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FOREIGN TRIP REPORT
ORNL/FTR-3379

DATE: September 29, 1989

SUBJECT: Report of Foreign Travel by S. A. David, Group Leader, Metals and Ceramics Division, to Finland and Denmark

TO: Alvin W. Trivelpiece

FROM: S. A. David

PURPOSE: The purpose of the trip was to participate in the 42nd Annual International Institute of Welding (IIW) Assembly and Conference held in Helsinki, Finland; visit and present invited seminars at Lappeenranta University of Technology, Lappeenranta, Finland; the Danish Welding Institute, Copenhagen; and the Riso National Laboratory, Roskilde, Denmark.

SITES VISITED:

8/31-9/1	Lappeenranta University of Technology, Lappeenranta, Finland
9/4-9/8	IIW Assembly and Conference, Helsinki, Finland
9/11-9/12	Danish Welding Institute, Copenhagen, Denmark
9/13	Riso National Laboratory, Roskilde, Denmark

ABSTRACT: The traveler was an invited member of the United States delegation and representative of the Basic Energy Science Welding Science Program at the 42nd Annual International Institute of Welding (IIW) Assembly and Conference held in Helsinki, Finland. The conference and the assembly was attended by about 600 delegates representing 40 countries. The theme of the conference was welding under extreme conditions. The conference program contained several topics related to welding in nuclear, arctic, petrochemical, underwater, hyperbaric and space environments. At the annual assembly the traveler was a delegate (U.S.) to two working groups of the IIW, namely Commission IX and welding research study group 212. Following the conference the traveler visited the Danish Welding Institute in Copenhagen and the Riso National Laboratory in Roskilde. Prior to the conference the traveler visited Lappeenranta University of Technology and presented an invited seminar entitled "Recent Advances in Welding Science and Technology."

MASTER *EP*

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COMPREHENSIVE TRIP REPORT

PURPOSE

1. To participate in the 42nd Annual IIW Assembly and Conference, Helsinki, Finland.
2. To visit Lappeenranta University and Technology, Lappeenranta, Finland, and present an invited seminar and discuss welding research.
3. To visit the Danish Welding Institute, Copenhagen, Denmark, and the Riso National Laboratory, Roskilde, Denmark.

THE 42ND IIW CONFERENCE AND ANNUAL ASSEMBLY

The IIW Conference and Annual Assembly was held in Helsinki, Finland, September 4-8, 1989. The annual meeting was attended by about 600 delegates from 40 countries including the Soviet Union and some eastern-bloc countries. The United States delegation consisted of 20 scientists and engineers from universities, industries and professional societies. The assembly was an eye opener for the traveler, in that he received a better perspective of the current status of welding science and technology worldwide. From discussions with delegates of various countries, it was apparent that the United States, and in particular ORNL, holds a commanding lead in certain areas of welding science and technology. ORNL's participation in the proceedings was very much appreciated.

The distinguished IIW Portevin Lecture was presented by Dr. H. G. DeLauze of France on welding in difficult conditions for the offshore and nuclear industries. He reviewed the current state of the art of welding under various conditions such as nuclear, arctic, under water, space, etc. In addition, several interesting papers, both basic and applied, relating to welding in various extreme conditions were presented. A list of papers presented is shown in Appendix A. Welding in the nuclear environment concentrated mostly on repair welding of the core grid of fast reactors, primary loops and pipelines in nuclear reactors. Papers related to welding in the space environment were predominantly related to the Russian space program. Two papers presented by the Russians, in particular Cosmonaut Djanibekov, dealt with fabrication and repair of large size structures in space and the development of electron beam welding as a tool for space applications. The paper also considered the needs for using welding processes in space and the uniqueness of the space environment for welding. The cosmonaut also discussed the role of zero gravity, high vacuum, buoyancy and surface tension forces on the welding of structures in space.

Following the conference, the traveler participated in the IIW Commission IX meeting dealing with welding metallurgy and was a delegate to the study group on welding research. At the Commission IX meeting, several research documents were discussed. A paper presented by Dr. Yurioka dealt with analysis of three-dimensional heat conduction during welding by dispersed point heat sources. It is a novel concept but is limited in its capability to predict transport phenomena. The model available at ORNL is the best one available anywhere. Dr. N. Abe discussed improvement of creep-rupture strength of welded joints in 9Cr1MoVNb steel (ORNL developed alloy ASTM A387 grade 91). They have carried

out some investigations to further define the composition and heat treatment conditions for the ASTM A387-91 alloy to optimize the creep-rupture strength of the welded joints.

The study group on physics of welding was chaired by Professor John Lancaster. Several interesting papers were discussed and recommendations were prepared for future IIW considerations. Fluid flow in welds related to Marangoni effect was a major topic of discussion. ORNL's latest findings on this aspect of transport phenomena were also discussed and the delegate expressed a great deal of interest in our work. The European community continues to investigate this phenomena in stainless steel welds. Similar effects with respect to weld penetration have been observed in other systems such as Cu-Ni and plain carbon steels. The Japanese investigator, Dr. Hasegawa of Daihen Corporation, has done some elegant work on spatter during welding. He has defined various causes of spatter and has illustrated by high speed cinematography and modeling one form of spatter. Another topic of great interest was the arc column. Recommendations are being made to set up a standard experimental layout and procedure to determine arc temperatures.

