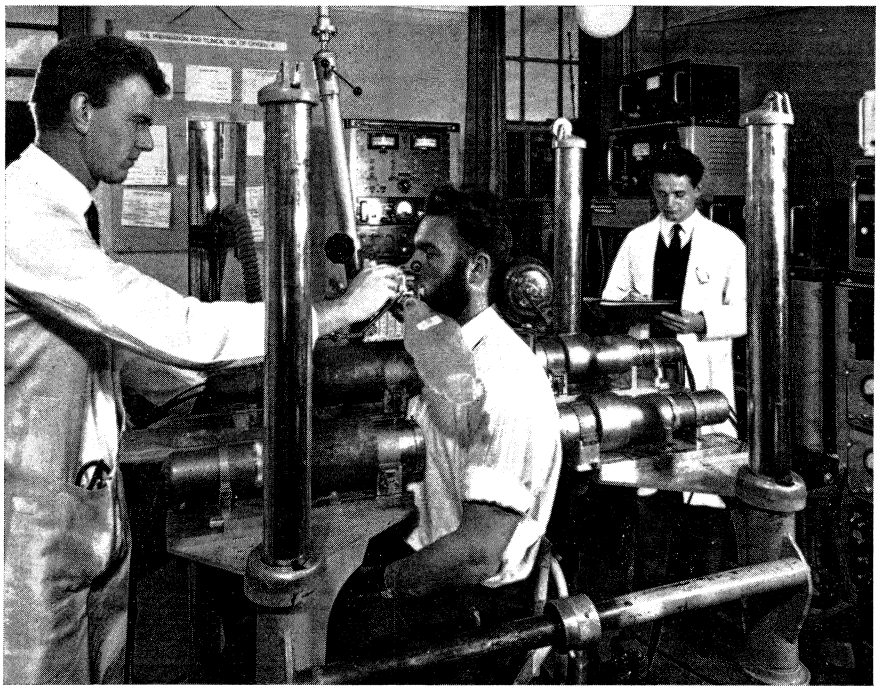


The patient is inhaling air containing oxygen-15 produced at a cyclotron. This radioisotope is over-rich in protons and the decay of the nucleus emits a positive electron (positron) which when it comes to rest will annihilate itself with an ordinary electron with the characteristic production of two photons, each of energy 0.51 MeV, moving in opposite directions. The position in the body where this annihilation occurs can be determined by detecting the photons with scintillation counters (two pairs can be seen on each side of the patient). By tracing in this way, the movements of the oxygen in the body, information can be obtained about the functioning of the heart and lungs. (Photo UKAEA)

of the crystal permits the current to flow along another axis, allowing the device to act as an amplifier or as a switch without moving parts. These devices are the basic components upon which modern high speed computers are entirely dependent; they are used increasingly in all kinds of other electronic systems from domestic portable radios to advanced navigational guidance systems.

Free electrons in gases and plasmas

If sufficient energy is transferred to the atoms of a gas to ionize them (that is, to shake free some of the outermost electrons from their orbits) the gas will become a conductor of electricity and is called a 'plasma'. Gases, especially at low pressure, can be ionized by heat, by X-rays, by the electro-magnetic or corpuscular radiation from radioactive decay, by high-frequency alternating current fields or by sufficiently high direct current potential differences. When a current flows in a plasma, some of the atoms are excited even further and electrons are pushed into abnormal orbits from which they revert with the emission of light or other electro-magnetic radiation of characteristic frequency. This way of producing light first became familiar in 'neon' signs and is now very widely used in the form of fluorescent lighting, in mercury or sodium street lamps, in ultra-violet lights and in electronic flash tubes. The earliest commercial form of electric light — the carbon arc lamp — relies upon a plasma initially created by the intense heat of an electrical short circuit and sustained by the heating effect of the current continuing to pass through the plasma. Arc lighting is still used in cinema projectors and searchlights, but the major use of the electric arc is now in welding, either in air or in an inert gas such as argon. The mercury arc is still the most important type of a.c./d.c. power rectifier.

The plasma which carries the current in an electric spark is produced by the ionization of the intervening gas by the potential difference across it. Intense local heating is produced in the path of the spark. The most familiar application is in the sparking plugs of the internal combustion engine, and other uses include the firing of explosive charges and the spark-erosion machining of complex shapes; spark-gaps are used in the safeguarding of electrical equipment, and in the operation of some types of radio transmitter.

Electrons in vacuo

Electrons 'boiled off' from a hot cathode will carry a current to an anode held at a positive potential. This forms the basis of the diode valve which, by allowing a current to flow in one direction only, acts as a rectifier. With the addition, between the cathode and the anode, of a grid on which the potential can be varied at will to control the flow of electrons from cathode to anode, the valve can be used as an amplifier. These simple valves and developments from them — some extremely complex — form the basis of nearly all radio, radar and television transmission systems and of most receivers, as well as of many industrial instruments.

In the cathode-ray tube, familiar to television viewers, a focused beam of electrons from a hot cathode is controlled in intensity by the incoming signal, while it is made to scan a fluorescent screen in step with the transmitter; the visible image that is produced corresponds to that 'seen' by the television camera. Radar receivers and many kinds of industrial instrument also use cathode-ray tubes to produce visible signals convenient to interpret or record. Scanning beams of electrons are also used in T.V. camera tubes; in one type the electron beam scans a light-sensitive plate on to the other side of which the picture is optically focused; electrons are re-emitted in accordance with the brightness of the optical image at each point of the scan, and these provide the signals which are amplified and transmitted to the receiving stations.

