

# PROGRESS IN FUSION

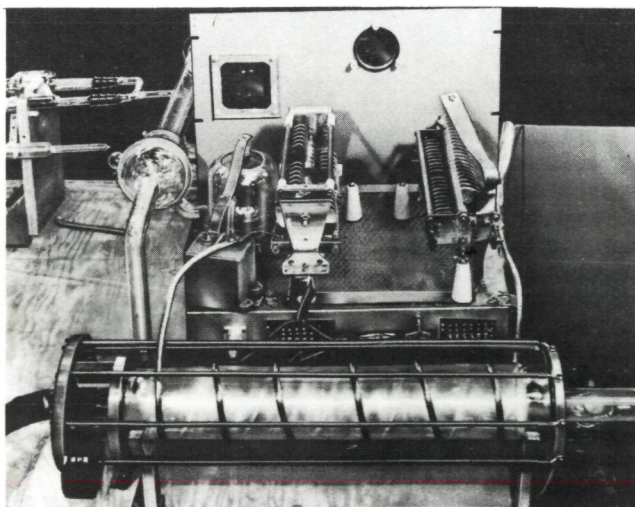
## NEW ROLE FOR IAEA

Controlled thermonuclear fusion is now the biggest challenge before atomic science, not only because of the exceedingly difficult nature of the problem but also because of the virtually limitless benefit that, it is expected, will eventually flow from its solution. The prospect is indeed thrilling; if controlled thermonuclear reactions can be brought about in such manner as would result in a net output of energy, a permanent solution may be found to the problem of the world's growing energy needs, for the fuel will be obtained from as plentiful a source as water.

The widespread enthusiasm that greeted early reports of this possibility, however, was not sufficiently tempered by a realization of the formidable difficulties involved in the task. The discussions at last year's Geneva Conference revealed to the general public the nature of some of these difficulties. Both at that conference and since, scientists have generally been chary of making very optimistic forecasts and the reports on thermonuclear research that have been available during the past year or so have further shown the need for this cautious approach.

At the same time, it might be pointed out that if some of the early optimism is now inevitably moderated, that is only because there is now a better understanding of the difficulties and, consequently, of the basic scientific and technical problems. And it is this progressively better understanding, this increasing knowledge and experience, based on continuing research and experiment, that holds the surest

The so-called "pinch" in super-heated krypton gas in an experiment conducted at Los Alamos Scientific Laboratory, USA. The white line shows the electric discharge and the "pinch" (Photo: Los Alamos Scientific Laboratory)



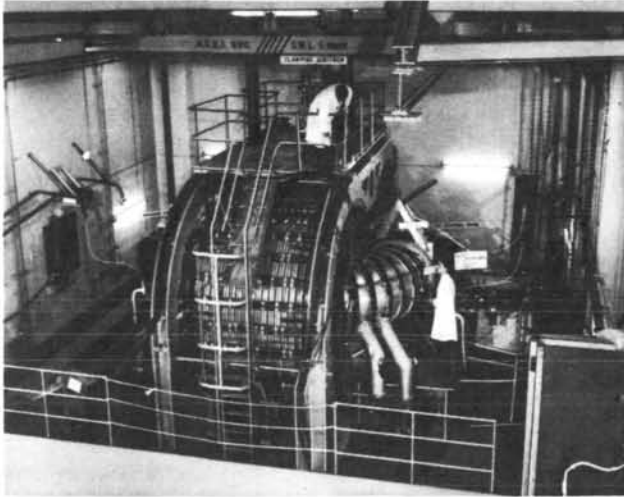
guarantee of ultimate success. Of eventual success, there is little doubt in the minds of those striving for it. But the road to that success is recognizably difficult and, in some respects, still unpredictable.

The basic problem, as is now widely known, is to heat heavy hydrogen gas to a temperature at which the nuclei will fuse by moving so fast as to overcome their mutual electrical repulsion, and simultaneously to keep the gas in a state of extreme density so that the nuclei may collide against each other, fuse, release energy in the form of heat, and thus set in a kind of thermal chain reaction. The temperature required is of a fantastically high order, but the scientists are confident that it can be obtained by fantastically powerful electrical discharges. More difficult seems to be the task of making the super-heated gas, or the plasma as it is called when completely ionized, to behave obligingly. It must remain in a state of extreme density even when it is heated to a temperature of many millions of degrees. As a matter of fact, it must be contained, so to speak, by itself; it must not touch the walls of its material container and thereby lose some of its heat and, on top of that, evaporate the container.

