FUSION
1992

Future generations could be provided with an almost limitless source of energy from nuclear fusion. Current research programmes world-wide are aimed at proving the scientific feasibility of using nuclear fusion for generating electricity. The Joint European Torus (JET) is the world's largest fusion experiment, which is paving the way to a full-scale reactor.

(Since this article was written JET has recorded a successful fusion experiment. In the Financial Times on November 11, journalist Clive Cookson wrote and we quote: "This weekend in Oxfordshire a doughnut-shaped ring of superheated gas reached a temperature of 200m deg C – 10 times higher than the sun's centre – and briefly produced 2MW of energy. The experiment at the JET in Culham was the first large scale demonstration on Earth of nuclear fusion, the reaction that powers the sun and is held out by scientists as the brightest prospect for giving mankind a clean and limitless souce of energy in the 21st century.")

VINES BEHIND THE

A SUCCESSFUL ROCC

Based at Abingdon, Oxfordshire, JET is renewing its networked computer system. This has been used for the operation of the experiment and for the analysis of results. The system, which will include an on-site electronic mail service, has evolved steadily since being brought into use in 1982.

An important requirement has been for all parts of the computer system to be easily accessible for the users, regardless of the type of terminal being used (eg PC, UNIX workstation, Apple Macintosh).

JET approached many UK and European companies with its LAN (local area network) requirements in February 1990. It was Banyan VINES, supplied by ROCC, that won the contract. The VINES network at JET, which supports a wide range of services, is now fully operational.

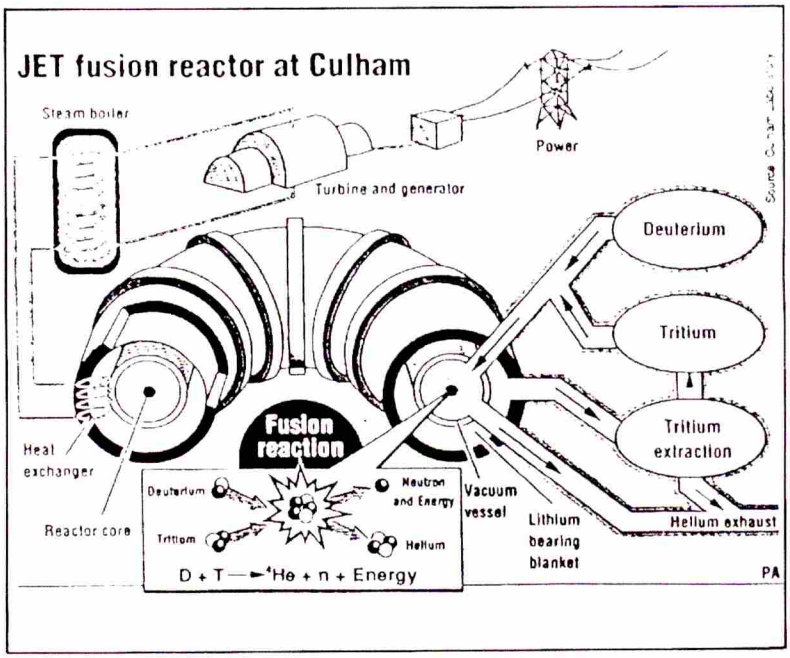
JET is the largest single project of the coordinated nuclear fusion research programme of the European Atomic Energy Community (Euratom). It aims to prove the scientific feasibility of nuclear fusion as a new energy source. The project was established in June 1978 and the experiment was constructed, commissioned and in operation by June 1983.

Nuclear fusion is the process taking place continuously in the sun and the stars. Large amounts of energy are released when light nuclei fuse to form heavier ones but the process is difficult to achieve on earth as the reaction occurs only at very high temperatures.

The most suitable reaction for energy production occurs between the two heavy isotopes of hydrogen - deuterium and tritium. Temperatures in excess of 100 million degrees Celsius are needed in a reactor. At these temperatures, the fuel has changed from a gas into a 'plasma' (a low-temperature plasma occurs in a neon advertising sign).

