



Report on the Henniker Conference on: Welding R&D—Problems and Opportunities

This Engineering Foundation Conference, cosponsored by AWS and WRC was held August 1-6, 1976 in Henniker, New Hampshire where over 80 scientists, engineers, and executives assessed current methods of solving welding problems and the need for new approaches

BY PAUL W. RAMSEY

Introduction

Welding R&D is important to the future of the American Welding Society and the Welding Research Council, and to the welding industry in the United States. In the past ten years there has been a de-emphasis in this area. At Henniker last August we talked and argued about this problem, and what opportunities for new approaches lie ahead. In the following pages I would like to share with you a summary* of the presentations and discussions.

It was gratifying to see the conferees work together, and at the end of a week come to some significant recom-

mendations for enhancing the status of welding R&D. As one of our speakers observed, "Research by its nature looks to the future and is an investment in the future. It can only be done successfully, by a company or nation confident of that future. That

confidence seems to have been missing in this country during the past few years. When it returns, I believe we shall have a better climate for research."

I believe that our country is regaining a large measure of confidence, and

*Because of space limitations, the speakers' remarks and discussions were edited by the author.

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All but a few of the 81 representatives from industry, universities, government and technical societies who attended the Engineering Foundation Conference at Henniker, New Hampshire, during August 1-6, 1976

that the time is right for new initiatives in welding research and development.

Conference Background

The Conference was held because of concern by a number of individuals, long active in the affairs of the American Welding Society (AWS) and the Welding Research Council (WRC), in the decline of welding research effort in the United States, in contrast to expanded activity in other industrialized countries—Fig. 1. The Conference was sponsored** by AWS and WRC, and was held at New England College, Henniker, New Hampshire, August 1–6, 1976, with an attendance of 81 scientists, engineers and executives. Sixty-four organizations were represented; these included 38 industrial companies, 8 government agencies, 7 universities, 4 independent laboratories, 6 technical societies and institutes, and one trade publication.

The Conference was intended as a first step in the formulation of a position on matters regarding welding research and development in the United States. Each day selected speakers made brief presentations, with much opportunity for dialogue and participation by all those attending the Conference. Session chairmen kept dialogue "on the track," and summarized areas of agreement and points of difference.

The daily schedule provided for morning talks and discussions, and evening workshops on several related topics:

- Monday, August 2—*A Perspective on Welding R&D and Its Problems.*
- Tuesday, August 3—*How Are We Solving Our Welding Problems? The Roles of Industry, University, Government, and Independent Laboratories.*
- Wednesday, August 4—*International Cooperation: An Idea Whose Time May Have Come For the U.S.*
- Thursday, August 5—*New Approaches for Organizing Welding Research.*
- Friday, August 6—*AWS-WRC Interaction in Achieving R&D Objectives.*

Summary

The most important result of the

**The organizing committee consisted of: Conference Chairman—Paul W. Ramsey, A. O. Smith Corporation; Co-Chairman—Richard K. Sager, Welding Engr. Specialist, Aluminum Company of America; Robert M. Gage, Manager Weld. Prod. Technology, Linde Division, Union Carbide Corporation; Gerald D. Ries, Chairman Welding Comm., Republic Steel Corporation; Dr. Irving A. Oehler, Treasurer—International Institute of Welding; Dr. Robert D. Stout, Dean of the Graduate School, Lehigh University.

Conference was a near-unanimous finding that the United States needs a central organization for welding R&D, and that such an organization should handle several functions, including:

- Group-sponsored welding R&D, but excluding basic research and proprietary process and product research.
- Welding information center.
- Technology transfer programs—education and publications.
- Failure analysis.
- Internships from industry, government and universities.

Membership would be open to all interested parties—institutions, industry, government agencies and individuals. Work would be conducted in existing laboratory facilities.

It was also recommended that a task force be established by AWS to study the conference results and make recommendations and proposals for future action. AWS President Robert H. Foxall has appointed such a special committee, and requested it to make an initial report to the AWS Executive Committee in February 1977. This committee will be chaired by Paul Ramsey and consists of the Organizing Committee, plus WRC Director Kenneth Koopman, AWS Executive Director J. Edward Dato, and AWS President Foxall.

On the question of who should be responsible for the establishment of a central organization for welding R&D, there were several opinions:

- Welding Research Council.
- American Welding Society.
- An AWS-WRC umbrella structure.

There were a number of other findings also considered of major importance:

- Improve professional and scientific

stature of AWS as means of attracting research engineers and scientists into welding R&D.

- Continue upgrading AWS staff with technical and professional personnel to implement its claim as one of the leading scientific organizations in the world devoted to the advancement of welding.

- Welding R&D conducted at universities is primarily a means to educate students; the research results are a by-product of the educational endeavor.

- A recent industry survey, which included the viewpoints of managers, research directors and welding engineers showed general agreement that the U.S. lags in welding R&D (compared to USSR, Japan, Germany and England).

- A proposal to establish a national welding R&D institute at an available National Bureau of Standards facility, with the cooperation of AWS, was made by a representative of NBS; the initial reaction was one of opposition to a government-run laboratory.