X-rays are produced when a beam of electrons from a hot cathode excites the orbital electrons in the atoms of the target anode; the energy of the X-rays depends

upon the atomic number of the target material and upon the energy of the electrons. For most practical purposes, including medical diagnosis and therapy and industrial non-destructive testing, the target is a heavy metal such as tungsten; the electrons are given an energy ranging from 1 to 1000 kilovolts, either by applying a simple potential difference between the cathode and the target anode or (for the highest energies) by employing some form of additional acceleration such as a linear accelerator or a betatron.

A beam of electrons in vacuo is used in the electron microscope; the beam passes through the specimen and is focused by means of a compound system of electromagnetic lenses (analogous to the optical lenses in a conventional microscope) upon a fluorescent screen; here it can be examined optically or recorded photographically. In a more recent version the electron beam scans the target in a manner similar to that in a television camera and the emitted electrons provide a current which is amplified and forms an image on a cathode-ray tube screen. Magnifications of several hundred thousand times are obtainable with the electron microscope.

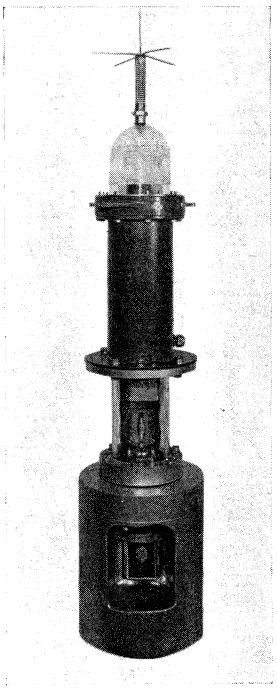
Beams of electrons in vacuo or emerging into air from a vacuum tube can deposit a great deal of energy in a short time. These are finding increasing applications in industry; for example, their heating effect is used for the welding of particularly difficult materials, while their ability to promote certain chemical reactions before causing a significant rise in temperature is used for cross-linking polyethylene to raise its melting point or to give it the property of heat-shrinkability.

Electron beams are being tried experimentally for the ultra-rapid drying of industrial paints, particularly on surfaces which cannot be heated without damage, and their biological effect enables them to be used for cold-sterilizing surgical materials or articles where no great degree of penetration is required, or where the dose rate has to be higher than that which can be achieved by γ-ray treatment.

Beta-particles — electrons from atomic nuclei

When a radioactive atom undergoes β-decay, a neutron changes into a proton and an electron, the latter being flung out from the nucleus with an energy characteristic of the particular radioisotope; in the case of many of these isotopes one or more γ-ray photons are also emitted.

Beta particles have found many practical uses, particularly in industrial measurement and control devices where the extent of their absorption or scattering by the material under test is measured electronically; a signal is produced which can be made to indicate the thickness, density or mass per unit area of the material; where low energy β-particles are involved the scattering is to some extent dependent upon the atomic number of the material. The signal can be fed into a metering or recording device, or back into the system which controls the characteristic being measured. Applications range from the laboratory measurement of the thickness of the gold conducting layer on a printed circuit to the automatic control of an entire sheet-metal rolling-mill.



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A model of RIPPLE II (Radioactive Isotope Powered Pulsed Light Equipment) in which a navigational light is powered by a radioisotope. The generator was developed at AERE, Harwell and uses the radioisotope strontium-90 which produces heat during its decay. The heat is converted into electricity by thermo-couples. This type of equipment should run for over ten years without attention. (Photo AERE)

Like cathodic electrons, beta-particles can be used to excite X-rays from other atoms; these isotope-produced X-rays are used in industrial devices, particularly for non-destructive analysis of alloys and minerals in factory or field, and for the continuous monitoring of the sulphur content of hydro-carbon oils.

Because of the ease with which β-particles can be detected, β-emitting radioisotopes are used as tracers in a very wide range of research, especially in biochemistry, medical diagnosis and industrial process investigations.

Because of their ionizing properties, beta-particles are used for medical treatment where limited penetration is required; for example, strontium-90 in specially shaped applicators is used for the treatment of the cornea of the eye.

Tritium and strontium

Because of its low radio-toxicity, long halving-time and relative cheapness, tritium (hydrogen-3) is used as an activator in luminous signs, for which it has largely replaced radium and strontium-90. This last, however, being available in large quantities from spent nuclear fuel and having a halving-time of 28 years, is finding application in the powering of thermo-electric devices such as flashing navigational beacons; once installed these can be expected to go on working for a decade or more without attention.

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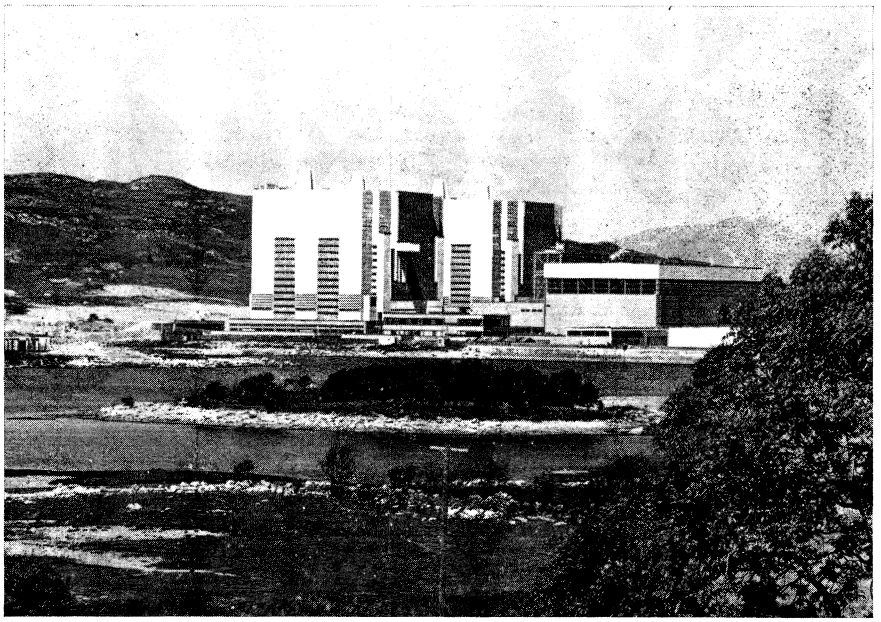


Nuclear reactors are now providing a significant proportion of the electrical power consumed in the U.K. This power station at Trawsfynydd in North Wales reached full power for the first time in Spring 1965. It houses two reactors designed for a net electrical output of 500 MW.