To achieve the very high temperatures required for fusion, the hot plasma must be isolated from the vessel walls. The European Fusion Programme concentrates on using magnetic fields to produce the necessary confinement of the plasma in a hollow ring-shaped vessel known as a torus.

One of the promising magnetic field systems is the Tokamak *(see inset)*.



The Tokamak

In a tokamak the plasma is confined away from the walls of the vacuum vessel by using a complex system of magnetic fields forming a magnetic cage surrounding the plasma. The main component of the magnetic field, the so-called toroidal field, is produced by coils surrounding the vacuum vessel. This field, coupled with that produced by the current flowing through the plasma (produced by transformer action) forms the basic magnetic field for the tokamak confinement system.

Additional coils positioned around the outside of the vacuum vessel (not shown in the diagram) are used to shape and position the plasma. These coils, together with the coils making up the primary winding of the transformer, are called poloidal field coils.

'USION
EXPERIMENT

Coordination of controlled nuclear fusion research in Europe began in 1957 with the creation of Euratom. At that time, fusion research was in its infancy in the six countries of the Community. Rather than set up its own research centre, Euratom chose to work by way of associations with the national centres to promote and coordinate research by making available financial aid.

During the 1970s a consistent set of results emerged from several tokamak experiments, leading to the large-scale experiment at Abingdon. Approval to proceed with the project was given by the EEC Council of Ministers in 1977.

A total of 14 European countries are currently participating in the project.

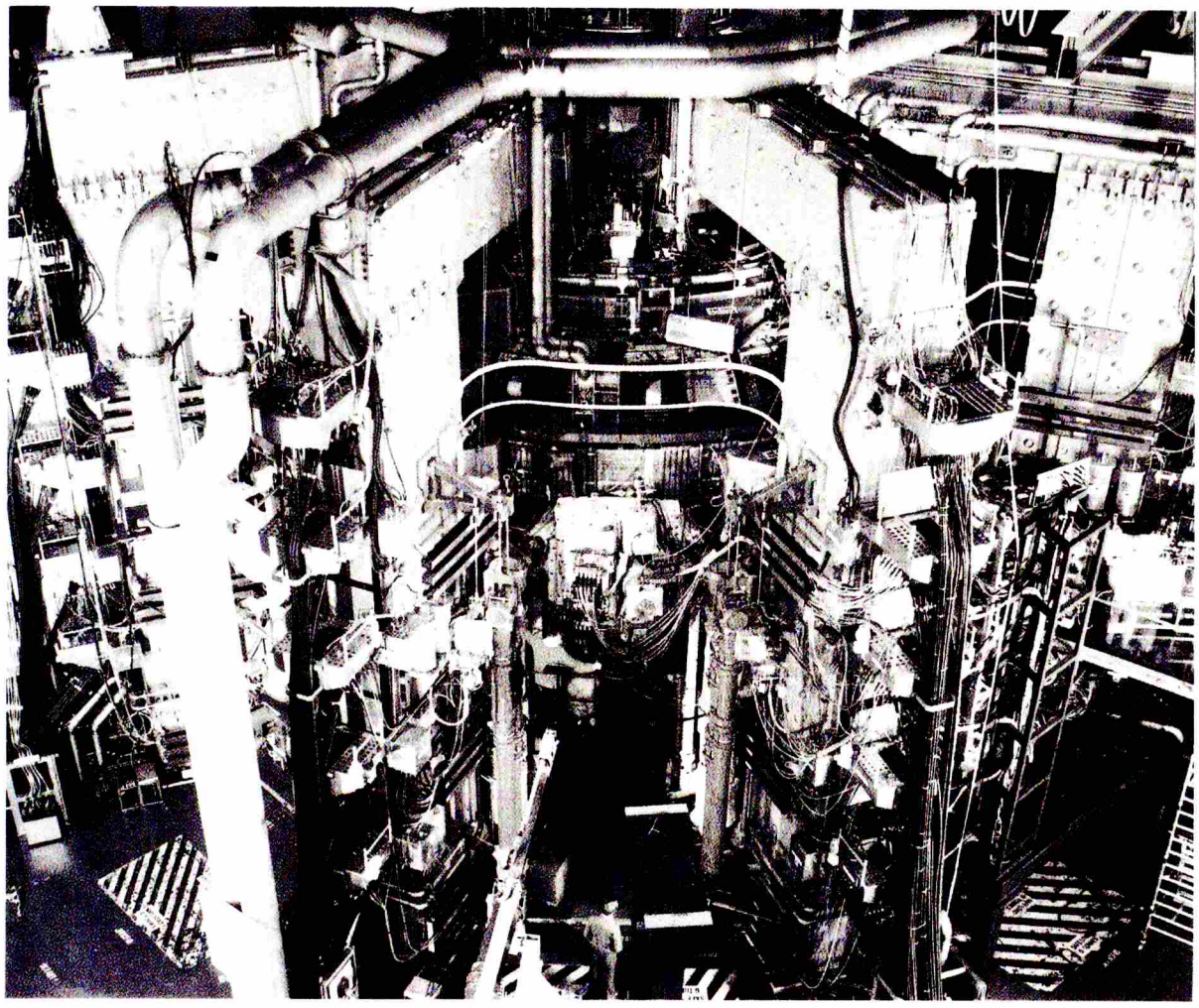
There is a refreshing openness at JET about the sharing of knowledge. About 450 scientists and engineers, many of whom are leaders in their field, work on site at any time, although considerable movement occurs between Member sites, with regular visits from scientists outside JET, such as those from America, Japan and Russia.