- The amount of welding R&D conducted in the U.S. has probably decreased in the past 10 to 15 years, although the difficulty of defining "R&D" makes quantitative comparisons impractical. It is reasonable to estimate that funding for welding R&D does not exceed 1% of sales directly associated with it.

- For most organizations represented at the Conference, the number of welding R&D papers was down significantly in the past 10 to 15 years. Several individuals also commented on the decline in quality as well as in quantity.

- After a review of the philosophy and operations of a number of central welding R&D organizations in other

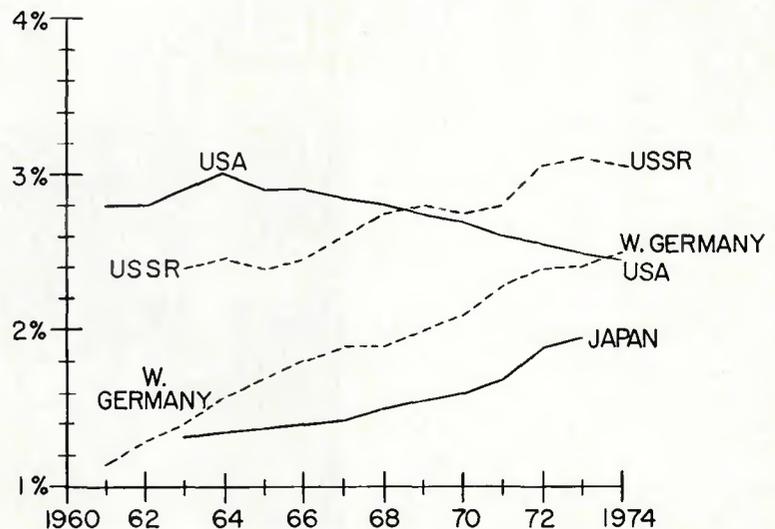


Fig. 1—R&D expenditure as a percentage of Gross National Product (Source—National Science Board). Welding R&D expenditures are thought to have followed a somewhat similar pattern in the past 10–15 years



Fig. 2—Chairman and speakers for Monday, August 2. Left to right: R. M. Gage, E. D. White, D. C. Hill and J. C. Williams. (P. M. Palermo not shown)



Fig. 3—On hand for Tuesday, August 3. Left to right—speakers F. R. Miller, W. F. Savage, W. D. Doty, and chairman G. D. Ries

countries (England, Canada, USSR), it was agreed that none completely meet the special needs of the United States.

- The primary importance of the International Institute of Welding is in the area of international standards, and in providing personal contacts with foreign colleagues, and only secondarily in welding R&D.

- WRC was established over 40 years ago as a means of conducting cooperative welding R&D. In recent years this research has been aimed at

pressure vessels (with close ties to ASME) and structural welding (significant assistance from AISC).^{*} In administering major research grants, WRC concentrates on only a few universities and nonprofit laboratories, although its University Research Committee does provide small "seed money" grants to a larger number of universities.

^{*}ASME—American Society of Mechanical Engineers; AISC—American Institute of Steel Construction, Inc.

Monday, August 2—"A Perspective on Welding R&D and Its Problems" (Session Chairman: Robert M. Gage)

Dr. David C. Hill, Research Supervisor, Linde Division, Union Carbide Corporation: "How We Got Wherever We Are"

- Evolution of welding can be traced by process, materials or applications. In many cases emerging welding technology has preceded fundamental understanding.

- Welding progress has resulted as a prerequisite for progress in other technical areas, e.g., military, aerospace, transportation, energy applications.

- Welding research in Russia (and Eastern Europe) is centralized in national welding institutes. In Russia, the Paton Institute sets goals, establishes standards, and many technical accomplishments are mandated for commercial application with little attention to economics or appropriateness.

- In Japan, welding and steel making industries are integrated with shipbuilding business. Welding research flows from needs of the shipyards, not from profits on welding equipment and consumables.

- In both Russia and Japan interchange between scientists' and engineers' work on welding is quite open.

The U.S. could benefit from freer interchange of technology and better technical overview, coordination and direction of welding research:

- There is a lack of a strong scientific organization in the U.S. committed to upgrading the quality of

welding research and improving published results.

- In many cases government support for welding research and development is not provided because the subject area appears to lack glamour.

Dr. James C. Williams, Associate Professor, Carnegie-Mellon University: "A Physical Metallurgist Looks at Welding Research"

- Need exists to gain predictive capability with regard to welding variables in order to minimize empirical studies on new materials.

- A useful step in gaining this capability would be to begin to understand relationships between:

1. Weld process parameters and weld microstructures.

2. Weld microstructure and weld properties.

- Specific examples of areas where there appears room for more good work include:

1. Controlled solidification (pulsed arc, arc vibration, inoculation).

2. Laser welding.

3. Weld properties.

4. Arc diagnostics.

- There is noticeable lack of application of the newer sophisticated analytical techniques in welding R&D (e.g., electron microscopy, both transmission and scanning, Auger electron spectroscopy, and electron scanning

chemical analysis).