Positrons

Radioisotopes that are rich in protons, as opposed to the more plentiful and easily produced isotopes rich in neutrons, decay by emitting positrons (positive electrons). When a positron comes to rest in matter it reacts with an ordinary (negative) electron and the whole rest mass of the two particles is converted into two photons of 0.51 MeV electromagnetic radiation, which can be very readily detected by a scintillation counter. If two such counters, arranged to register only when both receive a signal at the same time, are set up on opposite sides of a source of positrons the annihilation photons will be detected unmistakably even against a background of other radiations. A positron emitter can in this way be located and its strength measured, even at very low concentrations and through a substantial bulk of surrounding material, more or less independently of the background radiation. A typical example is the use of cyclotron-produced oxygen-15 for the study of the heart-lung function; here the uptake of oxygen into the lungs, its progressive removal by the blood circulation and its final exhalation, can be studied in detail in different regions of each lung by external counting of the annihilation radiation.

Negative pions

Although work is still at the early experimental stage it is possible that beams of negative pions may one day prove to be valuable weapons in the fight against cancer. Unlike γ- or X-rays they can be made to deposit the bulk of their energy at a controlled depth and in a limited volume of tissue. The biological effect of a negative pion beam at the tumour depth will be produced mainly by alpha-particles that result from nuclear interactions of the pions when they come to rest. Such alpha-particles have a high relative biological efficiency and a low oxygen enhancement ratio — that is to say, they do not need oxygen to be effective. In all other regions, radiation is produced by lightly ionizing particles which will have a low relative biological efficiency. At the present time potentially useful beams of pions can only be produced in a few of the world's largest particle accelerators.

Protons

Since hydrogen atoms consist of single protons each with one orbital electron, positively-charged H^+ ions are in fact free protons (unless combined for example, as H_3O+ in aqueous solution). Many chemical changes in which hydrogen takes part involve the existence — albeit fleeting — of free protons; in certain branches of organic chemistry the intra- or inter-molecular migration of protons plays an important part.

Free protons are present in the partially ionized gas of the 'atomic hydrogen' welding torch whose heating power derives largely from the catalytic re-formation at the metal surface of H_2 molecules previously dissociated by passage through an electric arc.

Beams of protons produced by accelerating hydrogen ions in a cyclotron are used in the production of proton-rich radioisotopes which decay by positron (β^+) emission. Protons ejected from a linear accelerator may one day find application as plasma jets for the propulsion of space vehicles.

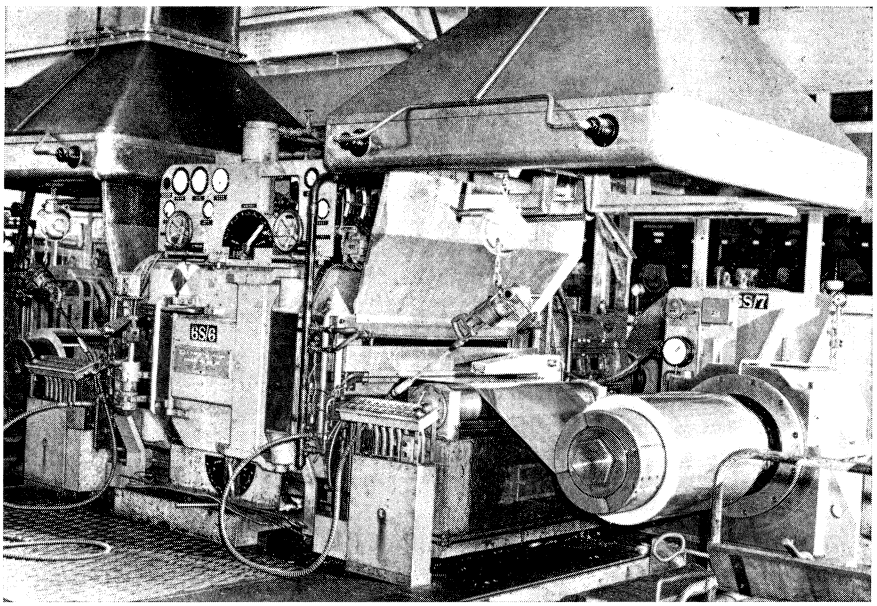
Neutrons

Since the discovery of nuclear fission in 1938, neutrons have played a role of rapidly increasing practical importance.

When a neutron causes fission of the nucleus of a uranium-235 or plutonium-239 atom, two or three fresh neutrons are produced in the process; this can lead in certain circumstances to a self-propagating chain reaction which can either be kept going at a steady rate in a nuclear reactor or made to build up explosively in a bomb. The energy produced is of the order of 10 million times that produced in chemical reactions involving the same mass of material.