The fuels for a fusion reactor will, it is hoped, be extracted from abundant sources such as sea water. Radioactivity of the reactor structure can be minimised by careful material selection. There are also no long-lived fission products, plutonium or other actinides produced which require storage and supervision for very long periods.

During the experimental programme JET operates for 16 hours per day, six days a week, with 20 second pulses for physics experiments taking place every 20-30 minutes. It is during these pulses of operation that scientists have to gather vast amounts of data with a view to refining and developing the fusion process.

In a typical year the torus is used over a six-month period. The rest of the year is used for modifying and enhancing the machine in preparation for a fresh set of experiments.

Minicomputers for real-time control of the experiment rather than mainframe computers were chosen and upgraded Norsk Data minis are still used for control and for preliminary analysis of results. The main off-line analysis is performed by its own IBM 3090/300J, with 2 vector facilities.



General view of JET (Joint European Torus).

The original computer terminal network used a Gandalf multiplexing system. Each office is fitted with a socket for the purpose. The current-loop method was chosen to cope with the long wiring runs - in excess of 600m in places. For the future, however, JET intends to move to UNIX open standards.

VINES user support at JET

IBM users: current access to the IBM 3090 mainframe is through 'real' 3270 terminals working over coaxial cable links or through the original Gandalf current-loop network. ROCC is about to provide transparent access to the IBM mainframe, with IBM terminal emulation over VINES. The initial 3270 licence is for 32 users.

UNIX users: most of these are on dumb terminals and can gain access to the Ethernet network either directly through a terminal concentrator or indirectly through the Gandalf network. UNIX users have their own SMTP Mail (standard UNIX mail), and there is a gateway between this and the VINES mail server.

Apple Macintosh users: mainly secretarial, these can be connected directly to Ethernet or indirectly to it through Apple's Local Talk, using a Fastpath IV gateway. The Mac users use QuickMail and there is a mail gateway between this and VINES.

PC users: these use the VINES e-mail directly.

During the operation of JET scientists work in two large control rooms filled with computer equipment. The areas are divided broadly into control and experiment. CODAS, a services division of JET, is providing new CODAS UNIX control and data acquisition systems and these will use Ethernet as their standard method of connection. Thus a transparent connection between the systems on the entire site over Ethernet, or as it is called 'JETNet', will be possible.

