

# News from abroad

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'The following individual, legal persons or bodies may become Ordinary Members of the Society:

- a) individuals who have shown by their contribution to European science, by their professional activity or otherwise, to the Council's satisfaction, that they can further the cause and object of the Society;
- b) societies, groups or laboratories organized or existing under the laws of the State of their incorporation or of their seat and which, in the Council's opinion, make a significant contribution to European science;
- c) individuals who are members of a society or group which has been accepted as an Ordinary Member of EPS and who fulfil the conditions laid down in the foregoing paragraph provided such individual membership in EPS is not precluded by the Constitution or by-laws of their society or group.

Membership fees are fixed in three categories — Individual members (72 Swiss Francs/year); Membership through a National Society which has joined the EPS (the National Society pays a fee varying according to the number of its members); Members of a National Society who wish to enroll also as individual members (18 Swiss Francs/year).

The first issue of the Bulletin of the Society, to be called 'Europhysics News', will be devoted to the formation of the EPS. It will appear on the 15 November.

## Enrolling in the European Physical Society —

1. Professor G. Bernardini (Director of the Scuola Normale Superiore, Pisa)
2. Professor L. A. Artsimovich (Academy of Sciences, USSR)
3. Dr. L. Cohen (Secretary of the Institute of Physics and the Physical Society, UK)
4. Professor B. Gregory (Director General, CERN)



CERN/PI 325.9.68

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CERN/PI 335.9.68

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CERN/PI 327.9.68

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## Superconducting accelerator programme at Stanford

The High Energy Physics Laboratory (HEPL) at Stanford University, USA, has for some years been the scene of an intensive attack on the challenging problem of a superconducting accelerator (SCA). The work, under the leadership of Professors W. M. Fairbank and H. A. Schwettman, has advanced to the stage where a large SCA will be put together during the next few years with every hope of successful operation.

The feasibility of constructing a superconducting linear accelerator was examined at several centres (CERN, Rutherford Laboratory, and Stanford University) in the early 1960s. It became obvious at that time that a severe research programme to achieve major technical advances would be needed to overcome the problems involved and only Stanford decided to confront the work.

In order to explain why the challenge was worth taking up, we should consider the properties of the existing linear accelerator, which have perhaps reached their optimum so far in the 20 GeV electron machine at the Stanford Linear Accelerator Centre. (Note: SLAC is a National Laboratory, distinct from HEPL which is a University Laboratory).

The 20 GeV accelerator is built up of 100 000 microwave cavities stretching over a length of 3000 m. Radio-frequency power is pumped into these cavities to establish the electric fields which accelerate the electrons. The bulk of the power is absorbed in compensating for the r.f. losses in the copper walls of the cavities. Several thousand megawatts of r.f. power are required from an expensive klystron and modulator system.

Because of the demand for power, the duty cycle of the accelerator has to be kept down to 1 in 1000 (in other words, the accelerator is switched on for only a thousandth of the time). For many experiments this is a serious drawback. A related problem, which also affects the experiments, is that it is difficult to hold the accelerating fields (and thus the final beam energy)

steady when pulsing the machine, coupled with temperature rises in the cavity walls where the power is lost which can change physical dimensions and thus the accelerator's characteristics.

The superconducting accelerator could get round these limitations. If it were possible to build the cavities from a superconductor, and to sit the accelerator efficiently in a very low temperature environment where superconductivity becomes effective:

- There would be a great reduction in the power lost in the cavity walls giving a dramatic saving in r.f. power
- The accelerator could then be operated continuously instead of having a very low duty cycle (the continuously maintained field would also lead to more stable output energy)
- Since the r.f. power system would no longer be under strain, more power could be used to increase the accelerating voltage to the breakdown point, thus reducing the physical length of the accelerator (perhaps a factor of two or three down on conventional linacs of the same energy)
- And, a surprise bonus, if superfluid

helium were used as the refrigerating medium it would be possible to maintain extremely stable temperature conditions which would contribute to exceptionally stable output energy.

To achieve these fascinating possibilities, HEPL mounted a long-range research programme to develop :

1. A new superconducting technology to produce high power superconducting microwave cavities where the power loss is a factor of million lower than in conventional cavities.
2. A new superfluid helium technology to handle power dissipation at low temperatures while maintaining near isothermal conditions over distances of hundreds of metres.