Nuclear weapons

If a mass of fissile material is assembled of such a size and shape that the rate of neutron production by fission exceeds the rate of neutron loss from the surface



In this aluminium-rolling plant a beam of β-particles from strontium-90 is passed through the metal sheet as it is being produced. The counting rate recorded by electronic counters on the opposite side of the metal provides a signal which automatically adjusts the spacing of the rollers to ensure that the correct thickness of metal is maintained. (Photo Baldwins Industrial Controls Ltd.)

or by other wastage, and if the material can be kept together for long enough for a substantial proportion of the fissile atoms to react, a nuclear explosion will result. The temperature — tens of millions of degrees Centigrade — attained in an 'atomic' bomb of this type is sufficient to bring about the fusion, in a thermonuclear or 'hydrogen' bomb, of light nuclei with the production of an even more violent explosion.

Nuclear power reactors

If the nuclear chain reaction is sustained at a steady level in a nuclear reactor by ensuring that just one neutron from each fission goes on to cause one further fission, the energy produced can be used to raise steam and generate electricity. About 14 % of Britain's electricity is at present being generated in nuclear power stations, and by the 1970s nuclear generation is expected to be the cheapest way of making electricity in Britain.

Radioisotope production

The hailstorm of neutrons present in an operating nuclear reactor can be used to make materials or objects radioactive by introducing further neutrons into their nuclei; such neutron-rich nuclei will decay by the emission of β-particles with, in some instances, γ-rays as well. Radioactive isotopes, both proton-rich and neutron-rich, are also produced directly in the fission of uranium or plutonium; these fission products can be separated chemically from the bulk of the spent fuel and converted to the required chemical or physical form. Radioactive isotopes of almost every element are now available commercially. The fissile isotope plutonium-239 is produced by bombarding uranium-238 with neutrons arising from fission of uranium-235 or of plutonium-239.

Analysis with neutrons

Specimens or materials for analysis may be bombarded with neutrons and the radiations subsequently given off by the radioisotopes so formed may be examined; the nature of these radiations indicates which radioisotopes are present, and their intensities indicate the amount of each. Knowledge of the nuclear reactions leading to the production of these radioisotopes makes it possible to determine, quantitatively and qualitatively, many of the elements constituting the original specimens. This technique, known as activation analysis, is limited in its practical application to elements which readily absorb neutrons. Because of its extreme sensitivity, it is particularly valuable in trace analysis, for example in forensic work; it can also be adapted to certain types of routine non-destructive analysis in industry, e.g., oxygen in steel. The usual source of neutrons for activation analysis is a nuclear reactor, but in the case of oxygen in steel and other on-the-spot analyses where no reactor is available increasing use is being made of neutron generators; in these, 14 MeV neutrons are produced by reaction between electrically accelerated deuterium ions and a tritium target, according to the equation

$$^{3}_{1}\mathrm{H} + ^{2}_{1}\mathrm{d} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n} + 17.6\ \mathrm{MeV}.$$

Portable instruments for use on site, e.g., for borehole logging or for soil-moisture measurement, depend upon neutrons produced on the spot by nuclear reactions such as that between beryllium and α-particles from radioactive decay; the instruments usually detect either prompt γ-rays (e.g., from chlorine in the brine associated with oil-bearing formations) or thermalized (slow) neutrons, scattered back by the hydrogen nuclei of water molecules, for example, in the soil adjacent to the neutron source.

Other neutron techniques under development include measurement by activation analysis of constituents of the living body (e.g. total sodium or chlorine); neutron beam therapy including that in which implanted materials such as boron are activated in situ; and industrial neutron radiography, which can reveal small inclusions of light materials that absorb or scatter neutrons, in a mass of much heavier material that is relatively transparent to neutrons but is too dense or massive to be examined satisfactorily by X-rays or γ-rays; for example, a piece of organic matter embedded in a block of lead.

BOOKS

High energy beam optics, by K. G. Steffen (London, John Wiley and Sons Ltd., 1965; 72 sh.).

The invention of the strong focusing principle by Courant, Livingston and Snyder in 1952 not only opened up the possibility of constructing accelerators with much higher energy than before, but also revolutionized the design techniques of secondary particle beams. The use of various combinations of quadrupole lenses and bending magnets has given rise to a large variety of particle beams, each designed for a specific experiment. Although several books on accelerator theory have existed for a number of years, Steffen's book is the first to give, in a comprehensive way, all the theory that is required to design high energy particle beams.

The first chapter discusses the optical properties of systems of quadrupoles, including chromatic and non-linear aberrations. The second chapter gives a very complete treatment of bending magnets, with a homogeneous field and with a gradient, and also considers wedge-shaped and rectangular magnets. The third chapter applies the theory of the first two chapters to the design of non-dispersive beams and to several examples of spectrometers.

While the first three chapters follow the approach of classical optics, where individual rays are traced from object to image, the last chapter gives the theory of the envelope of particle beams. This approach is especially useful in the case of the external beam from an accelerator, but also gives a much better understanding of the possibilities and limitations of, for example, separated beams.

It is natural, that in giving practical examples, the author mainly refers to work done in his own Laboratory (DESY), but this may not always be entirely representative. Steffen uses several paragraphs to describe the use of an analogue computer to design beams. However, most Laboratories have much better digital than analogue computer facilities and therefore nearly all beams are designed with digital computers. The example on quadrupole design, results in a large power consumption and is therefore not very suitable as a general purpose quadrupole. The treatment of separated beams is kept rather short since they are used very little around electron accelerators but their considerable importance at proton accelerators makes a more extensive discussion desirable.

In conclusion, I can recommend this book to anyone who wants to set up particle beams. The mathematics is not difficult and the theory is sufficiently complete to enable a beam designer to understand specific beams described in the literature and to work out his own beam.