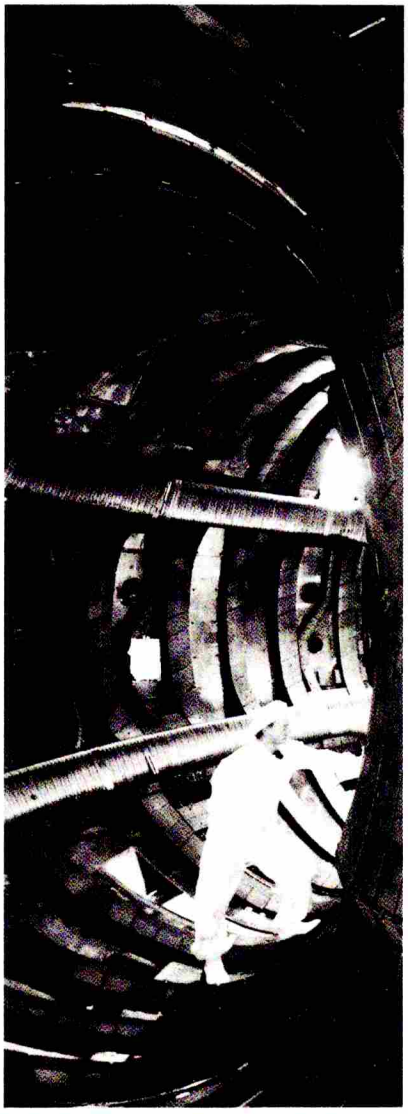
The role VINES plays is that it can transparently connect to all the systems when using a PC and allows the Macintoshes to access the PC file areas.

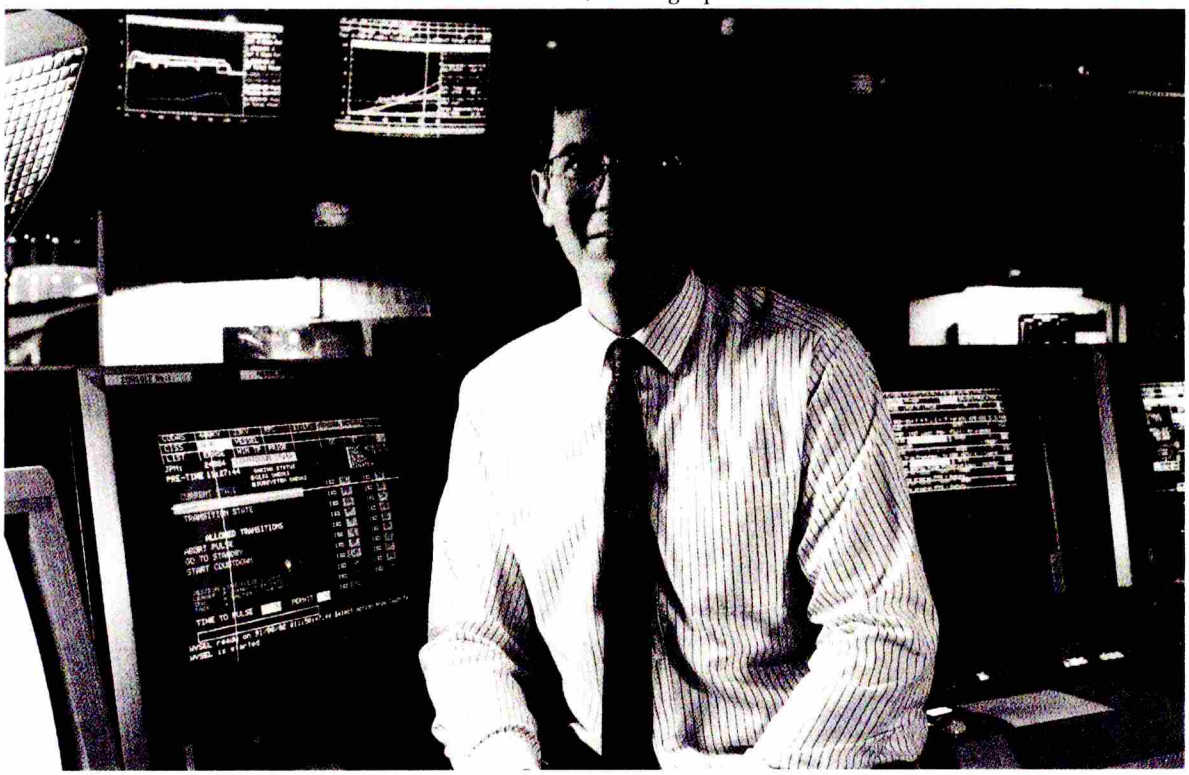
There are three Olivetti 386 network servers running Banyan VINES, supplied and installed by ROCC. The first supports the CODAS documentation office, where about 3500 engineering AutoCAD drawings are available on-line 24 hours/day. Drawings can be viewed on-screen or printed out on a laser plotter, typically in under two minutes.