More talented physicists and metallurgists are needed in welding R&D field; the welding community should work harder at depicting the challenging problems in welding in terms that make them realize the opportunity that exists rather than discourage them by the complexity of the problems:

- The government funds investigators, as well as projects, and good people will attract support.

Eugene D. White, Publishing Vice President, *Welding Design and Fabrication*: "Industrial Users Look at Their Welding Problems and Needs"

- Surveys and interviews were conducted with three groups of individuals, all qualified as having a deep concern with welding in their manufacturing operations:

1. Survey of 1000 (270 responded) engineers and managers in companies employing 100 or more persons (fabricated products, machinery, transportation equipment).

2. Survey of Ohio State welding engineering alumni at annual luncheon (AWS meeting—St. Louis).

3. Interviews with seven welding research directors in large user companies, representing cross-section of welding applications.

- Most industrial users feel U.S. welding R&D is adequate.

- Most welding engineers felt welding R&D effort is far from adequate and is falling behind that of Russia, Japan, and England.

- When asked where they might turn for R&D assistance, industrial users listed: *welding equipment manufacturers*—45%; *technical societies* (AWS, ASM, CDA)^{*}—11%; *The Welding Institute* (in England)—4.1%; *The Welding Research Council* (WRC)—3.8%.

- 84% of industrial users said there were unmet welding R&D needs now

^{*}ASM—American Society for Metals; CDA—Copper Development Association.

in their manufacturing operations...and ranked them as follows:

1. Central clearing house for information.
2. More government funding.
3. Better dissemination of data.
4. A U.S. welding research institute (like the British).
5. More practical research.
6. More basic research.
7. Standards of acceptable levels of weld defects.

Peter M. Palermo, Assistant Chief Naval Architect—Structures, Naval Ship Engineering Center: "The Navy Anticipates Problems of Availability in Welding Materials and Know-How"

• Present state-of-the-art in Navy shipbuilding is of the custom-type approach, and with the relatively simple materials of the past this was feasible.

• New higher strength hull materials require R&D in advance of production to optimize welding techniques and minimize deficiencies. The following factors must be considered:

1. Limit to number of highly skilled welders.
2. Automated welding to meet process control requirements.
3. Thermal and metallurgical effects of new materials.
4. Greater utilization of Al and Ti in ship structures.

• Advances in Naval ship structures will be possible only if an adequate supply of welding consumables and welding engineers can be assured.

A national facility for welding R&D, including nondestructive examination methodologies, appears necessary to more economically utilizing welding R&D dollars. Advantages include:

- Spin-off of Navy welding research on higher strength materials to commercial applications.
- Results of commercial work could be applied to Navy research.
- Central repository for welding information.
- Inherent uplifting of welding technology as a field for metallurgists, which should result in availability of more "welding engineers."

Discussion and Workshop Summary

• No major US welding supplier does R&D beyond that needed to create new products or refine existing ones which will sell in a highly competitive, low-margin market.

• When industrial users develop new products or processes they are typically considered proprietary secrets. The bulk of welding R&D has shifted from supplier to user, resulting

in fewer publications.

• "Welding" is not a defined science nor a widely accepted engineering discipline. It is difficult to attract welding R&D aspirants around a smorgasbord called welding engineering, if their professional training has been in metallurgy, chemical, mechanical, or electrical engineering or in physics.

• The quality of papers presented for publication, and the difficulty in attracting highly trained scientists to welding attest to the smoky image projected of welding in the U.S.

• *The total of welding R&D in the US, including that part of metallurgy aimed toward welding, may exceed that of any other country. Our total effort lacks the visibility of The Welding Institute, the coordination of a Paton Institute, the cooperation of the Japanese, the monopoly position inherent in the Eastern Bloc, and the proprietary positions once common among US suppliers when innovation was rapid.*

• The cause of the poor image of welding as a profession may be attributed, in part, to:

1. Welding is looked upon as a skill, not a professional discipline.
2. Neglect of sophisticated analytical techniques in much welding development.
3. Lack of an accepted definition of "welding engineer" among

professionals in the welding field.

4. Lack of an informed public.
• To attract and hold good people in welding R&D requires:

1. Upgrading professional stature.
2. Upgrading curricula in colleges and universities.
3. More program continuity.
4. Keeping them content—stature is even more important than salary.

• The number of laboratories doing good welding R&D in the U.S. is not large—probably no more than 10 university labs, and less than 50 industry, government, and independent labs. In many companies the effort may be too small to be identified.

• Welding know-how for manufacturing is provided mostly by suppliers (in new processes and products) and users (in applications). Only limited supplier-user cooperative work is done.

• It is impossible to determine if government funds are being wisely spent in welding R&D because of lack of details and accounting data. It appears that cooperation among government agencies is minimal, depending mainly on voluntary efforts of a few individuals. On the positive side, government technical monitoring has improved in the past decade, and the Air Force has increased funding of manufacturing technology programs from \$100 K to \$800 K per year in the past 2½ years.