B. de Raad

Also received:

Experimental reactor analysis and radiation measurements, by Donald D. Glower (New York, McGraw-Hill Book Company, 1965; $ 13.50) — laboratory manual for graduate-level courses in nuclear science and engineering.

Concepts and models of inorganic chemistry, by Bodie E. Douglas and Darl H. McDaniel (New York, Blaisdell Publishing Company, 1965; $ 10.50) — unifying course in modern inorganic chemistry for the advanced undergraduate student.

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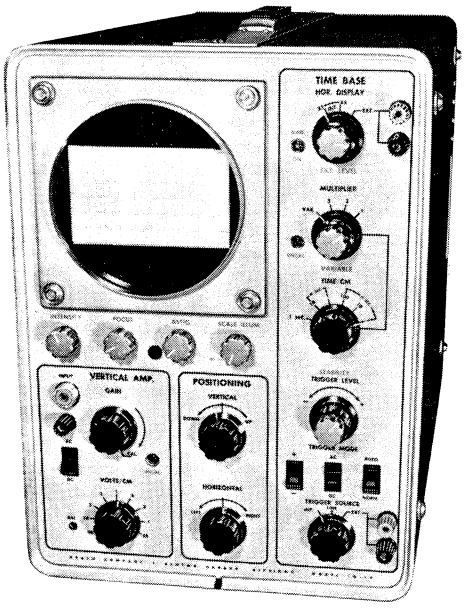

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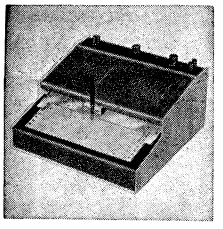

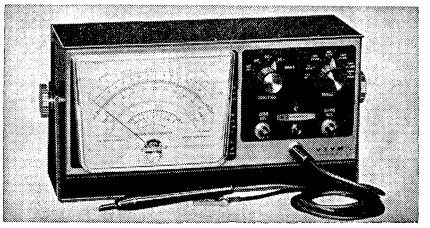

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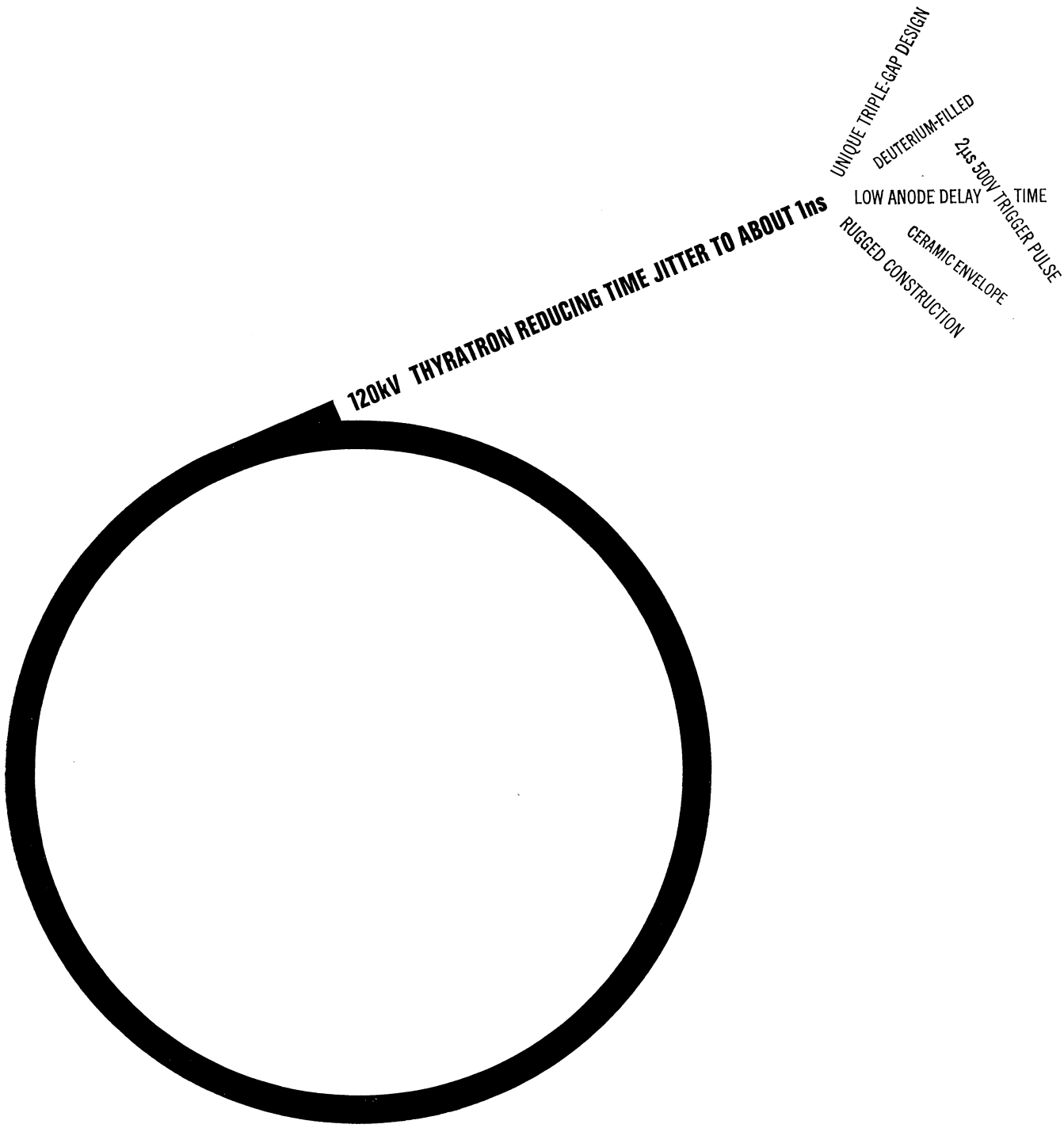