The second operates as a network server (others may be added later). It provides site network services to PC users.

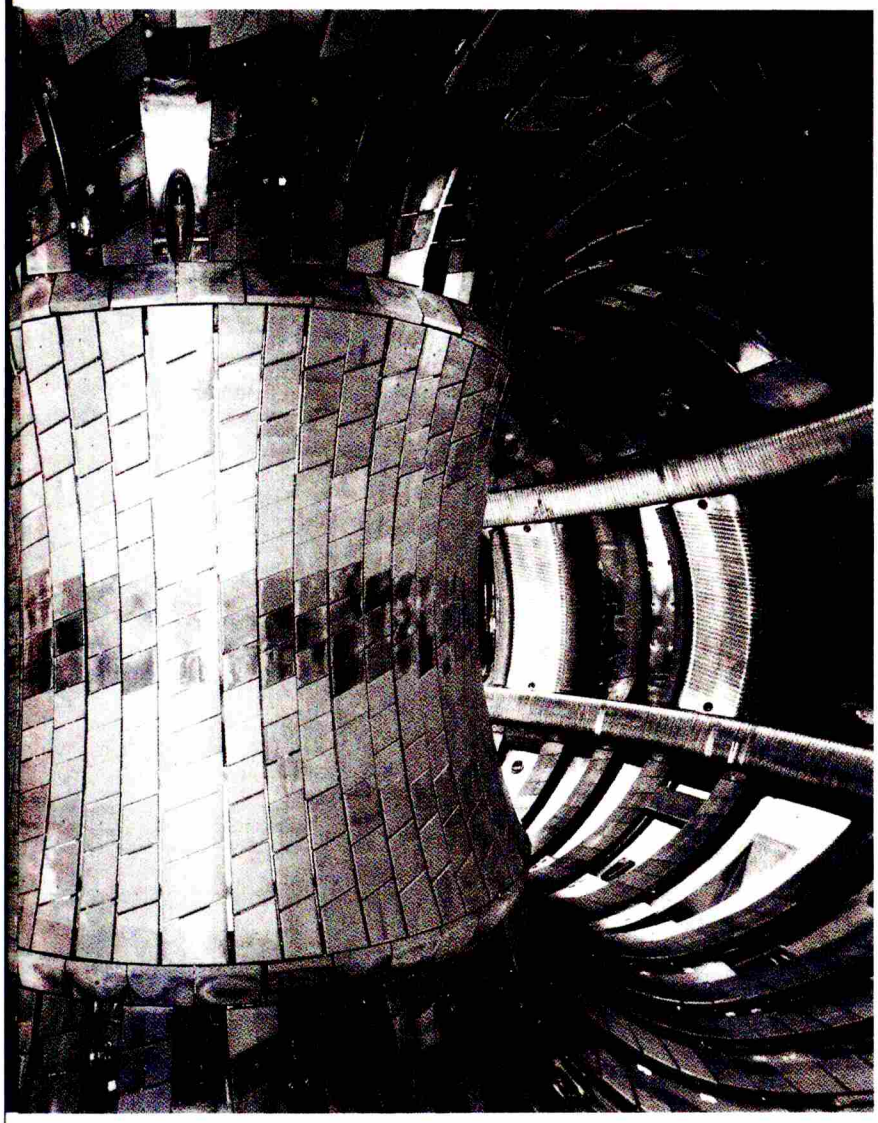
The third server provides the main services and will link six similar mail systems together, providing gateway services.