#### *Development of cavities*

The reason for the requirement of a factor of a million compared with the conventional cavities is twofold. First, if the power dissipation in the walls can be reduced by a factor of a thousand then, for the same power input, the same accelerating

voltage can be maintained continuously. Second, on extra factor of a thousand is needed to compensate for the inefficiencies of a refrigerator working at temperatures near absolute zero. In theory, superconducting cavities, made for example of lead or niobium, would produce such an improvement.

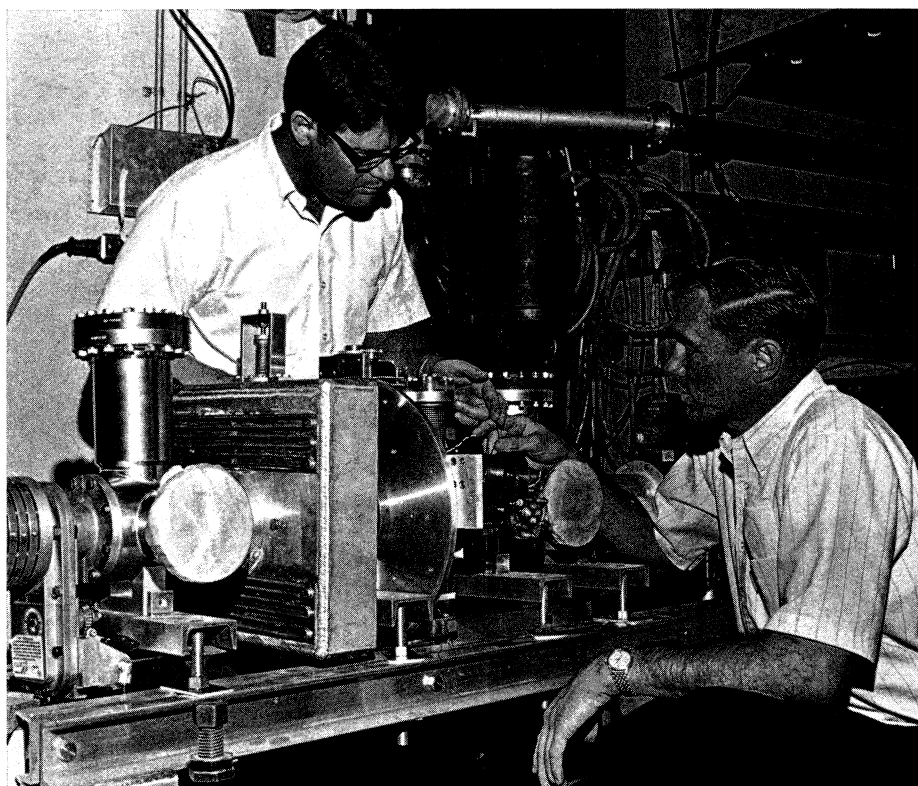
A more usual way of expressing what is required is to say that one needs to achieve microwave cavities with  $Q$ s exceeding  $10^{10}$ , compared with the conventional  $Q$ s of  $10^4$ .  $Q$  stands for 'quality factor' and represents the power utilization of the cavity; the higher the  $Q$  the less is the power needed to establish a required voltage.

If the power were fed into the cavity at zero frequency, the resistance of the superconductor would be zero below the transition temperature (when the metal becomes superconducting). However at high frequency, such as is involved in the principle of operation of a linear accelerator, the resistance vanishes only at absolute zero (and then only if some sources of residual resistance are eliminated). Prior to the Stanford work, the maximum values of  $Q$  which could be achieved in a superconducting cavity were around  $10^7$  (independent of temperature) and HEPL had therefore the task of improving on this performance by a factor of a thousand.

One source of residual resistance is that magnetic flux is trapped in the walls of the cavity when they become superconducting. When the cavities are cooled down in the earth's magnetic field, flux is trapped in the walls producing normal conducting regions. In a series of experiments carried out at HEPL, it was found that  $Q$  could be pushed progressively higher as the ambient field during cool-down was made lower. This increase continued down to a field level of 0.03 gauss.

Another source of residual resistance is that large thermal gradients can appear as the metal goes superconducting giving large thermoelectric currents, again resulting in trapped flux. Keeping these thermal gradients as low as possible resulted in further increases in  $Q$ .

