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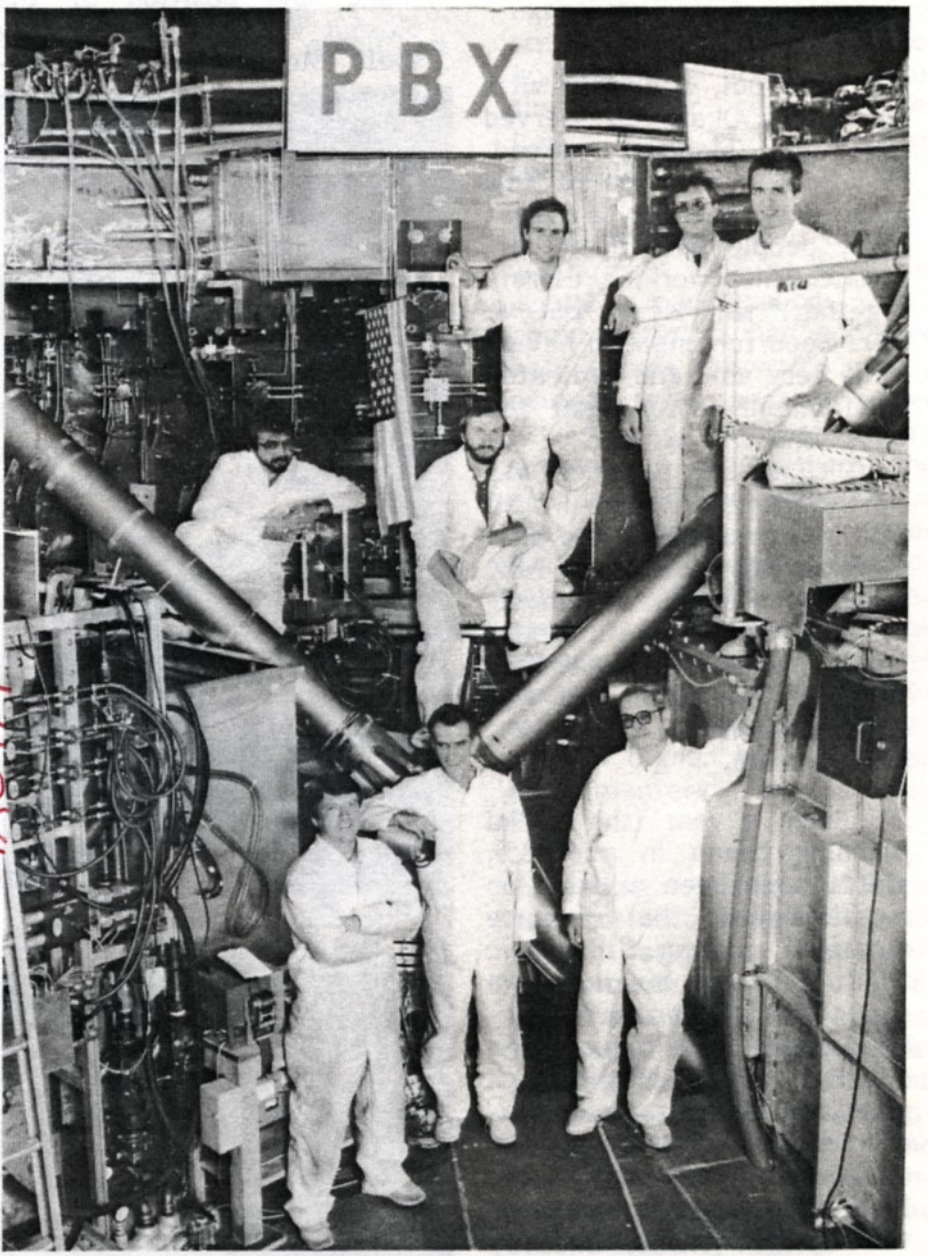
Synergy Energy:

PBX-M TEAM PUSHES FOR PLASMA PLUS

by Phyllis Rieger

Modifying a magnetic fusion device, such as the Princeton Beta Experiment (PBX), requires the patience of a saint, the precision of a surgeon, a few staff members on the lean side with Gumby-like limbs, all mixed with a great deal of very hard work. At least that's the impression one gets after talking to Dr. Kees Bol and Dan Huttar about a major PPPL project that began nearly three years ago--the transformation of PBX into PBX-M. The immediate goal of the project is to generate and to study magnetically confined plasmas with beta values in excess of ten percent. The longer range aim is to reach the so-called second region of plasma stability, a state akin to a Chinese finger trap in which the harder the plasma pushes to escape, the more tightly it is held by the magnetic fields that confine it.

Perhaps the best way to describe the relationship of all the engineering, technical, and research staff instrumental in the modification project is to use one of engineer Dan Huttar's favorite words which is "synergy," a working together. According to Dan, who replaced Dan Kungl as the Project Engineer a year ago after the latter was asked to become the deputy head for TFTR's D-T Division, "I



For over a year, these technicians have worked on modifying the PBX-M. Front row (left to right) are: Jerry Gething, Les Gereg and Ken Quadland. In the top row are: John Anastasio, David Moser, David Cylinder, Rich Krsnak and Eric Thorsland. (Photo by Ed Farris)

think modifying the PBX was a refreshing synergistic experience. Everyone involved at the Laboratory, from the precision welders to the electrical and mechanical people to the research staff, responded positively. Each person did his/her job with a common goal in mind. I believe it's probably one of the most collaborative efforts we've had here at PPPL."

Dr. Kees Bol, who along with Dr. Michio Okabayashi served as Project Manager, agreed. "You can't do a job of this magnitude without a great many people with many different skills working closely together," said Kees, "but we have been fortunate in having some very able and dedicated staff members to lead the way. The vast amount of effort, time, and patience was worthwhile and we're sure all will help us to attain the ultimate physics goals of the PBX program." Dan said the modification was also successful from a financial perspective. "The $10 million budget was underrun by half a million dollars," he said.

For over a year (the initial planning began in mid '85), staffs have been working on modifications that include moving existing magnetic field coils and building five new coils right inside the vacuum vessel. The biggest new coil is the "pusher" coil which gives the PBX plasma its unique indented shape (see illustration). Additionally, the PBX team greatly extended the system of electrically conducting "passive stabilizer" plates which are essential to the operation of PBX. Ten passive coils, five upper and five lower, completely circumnavigate the device inside the vacuum vessel, where they help control the plasma shape and position.