Tuesday, August 3—How Are We Solving Our Welding Problems? The Roles of Industry, University, Government, and Independent Laboratories (Session Chairman: Gerald D. Ries)

Dr. W. D'Orville Doty, Chief Research Engineer—Product Engineering, U.S. Steel Corporation: "Industries' Approach in Solving Our Nation's Welding Problems"

• The identification of priorities on current welding research problems, and for methods to improve benefits from research expenditures by industry and cooperative organizations supported by industry is an important goal of this conference.

• A number of recent publications are of value in reviewing welding research needs:

1. WRC Bulletin 202 "Current Welding Research Problems"
2. WRC Bulletin 209 "Long-Range Plan for Pressure Vessel Research"
3. ASME Pub. H00089 "Research Needs Report"

• Major welding research studies by the steel industry are currently directed at materials and welding processes in various areas:

1. Line-pipe steels, filler metals, NDE methods

2. Acceptance criteria for electroslag welds
3. Weldability of HSLA steel sheet for automotive use
4. Expanded application of welding in construction and maintenance of process equipment

• Nearly all of the welding research on materials is done "in house" by the base metal producers, with coordination between welding-electrode and welding-equipment producers. The development of weldable steels for hydro- and aerospace application are typical of this approach.

David C. Martin, Manager—Fabrication & Quality Assurance Section, Battelle-Columbus Laboratories: "Independent Research Laboratories Methodology for Solving Welding Problems"

• Almost all of Battelle's welding research is dictated by sponsors' requests, and the necessary sales effort is a major responsibility of a research engineer.



Fig. 4—Dr. I. A. Oehler with his speakers for Wednesday, August 4. Left to right: Dr. Oehler, H. B. Cary, Dr. N. F. Eaton and Mr. R. A. Dunn of Canada, G. E. Linnert and P. W. Ramsey



Fig. 5—Conference chairman Ramsey with the scheduled speakers for Thursday, August 5. Left to right: P. W. Ramsey, A. Lesnewich, P. Patriarca and N. Kenyon

- Marketing requires awareness of current state of the art (and research fads), problem spots, sponsors' desires, and being in the right place at the right time.

- Government sponsorship of welding projects now represents 1/3 of total vs. 2/3 in 1955-60. The size of the welding group was 40 in 1965, 18 in 1971, and is now 32 (2/3 welding, 1/3 NDT). Cost of a man-year total is in \$60-100 K range.

- Duration and scope of projects vary widely:

1. Long term—ship fracture study.
2. Short term, large economic importance—big inch pipeline (conversion from liquid to gaseous transport); Alyeska (waivers on joints)
3. Internal—narrow gap welding—AWS welding environment study
4. Short term—product fix; production problem; literature survey, failure analysis; specialized schools (introduction to technology of pipeline welding)

- The types of projects have changed drastically since 1955-60:

1955-1960

New materials

New process development

Freedom for future orientation

Improved properties

1976

Engineering materials

Process refinement

Systems—"now"-oriented

Lower costs

Fred R. Miller, Program Manager, Air Force Materials Laboratory: "Government Processes for Solving Welding Problems"

- Welding programs at AF Materials Laboratory are systems oriented and are handled in several divisions—Metals and Ceramics, Systems Support, Manufacturing Technology

- Most of the work is contracted to industrial or independent laboratories, and directed to structural or propulsion applications.

- Based primarily on Ti, Al, and steel, the welding research efforts aim at weight savings and cost reduction for both new and existing aircraft. Examples:

1. Diffusion bonding, spot welding, brazing—Ti parts.
2. Weldbonding of Al.
3. Thick section Ti—plasma arc, sliding seal EB, lasers, diffusion bonding.
4. Power metallurgy parts—Ti; superalloys—weldability study.
5. HY-180 (AF-1410) program—with Navy and US Steel.
6. Compressor cases/frames—Ti alloy weldability, brazing.
7. Static parts—superalloy frames—pulsed plasma arc study.
8. Turbine blade repair—filler metals, directional solidification, friction welding studies.
9. Joining Ti Aluminides.

- The Air Force, Navy, and Army hold an annual tri-service meeting on welding R&D in order to minimize duplication of effort.

- Emphasis in government funded welding programs appears to be short range, quick return and away from long range, high risk ventures.

Dr. Warren F. Savage, Director of Welding Research, Rensselaer Polytechnic Institute: "Role of Universities in Solving Our Welding Problems"

- Function of welding R&D at universities is primarily to train and educate engineers. The research results are a by-product.

- A survey was made by Professor Savage of 42 universities listed by the WRC University Research Committee as engaging in welding research:

1. Only 18 universities replied, 6 indicated no research in progress.
2. The remaining 12 indicated combined annual support for welding R&D of \$330 K (1973), \$475 K (1974) and \$506 K (1975).
3. In addition, Lehigh University

received \$400 K/yr for pressure vessel and structural welding projects.

4. These monies currently support 46 students—18 Ph.D. candidates, 20 M.S. candidates, 8 undergraduates.

- In past 40 years, some 490 engineers have earned advanced degrees working on WRC projects. Currently 100 of these are in teaching, 25 in government agencies, 365 in industry. Lehigh, RPI, and Ohio State are the main source of these engineers.