By now HEPL has shown that, with these precautions, it is possible to take the value of  $Q$  above  $10^{10}$ . (Similar values have since been obtained at Brookhaven and Karls-



Some photographs from the National Accelerator Laboratory where the USA 200 GeV accelerator is being constructed :

1. All the Laboratory staff have now moved on to 'The Campus' and this flag-raising ceremony took place on 24 September.
2. As reported in the last issue of CERN COURIER, the Laboratory has experimented with inflatable buildings. The one shown is for the 'Modeling and Measurements Group'.
3. An aerial view of the village of Weston which temporarily houses the Laboratory staff.



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ruhe using lead cavities.) The first requirement for a superconducting accelerator has thus been achieved.

Pure niobium looks the best material for the construction of the cavities because of its excellent high voltage properties. With niobium it should be possible to achieve very high accelerating fields leading to a compact accelerator (energy gradients of the order 20 MeV/m). Several techniques for manufacturing cavities of pure niobium, which at first sight could be an extremely expensive business, are being investigated. Electrodeposition on a copper mandrel looks particularly interesting both economically and as a method of accurate construction.

#### Helium refrigeration

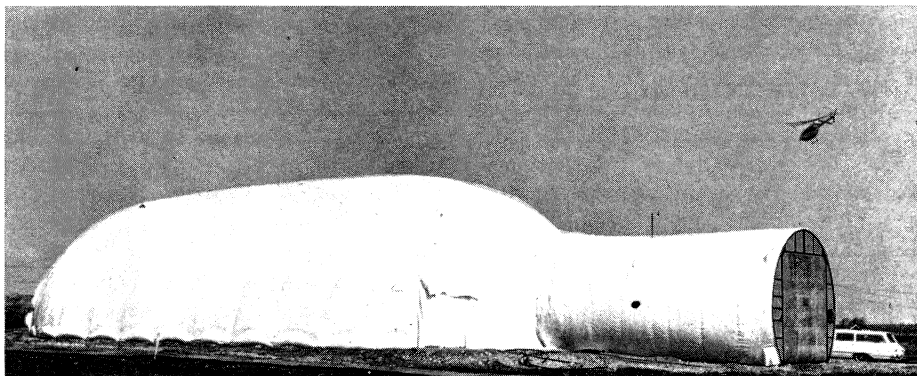
Superfluid helium has remarkably good heat-transfer properties and is an excellent heat reservoir, having high specific heat. It can therefore rapidly spread any heat generated in the cavities throughout a large thermal reservoir and thus play an essential part in the operation of a superconducting accelerator by providing a stable thermal environment.

The Stanford team had, however, to apply itself to the problem of realizing these properties in a practical system. A superfluid refrigerator had never been built, nor had a large-scale cryogenic system such as would be needed for a superconducting accelerator.

The firm Arthur D. Little Inc. modified an existing refrigerator for superfluid operation. This was a 30 W system and tests with it led to the design of a 300 W unit now being installed at HEPL. The use of this refrigerator should demonstrate the feasibility of operating a large and complex system from a central refrigerator. Work is already under way on the design of a 1000-2000 W refrigerator.

#### The near future

The 300 W refrigerator is designed to cool a superconducting accelerator 150 m long. (A 1.5 m prototype has been in operation since December 1966.) Within the next few years all the individual pieces of work which have been done on various aspects of SCA technology will be brought toge-



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ther in the design, construction and operation of a superconducting electron linac 150 m long. If all goes well it could eventually lead to a superconducting conversion of the SLAC accelerator.

During this exciting stage of the work at Stanford, two CERN people will be working with the team — E. Jones (who did research with the storage ring model, CESAR, at CERN) and P. Bramham (a linac r.f. specialist from the ISR Division).

## End of ING

The Intense Neutron Generator (ING) project has been rejected by the Canadian government. It was announced on 20 September that, in accordance with the government decision, the AECL (Atomic Energy of Canada Limited) will phase out its ING studies and experiments by the end of the current fiscal year.

The ING project was centred on the Chalk River Laboratory. It involved the construction of a 1 GeV proton linear accelerator providing a continuous beam of 65 mA to be used principally for the

production of an intense flux of neutrons. (See for example CERN COURIER vol. 7 page 200, for a fuller description).

The Canadian government decided that in the light of the other demands on the national treasury, the high cost of ING could not be met at this time. It would have been by far the largest, and most expensive, single scientific project ever funded by the federal government (capital cost \$ 166 million at 1966 prices over a construction time of seven years). Canadian scientists are left with TRIUMF (see CERN COURIER vol. 8, page 136), a cyclotron project on the west coast.