mak de Varennes design project, explains: "Because, by the end of the century or some time around then — it depends on how the forecasters draw their curves — Québec consumers are going to be demanding more power than we will be able to supply in the form of hydroelectricity. Where is the power going to come from? The future of fission is obviously a bit uncertain, but it looks as if fusion could be coming in at about the same time that conventional hydro is running out."

Not far from Bolton's office, in the basement of IREQ's High Power Laboratory, there is a muddy excavation, the first stage in the construction of Canada's first tokamak. Other countries already have such machines; more than 20 of them, of various sizes, are now in operation. Bolton knows their history well.

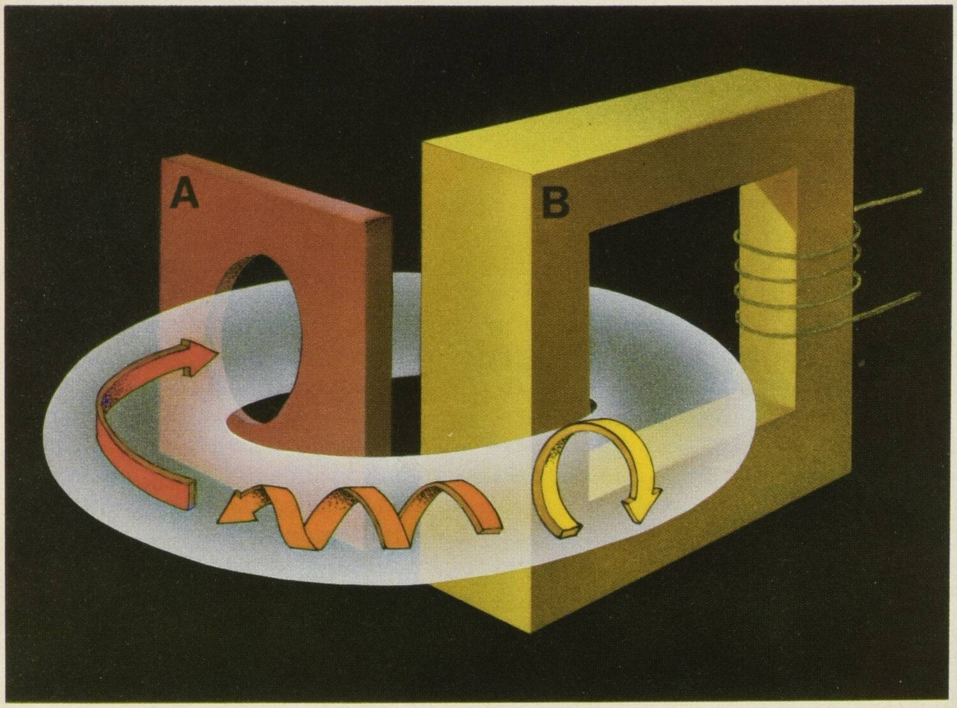
"The search for ways to tame the hydrogen bomb began in the early '50's," he says. "The USA, the USSR, the UK and France were working on fusion, independently and in secret. . . and realizing just how difficult it was. The Russians broke the ice. In 1954 Academician Kurchatov of the Russian program gave a famous lecture in Great Britain describing the first tokamak."

By 1959 the Russian tokamak approach seemed to provide better stability and higher temperatures than the competitive designs. Like the British toroidal pinch and American stellarator experiments, it entailed confining the plasma within a donut-shaped magnetic field.

"No one believed the Russians," Bolton continues, "until a group of British physicists actually went to Moscow with their own temperature measuring equipment and confirmed that the tokamak plasma was as hot as claimed. Most researchers then agreed that tokamak was the way to go."

The problem faced by fusion reactors in the past has been the instability of the superhot plasma within which the thermonuclear reaction takes place. In such reactors, the plasma particles tended to drift uncontrollably, hitting the walls of the donut container and making fusion impossible. The tokamak design, developed by the Russians, stabilizes the plasma by applying two magnetic fields called the poloidal (yellow) and toroidal (red) fields, the result of which causes the plasma particles to spiral in helix fashion (orange) around the vacuum chamber. The helical magnetic field effectively prevents uncontrollable particle drift, and has given physicists new hope that fusion will ultimately become a practical source of power. A represents the coils wound around the torus (donut) that produce the toroidal field, and B is a transformer that induces the poloidal field. *(John Bianchi)*

Dans le passé, le principal problème présenté par les réacteurs de fusion était l'instabilité du plasma superchaud au sein duquel se produit la réaction thermonucléaire. Dans ces réacteurs, les particules du plasma avaient tendance à dériver, heurtant les parois du tore et rendant la fusion impossible. Avec le système Tokamak, mis au point par les Russes, le plasma est stabilisé par l'application de deux champs magnétiques appelés champ poloïdal (en jaune) et champ toroïdal (en rouge), qui forcent les particules de plasma à circuler en spirale (orange) autour de la chambre à vide. Le champ magnétique hélicoïdal empêche la dérive des particules et a ranimé l'espoir des physiciens de parvenir un jour à maîtriser les réactions de fusion thermonucléaire pour en faire une source d'énergie utilisable. A représente les bobinages du tore (beignet) créant le champ toroïdal, et B est un transformateur qui induit le champ poloïdal. *(John Bianchi)*



None of the experimental fusion reactors so far built *has succeeded* in igniting a sustained, energy-producing reaction. The extreme conditions which this achievement requires — supremely high temperatures in a dense, stable, confined plasma — are gradually being approached, one by one, on different machines. The Tokamak Fusion Test Reactor which is now nearing completion at Princeton University in New Jersey should be the first machine capable of simultaneously meeting all these conditions. Sometime around 1984, it is confidently expected, the break-even point will be reached for the first time; that is, the energy poured into its plasma will be matched by the energy output of its fusion reactions.

The Tokamak de Varennes will never be a source of energy. In fact, when operating it will drain energy from the grid at about the same rate as a small town, to produce a plasma containing about as much heat as a kettle full of boiling water. No fusion reactions will ever occur because it will be fuelled with ordinary hydrogen, not with the hydrogen isotopes necessary for fusion. It will be like a model car engine which cannot run on gas, but which can be turned over to test compression. By eliminating the possibility of fusion, there is no need for equipping the facility with remote handling equipment and shielding to protect personnel.

"The unique thing about our tokamak," says Brian Gregory, the physicist who led the group responsible for the scientific and technological side of the design, "is that it will operate semi-continuously. Up to now, tokamaks have been operated in short pulses of, at most, one second. Except for the plasma, this doesn't give anything time to heat up. But the next generation of big machines will run for tens of seconds, and a commercial fusion reactor will operate continuously. We'll be 'square-waving' our current, holding things for 30 seconds, and this will give us data on how materials endure exposure to heat and radiation, how magnetic coils heat up, and a raft of similar engineering problems."

As well as this, the fact that the Tokamak de Varennes is plugged directly into the power grid will generate data on how to hook up a commercial power reactor. Being located at the terminus of a high-voltage power transmission