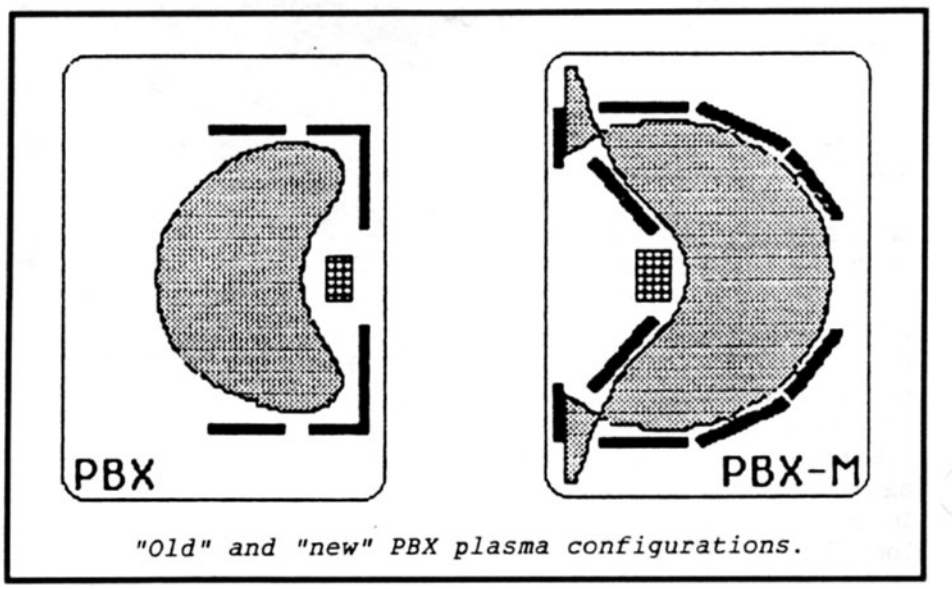
Power Supplies Installed

Besides these improvements, six new power supplies were installed. These power supplies drive the magnetic fields that accurately maintain the shape and position of the plasma within its enveloping shell. Modifications and power supply installations were completed in late May. Dan said, "We tested the power supplies severely and we were pleased with the results."

Think again if you envision replacing and installing new parts was a snap. Inside, the PBX is reminiscent of a Salvador Dali painting of stainless steel with odd shapes and bulges. According to Eric Thorsland, a member of the PBX technician team, "The PBX is composed of tons of stainless steel. When you work inside the machine, the key word is caution. Anywhere you step it looks like you're going to fall down," he said. "Sometimes you have to crawl or be on your back to work. It's sometimes a strange experience and certainly proved to be a challenging one. One day you can be wrestling with a 200-pound plate and the next inserting a delicate tiny screw you can just about see. But always, caution is the byword of those of us who work inside the machine."

Dan Huttar explained that because everything has to go through a port (similar to a porthole on a ship) in the vacuum vessel upwards of 200 nickel-plated, mechanical pieces, some with a tolerance that can only be measured in single millimeters, had to be accurately assembled, placed and electrically isolated. "Some have exotic shapes," said Dan. "For example, there are two sets of plates referred to as 'hockey sticks,' because of their shape."

He agreed, "Working inside the PBX means working in a small, confining space. Sometimes it's a tedious job. You have to be very careful, particularly with the instruments. Adherence to the highest standards of quality assurance is vital since all of the



"Old" and "new" PBX plasma configurations.

components must operate reliably to minimize the need for maintenance. We're very lucky to have people as able and experienced as Sam Hand and Les Gereg to plan and lead the assembly work."

Aim—High Beta

The crew believes that the work will help to achieve a high beta value. Beta is the ratio of the plasma pressure to the pressure of the magnetic field that traps the plasma. The plasma pressure is the product of temperature and density, two qualities which directly determine the potential fusion power output. The higher these values are above the minimum needed for fusion to occur, the more fusion power is produced. A higher beta means that greater plasma pressure, thus more fusion output, is achieved in a given magnetic field; or conversely, that the same output can be achieved in a weaker field.

Qualifying as "a few staff members on the lean side with Gumby-like limbs" are (l to r) Les Gereg and Eric Thorsland who worked inside the PBX-M. (Photo by John Peoples) 87A0344

Since the cost of a reactor is strongly influenced by the strength of the magnetic field that must be provided, beta values are directly related to the economics of fusion power production. Beta is usually expressed as a percentage, with the minimum value required for an economical fusion reactor generally believed to be in the range of ten percent.

When PBX was shut down in January of 1986 so that the actual modification work could begin, it had achieved beta values above 5% with a neutral beam heating power of 5.5 MW. Although a very respectable achievement, the plasma conditions were still in the first region of plasma stability. The changes incorporated in PBX-M, mainly the deeper indentation of the plasma cross section and the passive stabilizers, are designed to overcome the barrier to higher beta that the experimenters ran into on PBX.

According to Kees, "The first push for record high beta values will take place from January to summer or fall of 1988, and should tell us if we are on the right track. After that we will begin a careful and deliberate campaign of optimizing plasma conditions and the goal will be to demonstrate stable operation in the second stability region."

New Developments

He is particularly pleased with two new developments which should substantially

contribute to attainment of PBX-M goals.