- At RPI the welding program gets 50% of its support from industry, some from NSF, ERDA, ONR, BuShips, AF. WRC sponsorship is small.

- Research costs less at universities than at Battelle, but productivity is less because of several factors—student turnover, lack of technicians to operate and maintain equipment, educational requirements, equipment deficiencies.

- Needs of universities are most critical in these areas:

1. Capital funds for specific laboratory equipment.
2. Up-to-date welding equipment.
3. Project support by industry, government.
4. Student fellowships (\$7 K-\$10 K per yr).

Discussion and Workshop Summary

- It was suggested that not all the weldability problems for various grades of structural steels have been solved. The Department of Transportation has data indicating cracking problems with some welded highway bridges.

- It was agreed that the AWS Manufacturers Committee should be contacted for recommendations and help in securing equipment donations for university welding laboratories, and that the WRC University Research Committee act as a clearing house.

- A comparison of the numbers of professional people engaged in weld-

ing R&D today vs. 10-15 years ago was attempted. Lack of agreement on what constituted "R&D" made the results of questionable value. Some basic metals companies showed increases, while most welding equipment companies and users showed decreases.

- Trend in educational requirements for professionals engaged in

welding R&D was toward higher degree levels—more M.S. and Ph.D. people today compared to 10-15 years ago.

- Most companies present fewer welding R&D papers today compared to 10-15 years ago. There was also a general agreement that quality has declined as well.

Wednesday, August 4—International Cooperation: An Idea Whose Time May Have Come for the United States (Session Chairman: Dr. Irving A. Oehler)

George E. Linnert, North American Representative, Welding Institute of Great Britain: "Cooperative Welding Research—A Common Market Approach"

- In 1973 the European Research Institute for Welding (ERIW) was formed to provide a cooperative organization for conducting specific welding research programs. (The Secretary-General of ERIW is Dr. Jean Seville, located in Ghent.) Participants were:

1. The Welding Institute*, Abington, England
2. ISF, Technical Highschool—Aachen, Germany
3. Testing & Materials Laboratory, University of Ghent, Belgium

- Advantages are pooling of information, using special expertise and facilities of each lab, and exchange of scientific personnel for limited periods

- In 1975 ERIW proposed a 2-year study of the fracture toughness and defect tolerance of electroslag welds at a budget of \$200 K. This work is now in progress, with each laboratory contributing as follows:

1. Electroslag weld test plates—Aachen, Germany
2. Wide plate tests—Ghent, Belgium

*The Welding Institute, established in 1946, has a site at Abington, England of 26 acres, with a staff of 450 (1/3 are professionals). It has over 700 member companies around the world, and about 50 of these are in Canada and the USA. About 15 of the organizations represented at this R&D Conference are Research Members of the Institute. Originally, government grants provided major financial support, but it is now mostly limited to sponsored research on specific projects.

3. Fracture mechanics, literature search, information handling—Abington, England

- Data on the electroslag program are only available to sponsors at present. ERIW is considering other projects in reheat cracking and specialized fume studies.

Russell A. Dunn/Dr. Norman F. Eaton, Canadian Welding Development Institute: "Cooperative Welding Research—A North American Viewpoint"

- The Canadian Welding Development Institute (CWDI) was founded in 1973 with an initial government grant (\$175 K), and is supported as well by industry through membership from companies involved with welding technology

- This central R&D institute now has a staff of 16 and a budget of \$750 K. Projected staff in 5 years is 25. Sponsored research is carried by CWDI staff using existing facilities in members' laboratories at present.

- *The development and transfer of welding technology is a primary goal of CWDI, (it views itself as a catalyst to the activities of existing welding laboratories in universities and industry) engaging itself in programs which will overcome the limitations and utilize the strengths of other organizations—Fig. 6.*

- Still in the planning stage is a CWDI technical center, envisioned as much more than an experimental program laboratory. In addition to technology development and experimental investigations related to members problems, its objectives include:

1. Resource center for technical information.

2. Technical advisory center.
3. Resource for educational materials.
4. Organization of courses, seminars and conferences.
5. Support for educational programs in universities.
6. Re-training of industry personnel in technology developments.
7. Personnel and facilities to supplement those of industry.

- The CWDI will also coordinate welding developments conducted at 4 provincial centers (B.C., Alberta, Quebec, Maritimes). For example, CWDI is working on HSLA pipeline steels. The extension of this program to the specific applications stage is planned for the CWDI's Alberta Centre, located where much of the pipeline construction and operation will occur.

Howard B. Cary, Vice President—Welding Systems, Hobart Brothers Company: "The Eastern Europe Approach to Welding Research"

- The USSR, Czechoslovakia, E. Germany and Poland all have national welding institutes, the largest being Russia's E. O. Paton Institute of Electric Welding (NEC) in Kiev with a staff of 3000-5000. Financing is through direct government grants, and from projects sponsored by various industries (pipelines, shipbuilding, pressure vessels, etc).

1. Czechoslovakia's Welding Research Institute (VUS) is in Bratislava, was organized in 1949, and has a staff of about 700.
2. East Germany's Welding Institute (ZIS) is in Halle, was organized following WW II and has a staff of about 400.
3. Poland's Institute of Welding was organized in 1948, initially to train welders.

