LETTERS TO THE EDITOR

COMMENT ON "AN OVERVIEW OF INERTIAL FUSION REACTOR DESIGN" AND "TECHNOLOGY REQUIREMENTS FOR COMMERCIAL APPLICATIONS OF INERTIAL CONFINEMENT FUSION"

A paper by M. J. Monsler et al.[1] in the July 1981 issue of *Nuclear Technology/Fusion* (*NT/F*), giving an overview of inertial fusion reactors, including a historical perspective, completely ignores the technical designs published many years earlier by F. Winterberg. The concepts first proposed by Winterberg are both (a) the wetted wall reactor cavity concept and (b) the magnetically protected wall concept. These technical concepts were presented in all detail at the Enrico Fermi School Course on High Energy Density in 1969 and were published in the proceedings by Academic Press in 1971. Thus, Monsler et al. rediscover well-known concepts due to Winterberg.

In another paper by T. G. Frank and C. E. Rossi,[2] in the same July 1981 issue of *NT/F*, no mention is made of the magnetically insulated, pulse power driven light ion beam diode concept, first proposed by Winterberg in the same paper published by Academic Press in 1971. Thus, Frank also rediscovers a well-known idea due to Winterberg.

Since Winterberg is recognized as the originator of these technical concepts in the international literature, it is difficult to conceive that Monsler and Frank were unaware of the original work of Winterberg.

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REFERENCES

1. M. J. MONSLER et al., "An Overview of Inertial Fusion Reactor Design," *Nucl. Technol./Fusion*, **1**, 302 (July 1981).

2. T. G. FRANK and C. E. ROSSI, "Technology Requirements for Commercial Applications of Inertial Confinement Fusion," *Nucl. Technol./Fusion*, **1**, 359 (July 1981).

COMMENT ON "AN OVERVIEW OF INERTIAL FUSION REACTOR DESIGN"

This is in reference to a paper by Monsler et al.[1] in the July 1981 issue of *Nuclear Technology/Fusion*. The paper gives a historic review of inertial confinement fusion (ICF) reactor designs. In Monsler's paper the following claims are made.

1. The first ICF reactor design was made in 1971 by Fraas of Oak Ridge National Laboratory.

2. The wetted wall reactor concepted was first proposed in 1973 by L. A. Booth of Los Alamos National Laboratory (LANL).

3. The magnetically protected wall concept was first proposed in 1974 by T. Frank, D. Freiwald, T. Merson, and J. Devaney of LANL.

In rebutting these false claims, I state the following. In 1969 I proposed at the Enrico Fermi International School of Physics both the wetted wall and magnetically protected ICF cavity reactor concepts. The proceedings of that meeting were published in 1971 by Academic Press of New York as *Physics of High Energy Density*. I therefore believe that the above named LANL scientists had simply reinvented several years later what was already widespread knowledge at that time. I only concede that Fraas did not know of my work because it took Academic Press two years to publish the proceedings. The concept by Fraas, showing great originality, was also quite different from my own proposals.

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REFERENCE

1. M. J. MONSLER et al., "An Overview of Inertial Fusion Reactor Design," *Nucl. Technol./Fusion*, **1**, 302 (July 1981).

REPLY TO "COMMENT ON 'AN OVERVIEW OF INERTIAL FUSION REACTOR DESIGN' "

We welcome the chance to acknowledge F. Winterberg's[1] early suggestion for an inertial confinement fusion reactor, published in the Proceedings of the Enrico Fermi International School of Physics, Course XLVIII, *Physics of High Energy Density*, P. Caldirola and H. Knoepfel, Eds., Academic Press, New York (1971). The authors[2] regret they were unaware of this reference.

We note however that, contrary to H. Wilhelm's[3] statement, Winterberg provided no details or analysis of his liquid-film reactor concept. Many man-years of engineering calculations are required to assess even the conceptual feasibility of a particular reactor design. These studies, usually performed by interdisciplinary teams from national laboratories, universities, and industry, are widely circulated and criticized. Old ideas often reemerge in new clothes. In the future we shall endeavor to cite both the inspiration and the perspiration.

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REFERENCES

1. F. WINTERBERG, "Comment on 'An Overview of Inertial Fusion Reactor Design,'" *Nucl. Technol./Fusion*, **2**, 430 (July 1982).