VISIT TO THE LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

The traveler visited the Lappeenranta University of Technology on August 31 and September 1 and delivered an invited seminar on "Recent Advances in Welding Science and Technology." In addition, he visited their welding research laboratory and the laser center. The laser center at Lappeenranta University of Technology is unique in all of Finland. They have a Ferranti 2.5 and 6 kW CO₂ laser. The laser research has concentrated on laser surface hardening, welding and cladding of metals. Research covering porosity in weldments, welding of dissimilar sheets, and the use of filler metals during laser welding have been studied. Extensive work is also being carried out in the area of arc sensing and control for welding automation purposes.

VISIT TO THE DANISH WELDING INSTITUTE

The traveler visited the Danish Welding Institute on September 11 and 12. The Institute is a nonprofit organization established in the 1930s. Currently it employs 350 scientists, engineers, and their supporting staff, with a budget of \$25M U.S. dollars. The Welding Institute is more process oriented with major efforts directed toward nondestructive examination, welding and education. Projects on ultrasonic weld inspection and corrosion mapping, under-water welding, and laser processing are being carried out. They have done an extensive amount of work in the area of projection image scanning and are currently marketing a unit in this area. In addition, they have developed ultrasonic inspection techniques such as remotely controlled magnetic wheel ultrasonic scanner; compact low profile automatic pipe scanner; miniature ultrasonic pipe scanner; ultrasonic scanner with probe swivel capability; ultrasonic scanner for inspection of pipe welds in nuclear power plants; and superimposed soft ultrasonic image reconstruction.

VISIT TO THE RISO NATIONAL LABORATORY

The traveler visited the Metallurgy Department at the Riso National Laboratory on September 13. Riso is a Danish government supported energy research laboratory similar to ORNL. In recent years it is the intention of the

Danish government to intensify publicly funded research in order to increase the competitiveness of Danish industries and trade. It is reflected in various programs carried out at the Laboratory. In their overall program, a number of priority areas of research have been selected and the Metallurgy Department is actively engaged in two of these areas, energy research and materials technology.

Energy research work on fuel cells is given high priority since fuel cells appear to have a high potential for production of electricity and heat with high efficiency and low atmospheric pollution. The research at present is concentrated on materials developed for solid oxide fuel cells and the construction of a small prototype fuel cell. The energy program of the metallurgy department also covers design and materials development for windmills and materials for fusion reactors.

Within the area of general research and development, the Danish government has recently approved a national program on materials technology. In this program the Metallurgy Department is actively involved in three areas of research, namely polymer composites, powder metallurgy and engineering ceramics. In addition to various applied programs, the department is also actively engaged in materials science projects of relevance to the applied programs. This also includes the development of advanced techniques for characterization of materials. The research concentrates on the following three major subject areas:

1. mechanical properties and modeling related to the behavior of single crystals and polycrystalline metals as well as to two-phase materials such as composites and dispersion strengthened materials.
2. thermomechanical behavior and texture with special emphasis on structural and textural changes during recrystallization.
3. irradiation-induced defects and microstructures, both theory and experiments.

SUMMARY

The trip was very useful in that it gave a better perspective of the current status of welding science and technology worldwide. It was apparent that the United States, and in particular ORNL, holds a commanding lead in certain areas of welding science and technology. This was very apparent from the discussions, references to ORNL's work and other complimentary remarks received from the delegates of various committees. ORNL's participation in the proceedings was very much appreciated. Through visits to various institutions, valuable information was gained on diverse topics related to welding science and technology. Also, new ideas have been formulated to strengthen and expand our current welding science program. Because of ORNL's achievements and leadership in welding science nationally and internationally, some of the commissions of IIW have requested our continued participation in the future.

APPENDIX A

**INTERNATIONAL CONFERENCE ON WELDING UNDER EXTREME CONDITIONS
CONFERENCE INTERNATIONALE SUR LE SOUDAGE EN CONDITIONS EXTREMES**

Portevin Lecture	Conférence Portevin	
Welding in difficult conditions for the offshore and nuclear industries	Le soudage en milieu hostile pour l'industrie offshore et le nucléaire	1
H. G. DELAUZE (France)		
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ITINERARY

Aug. 29-30, 1989	Travel from Oak Ridge, TN, to Lappeenranta, Finland, via plane
Aug. 31-Sept. 1	Visit Lappeenranta Institute of Technology, Lappeenranta, and present invited seminar
Sept. 2-3	Weekend and travel to Helsinki, Finland
Sept. 4-8	Attend 42nd Annual IIW Assembly
Sept. 9-10	Weekend and travel to Copenhagen, Denmark
Sept. 11-12	Visit Danish Welding Institute, Copenhagen, Denmark
Sept. 13	Visit Riso National Laboratory, Roskilde, Denmark
Sept. 14	Travel from Copenhagen, Denmark, to Knoxville, TN

APPENDIX C

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