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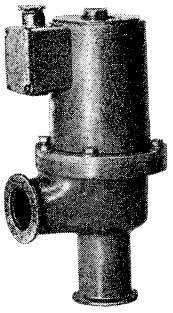

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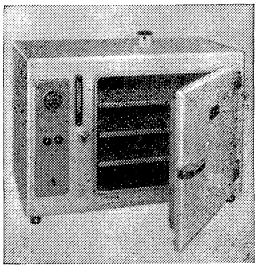

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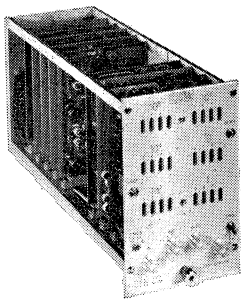

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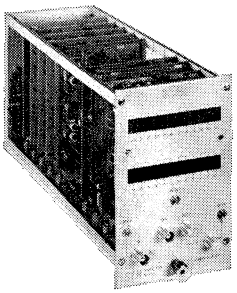
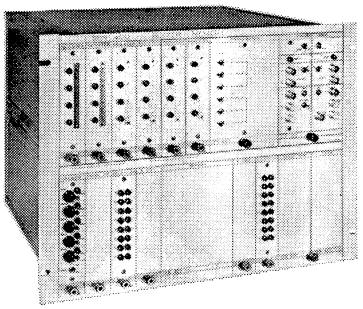
- Input circuit protected against overloads
- Capacity: 10^6



100 Mc COUNTER, BINARY VERSION-SEN 194

- Same general characteristics as the SEN 176 counter
- Straight binary output for efficient operation with "on line" computers
- Capacity: 2^{24}



BUFFER MEMORY-, SEN 400

- Allows recording of several events during each burst of accelerators
- Provides most efficient use and considerable economy of magnetic tape
- Capacity: 1024 words of 24 bits
- Compatible with SEN standard counting systems
- Standard chassis for 19" rack

NEW LINE OF MEMORY MODULES SOLVING SPECIFIC NEEDS OF PHYSICISTS.

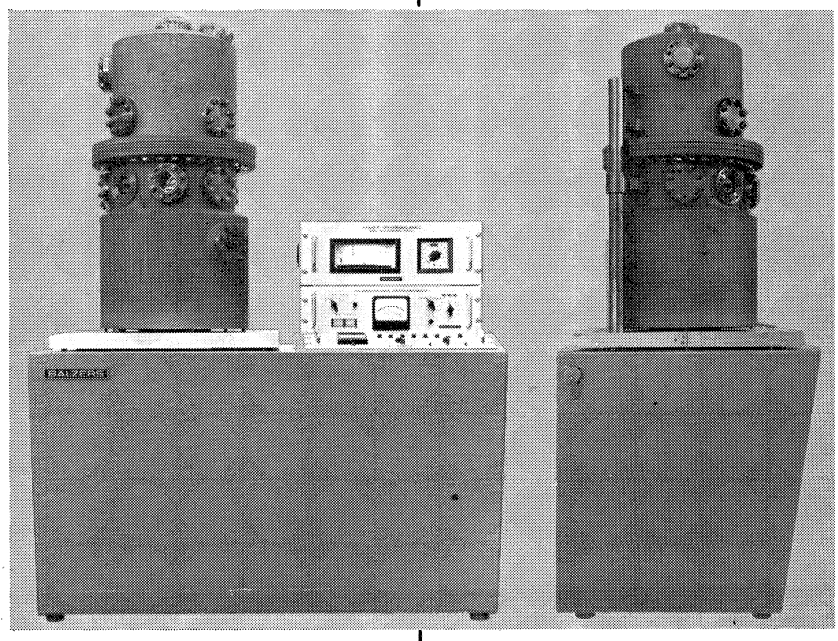
SEN

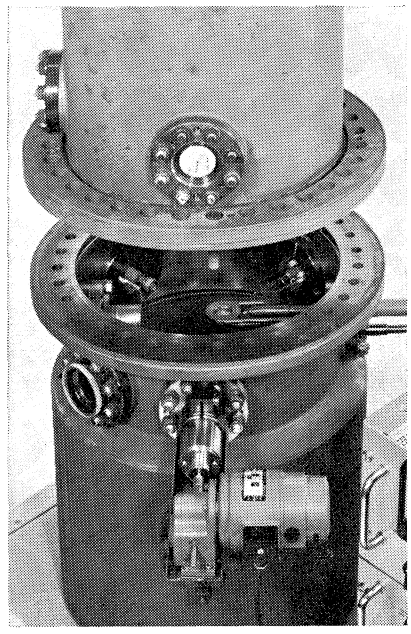
SOCIÉTÉ D'ÉLECTRONIQUE NUCLÉAIRE
31, AV. ERNEST-PICTET GENÈVE-SUISSE TÉL. (022) 44 29 40

FROM 1rst OF APRIL 1966

NEW ADDRESS
31, av. Ernest-Pictet - Geneva / Switzerland

Fully automatic Ultra High Vacuum Unit BA 350 U for ultimate pressures as low as the 10^{-12} Torr range





In designing the new ultra high vacuum unit BA 350 U, our design staff had the benefit of the knowledge and experience gained in twenty years of building high vacuum units.
A wide range of ancillary equipment makes the standard model extremely flexible, so that the BA 350 U is a versatile unit for both research and production in the fields of semi-conductor techniques, magnetic and super-conducting films, space chamber simulation, and general thin film and UHV-physics.