- Paton Institute has a Coordinating Committee for Welding, which includes the chief welding engineer from each industry technical institute. They meet annually to review new welding technology and list welding problems needing work. In addition to sponsored work, Paton Institute has other functions:

1. Independent research.
2. Design and experimental construction.
3. Development of welding equipment.
4. Translates and distributes foreign welding literature and specifications.
5. Training and education of all levels of personnel.
6. Design, analysis, consulting, training for industry groups.
7. Publishes monthly journal—"Automatic Welding."

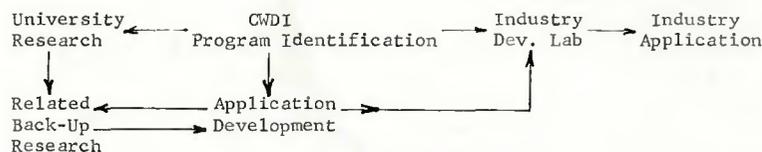


Fig. 6—Schematic representation of how the development and transfer of welding technology is a primary goal of the Canadian Welding Development Institute (CWDI)

8. National welding standards and codes.

● Paton Institute cooperates with other institutes, and may send work to their experts, e.g., heat flow (Rykalin, Baykov Institute, Moscow), power sources (Kochonovsky, Electric Arc Welding Institute, Leningrad).

Dr. Irving A. Oehler: "Impact of IIW on World-Wide Welding Developments"

● Principal impact of the International Institute of Welding (IIW) on welding developments is in face-to-face contacts between the leading researchers throughout the world. Work in progress in various countries can be compared and new insights gained.

● IIW also makes recommendations to the International Standards Organization (ISO), and U.S. participation is required if our viewpoints are to be considered.

Discussion and Workshop Summary

● A wide variety of opinions emerged from workshop discussions of the several types of national welding institutes (English, Canadian, Eastern European), and what might be borrowed for a possible US welding institute:

1. No need for any new organization. Beef up WRC with staff and funding (currently too much dependence on volunteer help)
2. Do not like Eastern European, government-controlled approach
3. Agreed on need for a central welding institute and that funding seems feasible (start up funding for 5-6 man staff est. at \$250 K)

● *One group provided a detailed list of functions considered desirable for a central welding institute (in the event that a U.S. institute were formed): data bank or depository of technical information, laboratory facilities, translations of foreign literature, guidance of R&D by experts in field, regional centers—specialties, and qualification and certification. Also: group-sponsored research on major problems, industry, government, and individual membership, consulting services for specific, limited problems, failure analysis service, transfer of technical information—education and publications, and internships from industry, government, and universities.*

● One benefit of establishing a central welding research organization would be an improved scientific stature for welding.

Thursday, August 5—New Approaches For Organizing Welding Research (Session Chairman: Paul W. Ramsey)

Dr. Alexander Lesnewich, Director—Filler Metal R&D, Airco Welding Products: "The Research Dilemma—Public vs. Proprietary"

● Welding research which should be done is not being worked on today (such as permissible defect levels, fume hazards, fissure-free austenitic weld metal, etc).

● In past 20 years we have revolutionized the arc welding processes, with proprietary laboratories doing most of the work. Today we can weld almost anything in any position, and at lower cost than ever before.

● During the 1950's and 60's new processes were invented at too fast a rate for industry to properly absorb. Then, triggered by a few recessions, the cost crunch led to the abandonment or dispersion of many research laboratories.

● Return on investment was used to justify welding R&D, and most long range and basic research was abandoned. Safe, evolutionary development rather than revolutionary research is the key to survival.

● There are many unsolved welding problems that are mostly ignored by proprietary laboratories because of the costs involved. The public, governmental laboratories don't have the

people or facilities for such problems, and we would have to anticipate a long nucleation period. In other words neither public nor proprietary laboratories have done well recently, and this is the research dilemma.

● We need a mechanism for funding group research for benefit of entire industry. Work should be done in proprietary laboratories, with the assistance of highly specialized public laboratories.

Dr. Norman Kenyon, Joining Section Manager, International Nickel Company: "Economic Factors in Organizing Welding R&D"

● Analysis of the level of welding R&D in the U.S. shows that it is less than in other industrialized nations. It is probably reasonable to say funding for welding R&D does not exceed 1% of the sales directly associated with it.

● If the U.S. is not to fall further behind, a more concentrated effort will be needed. This will mean more money and better use of it in the form of increased productivity, and raises the question of whether the *available industrial research money might be put to better use if it were pooled to*

finance a cooperative research effort.

● When more government funds become available, as now seems likely, it is up to the welding industry to join the call by the scientific and technical community for more funds for R&D, and to demonstrate the importance of welding so that a fair share is devoted to welding technology. There is a need for a broader realization that welding is not an appendix but a vital organ of the technological body, and that if it is unhealthy, the well-being of the entire body is likely to be seriously affected.