## Plasma Behaviour

The plasma behaves to the extent that as a result of a powerful electrical discharge it is constricted and confined by its own magnetic field. This so-called pinch effect produces a kind of magnetic bottle for containing the plasma, but the trouble seems to be that it is difficult to make the bottle stable and leak-proof. Attempts have been made to plug the leaks by applying additional magnetic lines of force, but as one scientist put it, the plasma has so far proved too cunning for the scientists. It has largely defied various attempts to make it stable, but scientists are gaining a progressively clearer understanding of its instabilities and hope a way will be found to remove them. If the plasma can thus be tamed and if the temperatures can be created and sustained as required, thermonuclear fusion is expected to take place. The next task will be to ensure that the output of energy from this fusion is greater than the input of energy to heat the plasma. Production of power can then follow the conventional cycle or, as some scientists have forecast, a way may be found for the direct generation of electricity from this heat.

Intensive research and experiment on these problems have been going on in several countries, notably in the UK, the USA, and the USSR. At the Geneva conference last year, a great deal of information on this subject was made public, and the striking fact that emerged from this information was



A view of Zeta, the apparatus in which experiments towards controlling thermonuclear reactions were made at Harwell, UK. The transformer windings and the doughnut-shaped tube in which heavy hydrogen gas was heated to a temperature of 5 million degrees centigrade can be seen (Photo: UK. Atomic Energy Authority)

that in all the countries most advanced in thermonuclear research, the work was being conducted on more or less similar lines. The technical approach of course, differed in certain respects; even within one country the problem was being attacked with different technical arrangements. But in all these experiments, the basic problems encountered were the same and the results obtained were strikingly similar. Commenting on this fact, Professor Edward Teller of the United States said: "It is remarkable how closely parallel the developments are. This is of course due to the fact that we all live in the same world and all obey the same laws of nature."

And this underlined, more than ever before, the need for a wide exchange of knowledge and experience so that duplication of effort could be avoided and progress made quicker by a pooling of information on the latest experimental results and theoretical deductions. A major concrete step in this direction has been taken by the Scientific Advisory Committee of the International Atomic Energy Agency, which recommended that the Agency should serve as the world focal point for the exchange of information on progress in thermonuclear research and plasma physics. Among the Committee's specific recommendations was that the Agency should start a scientific journal devoted exclusively to this subject. The Committee felt that in view of the increasing interest in thermonuclear research in many countries it would be useful if efforts could be directed in the most promising directions and world-wide co-operation initiated. The members of the Committee from the three countries most advanced in this field - Sir John Cockcroft from the United Kingdom, Professor Vasilij S. Emelyanov from the Soviet Union and Professor Isidor I. Rabi from the United States - assured the Agency that in their individual capacities they would try to obtain strong

support for its new role from their respective Governments.

Plans for the implementation of this recommendation are now well advanced. The proposed journal is expected to make its first appearance next year. It will contain, among other things, original papers on theoretical and applied research as well as on related engineering developments.

### Value of Co-operation

If the aims of the recommendation are adequately fulfilled, there will be a powerful impetus to fusion research not only in the countries where it is already well established but also in several others where such research has been initiated or planned on a small scale. A wide diffusion of existing knowledge and experience would enable the latter to avoid some of the preliminary gropings and start from a point which is already some way towards the goal. As for the advanced countries, the value of an exchange of information has been stressed by many leading scientists. Commenting on the exchange that took place in Geneva last year, Professor L. A. Artsimovich of the Soviet Union said: "This is probably the most important step which has been made towards the solution of the problem."

A year has passed since the step was taken, and for fusion scientists this has been a year of intense activity. The results obtained have been reassessed, while fresh experiments have been made with such technical modifications as have been found most promising. The results of these experiments may suggest new lines of approach or improvements in the current experimental techniques. The need, therefore, arises for a permanent forum for a continuous exchange of information and that need will be met in large measure by IAEA's programme of work in this field.

Model of Ogra, the experimental thermonuclear machine built in the USSR. Professor Werner Heisenberg, the famous German physicist (second from left), looking at the model at an exhibition held with the Geneva conference last year (Photo: United Nations)