Special Features of the BA 350 U:

Guaranteed ultimate pressure better than 2×10^{-10} Torr; or if an additional titanium sublimation pump is fitted, better than 5×10^{-11} Torr.
Ultimate pressure obtainable in the 10^{-12} Torr range net pumping speed at the vacuum chamber approximately 400 l/sec. for air and 4 000 l/sec. for water vapour; if an additional titanium sublimation pump is fitted approximately 2 000 l/sec. (except for rare gases).
An efficient baffle and large creep paths assures virtually oil-free UHV.
Stay-down time of more than two weeks, without the use of liquid nitrogen.
A new type of throttle valve in the baffle system enables the high vacuum to be maintained in the diffusion pump, whilst carrying out glow discharge, gas control processes, cathode sputtering etc.
Instead of the gold wire seals, the main chamber seals can be viton so that the vacuum chamber can be opened and closed as in normal high vacuum units (clamping is unnecessary).
Ultimate pressure obtainable using viton seals 10^{-11} Torr range.
The vacuum cycle is controlled by the fully automatic pumping station and programme sequenced automatic bake-out assures reliable evacuation and bake-out without supervision. The unit is "bakeable" (even if Viton seals are fitted). If required Ion getter and Sorbtion pumps can be provided as ancillary equipment.
12 spare ports are provided for fitting additional equipment.

Main Accessories:

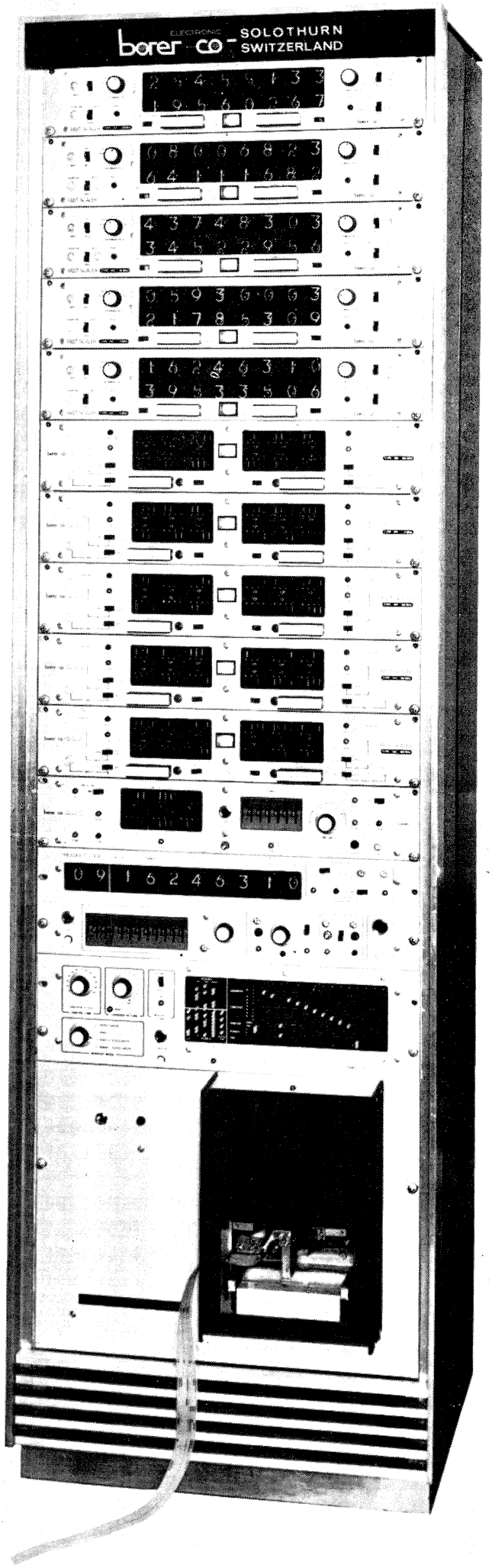
Titanium sublimation pump with control unit; 3-kW-electron beam evaporation equipment with fully bakeable source; complete glow discharge equipment; 2-kVA high current unit with built-in glow discharge control; rotary cage assembly with external drive; substrate heater device; filling device for liquid nitrogen; water-cooled high current lead-ins; high voltage lead-ins; measuring current lead-ins; mechanical and magnetic lead-ins; sight glasses, etc.

BALZERS®

BALZERS AKTIENGESELLSCHAFT
für Hochvakuumtechnik und Dünne Schichten
FL-9496 Balzers · Principality of Liechtenstein

United Kingdom:
BALZERS HIGH VACUUM LIMITED
Berkhamsted, Herts.,
Telephone: Berkhamsted 2181

MULTI-CHANNEL SCALER SYSTEMS



The collection and recording of data in nuclear physics experiments is not only time consuming, but also a possible source of error which should be avoided. The Borer Multi-Channel Scaling System fulfills this requirement rapidly and reliably with its versatile equipment having counting rates up to 100 Mc/s.

The units making up the system can be used in both high energy and low energy nuclear physics. Each instrument incorporates its own stabilised power supply and can therefore be used independently.

Scalers are available with:

6 or 8 decades

decimal or binary display

2, 20 or 100 Mc/s count rates

single or double units

flexible data output using teleprinters, punched tape, magnetic tape, output writers, and parallel printers

All units use solid state devices throughout, and all components are of the highest quality.

Borer Electronic Co are the largest manufacturers of scalers in the western hemisphere, and offer the widest range of scaler systems. Present us with your problem—we will provide the optimum solution.

Please ask for latest literature, or for a demonstration.