2. M. J. MONSLER et al., "An Overview of Inertial Fusion Reactor Design," *Nucl. Technol./Fusion*, **1**, 302 (July 1981).

3. H. E. WILHELM, "Comment on 'An Overview of Inertial Fusion Reactor Design' and 'Technology Requirements for Commercial Applications of Inertial Confinement Fusion,'" *Nucl. Technol./Fusion*, **2**, 430 (July 1982).

SOME THOUGHTS ON THE ENGINEERING PROBLEMS OF FUSION RESEARCH

The following facts and thoughts were brought to my attention in relation to the "Workshop on the Engineering Aspects of Fusion Ignition Experiments," which was held at Chicago during October 29-30, 1981 (see p. 433) in conjunction with the 9th Symposium on the Engineering Problems of Fusion Research. I would emphasize that these views are not my own nor represent any organizations that I might represent. They are published as a note that, I think, impacts on the fusion community. But for convenience, I have used a singular person, "I," in the following comments.

If you look at the costs of electric power from fusion, most of the costs by far come from amortization of the capital investment; fuel costs are negligible, as Dick Post pointed out eons ago. Therefore, it is most important to keep our capital costs down. (As a matter of fact, I have to keep track of all new energy forms, and one almost always finds that capital costs are of dominant significance.)

So what contributes to high capital costs?

1. *Lots of power.* Power plants in the 100- to 1000-MW(electric) range seem most acceptable to the power industry. The lower range is of most interest abroad; the higher range in the United States. Regardless of the unit cost of power, one is often concerned with whether or not a utility can afford to buy any power plant at all. The only real reason for building large power plants is economics of scale. I do not accurately know present costs of transmission of electricity, but I think it is somewhere between 25 and 50%. Thus, if one had a lot of little plants scattered around, one could save at least some of these transmission costs and have a more reliable system, *assuming* that we could get people to accept such plants in their midst, which means a small amount of radioactivity, and *assuming* that there were not large economies of scale. Thus, I find some of the field-reversed mirror ideas we discussed at the workshop quite interesting. Further, utilities *do not* want more than 10% of the power capability of the grid to come from any one source for reliability reasons. (By the way, the cost of a nuclear steam supply system is only ~13% of the total cost of a power plant.)

2. *Large amounts of recirculating power.* However, I feel one does not really need to go so far as ignition to reduce circulating power, but only to get one's Q up to something reasonable, since in any event one has to supply power to pumps, lights, control systems, communications, and God knows what else. Thus, it makes economic sense to push Q only to the point where the power recycled to the reactor itself for reactor purposes is comparable to the power required anyway to supply overhead (on the order of 10 to 15% of the total).

3. *Physically large, intense magnetic fields.* Thus, high-beta machines are much preferred to low-beta ones. Machines having relatively simple coils to make are much preferred to those having complicated ones.

4. *Fast pulsed magnetic fields.* These are costly because of the huge number of wires needed to keep the inductance down and because it is devilishly hard and costly to design and construct a blanket for a fast-pulsed machine, despite Bob Krakowski's cleverness. Where do the magnets go? Where does the shielding go? Eddy currents, heat dumped into superconducting (S/C) magnets, and all that.

5. *Pulsed operation.* This type of operation requires energy storage devices. Further, one must design components to endure the stress cycling that takes place. Steady-state operation greatly reduces the engineering problems connected with eddy currents in S/C magnets.

6. *Need for divertors and limiters.* As you know, divertors are not easy to build into a system and make it much more complex, more costly, and larger. Magnetic limiters and magnetic configurations that automatically have some field lines leading to the outside world for impurity removal are, I feel, to be preferred, simply because one will not have the high Z contamination, the limited life that goes with limiters, and the constructional disadvantages that go with divertors. Of course, it would be pleasant to discover a way of running with dirty plasmas, but that is not in the cards, I think, simply because of the radiation and charge exchange losses that necessarily follow.

7. *Large machines for a given amount of power.* It is extremely desirable to achieve a high power density in our fusion machines in order to reduce their capital cost. This statement implies a very high flux through the first wall. I believe this goal can be achieved for the reasons outlined below. It is probably a mistake to design our first walls to last more than a year or two, and as a consequence, we can use much higher fluxes through this wall than is often contemplated now. The first wall will have to be changed annually, but that is all right *provided* it is easy to change. This statement implies modularity of the magnets and