"We're very lucky to borrow two megawatts of lower hybrid radio frequency (rf) power from the fusion group at the Massachusetts Institute of Technology (MIT)," said Kees. Its four megawatt system became available when the Alcator C tokamak was decommissioned so a new machine, C Mod, can be built. Two megawatts will be used experimentally by PPPL and two by Lawrence Livermore Laboratory. According to Kees, "MIT may want its power system returned eventually but it's been much quicker for us to 'import' Alcator C's power resource from MIT than to build it from scratch. A brand new one would cost $3 to $4 million. Our cost now is $1 million."

Essentially, the rf power will be used for additional plasma heating and current drive. Kees said, "We'll try to adjust the current profile in the outer part of the plasma to improve plasma stability." To measure the current profile, an 80-kilovolt diagnostic neutral beam has been ordered from a specialist group at the Culham Laboratory, United Kingdom.

The other new development will assist in shaping the plasma density profile. It is a new "pipe gun" that will shoot pellets of frozen deuterium deep into the plasma to fuel it, as compared to bleeding gaseous deuterium into the vacuum chamber through a small piezoelectric valve. The new gun will be built for PBX-M under OFE (Office of Fusion Energy, U.S. Department of Energy) auspices by Hal Haselton's group at the Oak Ridge National Laboratory in Tennessee, for delivery next summer.

These two developments, plus the many modifications, will help to give PBX-M a notable chapter in the history of magnetic fusion energy.

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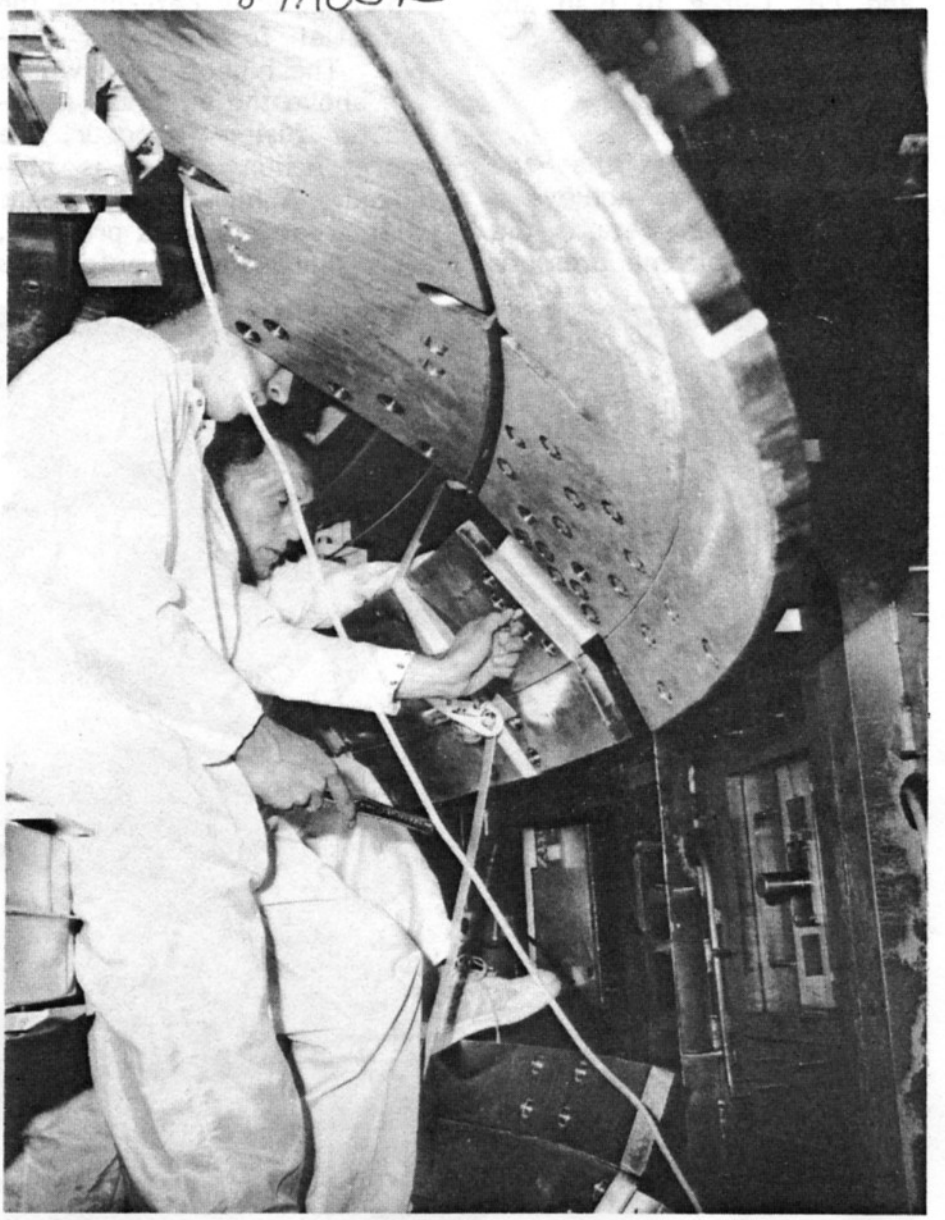