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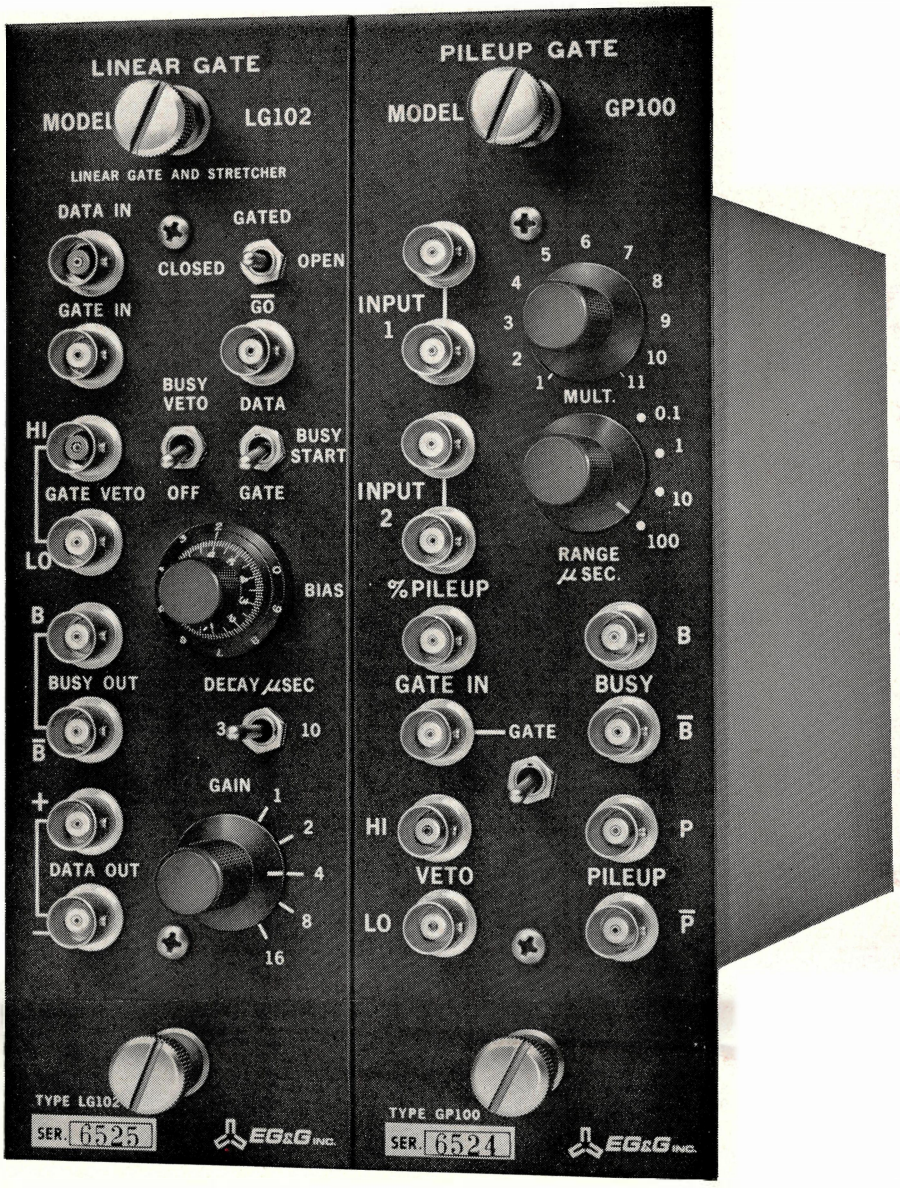
Kaiserstrasse 10, D-8000 München 23
Telephone 34 80 16

France: Sorelia Electronique
25 rue de Normandie, F-92 Courbevoie
Telephone 333 82-96

Italy: DISI Nuclear Corporation
Viale Lunigiana 40, Milano
Telephone 69 10 72

Two new tools help you squeeze more data out of mother nature.



LINEAR GATE AND STRETCHER. The LG102 is a fast, direct-coupled linear gate and stretcher incorporating extensive control and supervisory logic. Among its many unusual features are: high input sensitivity; adjustable zero suppression of the fast input; output proportional to peak; suicide mode operation.

- Linear down to 5 mv. 5 nsec input (0.25 picocoulomb).
- Zero suppression of up to 0.5 volt on gated fast signal.
- Post stretcher gain of X1, X2, X4, X8, X16.
- Busy signals available, may be used for "SUICIDE" operation.
- Two units may be used in a de-randomizing scheme.
- May be used as a sampling gate.

PILE-UP GATE. The GP100 Pile-Up Gate embodies a new concept in protection against spectrum distortion due to pulse pile-up. An "updating" timer is triggered or updated each time an input appears. If an input comes within the duration of the timer output, a pile-up gate signal (P) is generated which may be used to control the flow of information to the analyzer or to control the analyzer. The gate signal (B) is also available. The "updating" timer provides true no-deadtime operation.

- Gate width variable from 0.1 μsec to 1100 μsec in four ranges.
- 10 nsec resolution for pile-up detection.
- Input signal overrides reset at end of gate.
- Inputs accept wide range of linear or digital signals.
- Built-in high-level gate amplifier allows M100 system gating directly from B or P signals.

Illustrated application notes and specifications on these two new modules, as well as on the entire M100 Counting System are available. Write: EG&G, Inc., Salem Laboratory, 40 Congress Street, Salem, Massachusetts 01970. Phone: (617) 745-3200. Field offices: Chicago, Ill., Phone: (312) 237-8565; Palo Alto, Cal., Phone: (415) 327-8328. Representatives in most foreign countries.

Positions available for creative engineers with experience in nuclear instrumentation. Contact W. M. Henebry — 617-745-3200.

EG&G INC.