VINES users have access to the 'external mail' through modems to British Telecom's ISDN/PSTN telephone network and to X.400 mail services, using packet-





Simmonds .... "We have shown that we can provide a secure external service."



Inside of the JET (Joint European Torus) vacuum vessel in which plasma is heated and confined. The two large rings are belt limiters which define the outer edge of the plasma; radio frequency antennae between the limiters are for plasma heating. Carbon or Beryllium tiles cover many areas of plasma contact.

switched services on a BT line running X.25 protocols.

JET can also use UUCP mail (UNIX-UNIX command protocol) to provide a link to university networks like JANET (joint academic network) and access NEWS services.

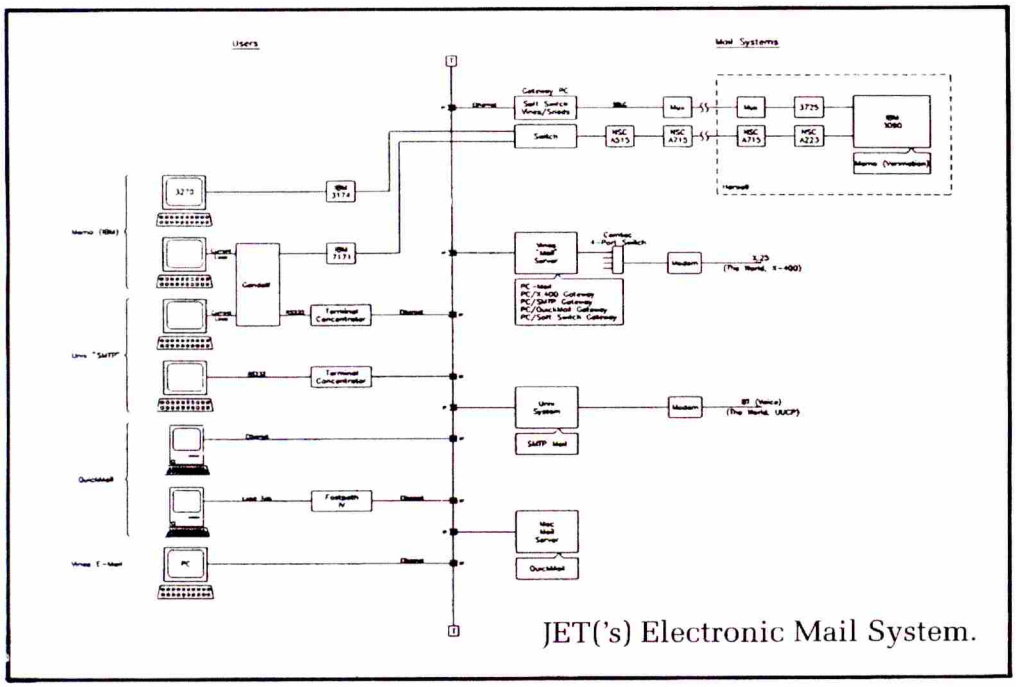
User-friendly front-end software has been written so that users can access services on the networks without having to remember complex commands:

"The e-mail is transparent between all six systems. Mail can be sent directly; it is not necessary to know where the addressee is or what system they are on," said Paul Simmonds, a network consultant working with JET. In practice, a scientist can have access to all his/her resources from any terminal on site, without having to worry about how the system operates.

A pilot scheme was tried in over 30 offices, with two servers based in the computer room.

In practice the network will cover eight defined areas, using a total of 3.5-km of optical fibre cable. About 1000 outlets (nodes) are to be installed throughout the site. Spare fibres in the cable will enable this Ethernet service to be enhanced to Fibre Distributed Data Interface, giving a ten-fold increase in data transmission speed.

"Tests have proved that we can run e-mail to the entire site and many people at JET are now using e-mail," said Simmonds. "We have shown that we can provide a secure external service via both UCCP and X.400, and JET now has both of these services running. JET has decided that it will commit itself to putting Ethernet throughout the entire site into every office."



JET('s) Electronic Mail System.

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