● In discussing industrial funding for welding R&D in the U.S. it is impossible to escape the fact that the fragmented nature of the industry introduces special problems that influence productivity of research. Certainly a case can be made for pooling of some research funds in order to do cooperative research. There is an obvious coordinator role here for AWS and WRC.

● On a final philosophical note, research by its nature looks to the future and is an investment in the future. It can only be done successfully by a company or a nation confident of that future. That confidence seems to have been missing in this country during the past few years. When it returns, I believe we shall have a better climate for research.

Peter Patriarca, Manager—LMFBR Fuels & Materials Program, Oak Ridge National Laboratory: "The Need for Cooperative R&D in Energy Related Programs"

● A review was made of certain welding research projects related to the proposed Clinch River liquid metal fast breeder reactor plant. A typical problem involves the welded transition joint between Type 316 stainless steel (primary) and 2½ Cr—1 Mo steel (secondary) components.

● Primary need is to devise a weld system that can be inspected.

● Both the Energy Research and Development Administration (ERDA) and the Electrical Power Research Institute (EPRI) are involved. EPRI's interests lie more in the area of fracture mechanics and defect significance. ERDA is more receptive to welding-related problems.

● The cost of a man-year at Oak Ridge National Laboratory is estimated at \$80-90 K.

Paul W. Ramsey, A. O. Smith Corporation: "Is an American Welding Institute a Viable Option?"

● A properly planned central welding institute could perform many functions that would supplement and enhance current activities in welding R&D, welding education, and training

and evaluation of welding personnel. Existing laboratory facilities could be utilized—university, government, industrial or independent laboratories as may be appropriate.

- There is ample documentation the % of GNP spent for R&D (including welding R&D) in the U.S. has declined steadily in the past decade, while growing substantially in Russia, W. Germany, Japan and France. Many U.S. companies are having R&D done abroad because of lower costs.

- AWS has constitutional mandates to conduct welding research, and to join with others in cooperative research in welding. To date, its only significant efforts have been in welding environment studies conducted at Battelle-Columbus.

- WRC, in the 41 years of its existence, has funded much welding research at universities, helping train about 500 graduate students who have been of great value to industry, government, and universities. While major research grants have concentrated on only a few universities, WRC has provided seed money grants to a large number of universities.

- While AWS and WRC programs are good, there is much more that could be achieved through a centralized welding institute and the best research talent could be kept on long range programs.

- The governing body might be established under an AWS-WRC umbrella. The venture capital would come from the sponsoring organizations, with additional help solicited from foundations and other sources.

- Soliciting of industrial, governmental, and individual members would follow as advantages of membership become obvious.

- In addition to R&D work, these talented research specialists (as in similar institutes abroad) would also provide educational and training services, translations of foreign literature, etc.

- The timetable for establishing such an institute would be 3-5 years, depending on time required to develop a suitable plan, and obtain the necessary support and approvals.

Discussion and Workshop Summary

- The workshops discussed *need, desirability, and possibility* of establishing a central organization for welding research and development—and what *form* it should take:

- Concerning "need and desirability", all groups agreed there was a need, although with some qualification as to its functions:

1. Unanimous need for an organization to enhance welding R&D

2. Needed, but restrict to contract research
3. Needed, but restrict to group-sponsored research, or to research meeting general needs of industry
4. Agreed that a central organization was needed, desirable and feasible. Functions should preferably be at one location.

- Concerning "possibility", there was strong feeling on the desirability of mutual cooperation between AWS and WRC:

1. Can be done through increased AWS activity, but AWS/WRC cooperation desirable and essential.
2. Can be done by WRC—as now constituted or reconstructed, or by an AWS/WRC umbrella structure.
3. Both AWS and WRC have well defined charters; functions of "central R&D organization" could be split along present lines.
4. Possible only if potential sponsors can be assured organization is structurally sound and staffed to do effective job.

- Concerning the "form", one workshop group provided a survey listing the 12 functions (proposed Wednesday, August 4) in order of desirability:

- | | |
|--|-----------|
| | % |
| | Approving |
| 1. Group-sponsored research on major problems. | 100 |

- | | |
|--|-----|
| 2. Data bank or depository of technical info. | 100 |
| 3. Industry, government, and individual memberships. | 94 |
| 4. Translations of foreign literature. | 88 |
| 5. Failure analysis. | 88 |
| 6. Transfer of technical information—education and publications. | 82 |
| 7. Internships from industry, government and universities. | 82 |
| 8. Guidance of R&D by experts in field. | 75 |
| 9. Consulting services for specific, limited problems. | 71 |
| 10. Qualification and certification. | 53 |
| 11. Regional centers—specialties. | 18 |
| 12. Laboratory facilities. | 11 |

- A second group proposed that the ad hoc AWS committee study specific needs and functions.

- During the discussion a representative of the National Bureau of Standards speculated on the possibility of a national welding R&D institute at an NBS laboratory facility. The general reaction was one of opposition to a government-run institute. Unfortunately time was not available to properly discuss this subject, but it will be further reviewed by the ad hoc committee.