According to Eric Thorsland (l) and Les Gereg (r) when you work inside the PBX-M one day you can be wrestling with a 200-pound plate and the next inserting a delicate tiny screw you can just about see. (Photo by John Peoples)

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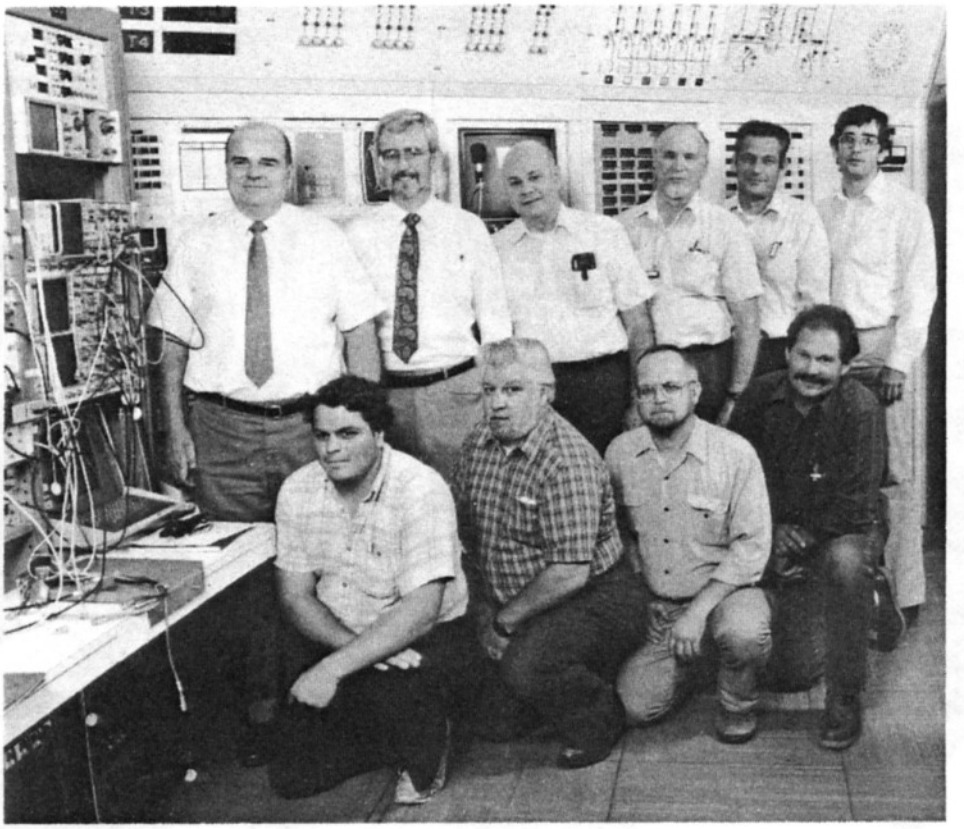
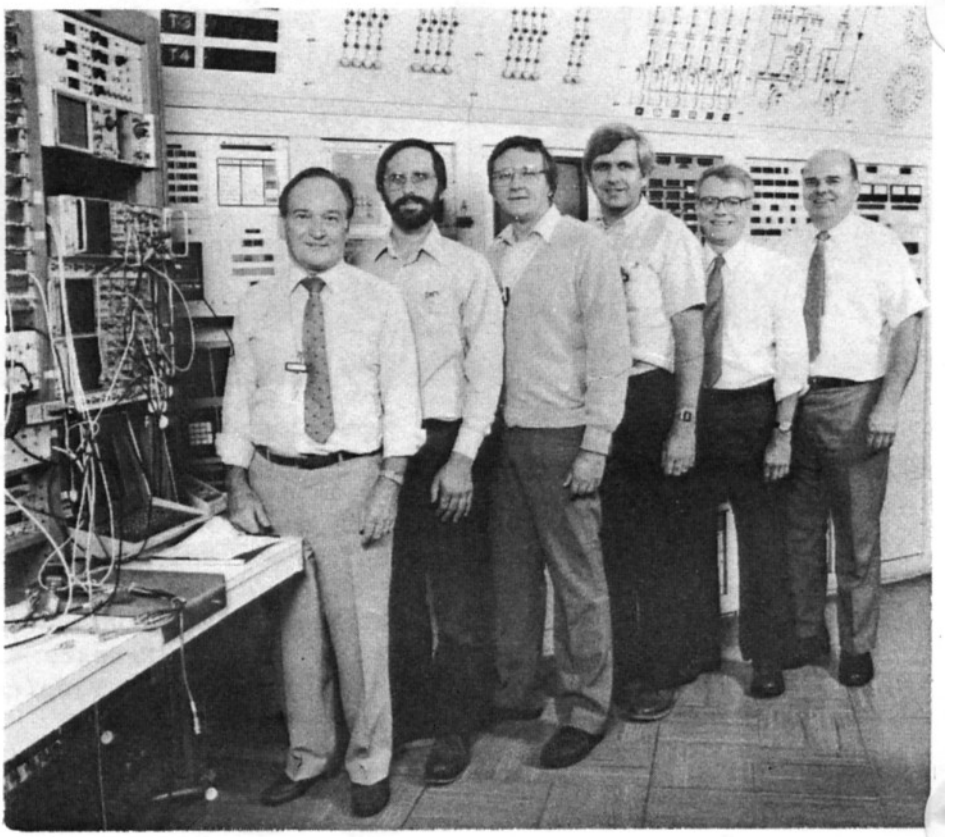
According to Dr. Kees Bol, who along with Dr. Michio Okabayashi served as Project Manager of the PBX-M research team, "You can't do a job of this magnitude without a great many people with many different skills working together." Some of the skilled people pose in the PBX-M control room. Top (left to right) are: Stan Kaye, Stephen Paul, Kees Bol, Michio Okabayashi, Sam Hand, Arthur Holland and Henry Kugel. Front row (left to right) are: George Gammel, Steve Sesnic, Hiro Takahashi, Bob Kaita and Ray Fonck. Part of the team but unavailable for the photo were: Michael Reusch, Ernesto Mazzucato, Nobu Asakura, John Semler and Dan Bollenbacher. (Photo by John Peoples and Ed Farris)



Dan Huttar, Head of the Power Engineering Staff and the Project Engineer for PBX-M (left-top), poses with the crew responsible for the electrical and power modifications. Top (left to right) Huttar, Charles Ancher, Dale Ashcroft, Richard Farley, Robert Persons and Peter Mathe. Kneeling (left to right) are: Dave Sutton, Jim Nelson, Denis Shaltis and Tom Sereni. Also part of the team but unavailable for the photo were: Bob Mika, Frank Lawn and Wes Reese. (Photo by Ed Farris)



Supervisor Jeff Alton (left) of the Coil Development, Maintenance and Test Section leads the group of personnel who were instrumental in modifying PBX-M. Others include: Peter Materna, Jim Chrzanowski, Tom Meighan, Don Knutson and Dan Huttar. (Photo by Ed Farris)