Friday, August 6—AWS-WRC Interaction in Achieving R&D Objectives (Session Chairman: Dr. Robert D. Stout)

Kenneth H. Koopman, Director, Welding Research Council: "The Welding Research Council—A Cooperative Institution"

- WRC was established in 1935 by the Engineering Foundation, under the sponsorship of the major engineering societies:

1. To provide a mechanism for conducting cooperative research in welding and closely allied fields
2. To disseminate welding research information
3. To promote welding research at universities
4. To cooperate with similar agencies abroad

- The budget for WRC has grown from \$15 K to over \$1000 K currently. Over the years the Engineering Foundation has contributed a total of \$65 K, but no longer provides any financing. The budget is raised from a variety of sources—over 330 companies, engi-

neering societies, government agencies, and trade associations.

- Some 600 leading scientists and engineers from industry, government, universities, etc., direct the research through eleven project committees, and numerous subcommittees.

- Most of the research is conducted at universities and nonprofit laboratories, and results are printed in a variety of publications to give the widest circulation. (Research Supplement of *Welding Journal*, Reports of Progress, Bulletins, books and monographs)

- WRC contributes to AWS a significant share of the cost of printing the *Welding Research Supplement of the Welding Journal*. (\$15 K out of Research Supplement costs of \$100 K for printing and postage).

- Research projects of WRC helped train some 500 university graduate students in welding problems. Of these, 175 received Ph.D's, the remain-



Fig. 7—Speakers and their chairman for the last day of the Henniker Conference—August 6, 1976. Left to right: AWS President R. H. Foxall, Chairman R. D. Stout, WRC Director K. H. Koopman and AWS Executive Director J. E. Dato



Fig. 8—A Henniker Conference workshop in progress. Left to right facing camera: H. J. Addison, Paul Ramsey and WRC's Ken Koopman

der M.S. degrees.

- The Structural Committee has several projects underway to develop better design formulas for welded plate girders, use of stiffeners, and proper design of welded connections for use in plastic design of welded structures.

- The Pressure Vessel Research Committee is guiding some 20 active projects—in areas of materials, design, and fabrication. Both pressure vessels and pipelines are under study.

- Most of the WRC research projects interface with ASME, ASCE, SNAME,* and various trade associations.

J. Edward Dato, Executive Director, American Welding Society: "The American Welding Society—Now and in the Future"

- Today AWS continues to grow with over 28,000 members whose dues contributed about 1/3 of its \$1900 K budget in 1975-76.

- The annual technical meetings and exposition at St. Louis in 1976 was the largest yet in a "new city" location. Indications are that the 1977 Philadelphia meeting will set an all-time record.

- Publications show improvements in quality and quantity:

1. *Welding Journal* will get new look in 1977.
 2. Technical documents increase in new and revised standards, codes, recommended practices.
 3. *Welding Handbook—Volume 1* of the new 5 volume 7th Edition was distributed in 1976.
- Qualification and certification

program for welding inspectors is under way with nationwide examinations given to over 1000 applicants in September-October.

- A welding careers program has been launched with prepared radio and television public service announcements, in an effort to attract more young people into all phases of welding.

- In research AWS has sponsored two programs in the environmental area at Battelle, with our Safety and Health Committee coordinating the studies (fume, radiation, noise, ventilation, etc). The current 2 year program has been funded at \$300 K by industrial and governmental sponsors.

- Continued growth of AWS will require additional facilities in the next few years—quite probably laboratory and training facilities to further our qualification and education programs.

- AWS looks forward to assisting in any way possible in bringing any recommendations that come from this week's conference to a successful conclusion.

Robert H. Foxall, 1976-77 AWS President and Assistant Sales Manager, Wean-United, Inc.: "Cooperative Research—An AWS Mandate"

- AWS has a constitutional mandate regarding research:

Art II Objects; (b) "To encourage and conduct research, both basic and applied, in all sciences as they relate to welding"

Art V Cooperative Research; "In order to further its objects most effectively, the Society shall provide for the formation of a separate body to be known by some appropriate title for the purpose of joining with other societies, asso-

ciations, and governmental departments in cooperative research in welding."

- A number of points have been emphasized during the week's discussions: need for central depository for R&D information—better definitions of common terms (welding engineer, R&D, weldability)—poor image of welding—cost of doing R&D—funding problems for R&D labs—AWS/WRC operations and interactions and finally:

Need and possibility of establishing a central organization for welding R&D and what form it should take. We have agreed this is needed and some action must be taken.

- I heartily agree with this conclusion, and AWS is committed through its charter and bylaws, to encourage research and to cooperate more closely in that effort with WRC.

- I can envision a permanent AWS board committee on Research, reporting directly to the Executive and Finance Committee.

- *As a first step I plan to set up an ad hoc committee to analyze and study the results of this Henniker Conference and to make recommendations to the Executive and Finance and to the AWS Board of Directors.*

- This ad hoc committee will be comprised of the group that organized the conference: Paul Ramsey (chairman)—Richard Sager—Robert Gage—Gerald Ries—Dr. Irv Oehler—Dr. Robert Stout—plus Ken Koopman—Edward Dato—and myself as AWS President.

- A status report will be requested by February, 1977 at our Executive-Finance Committee meeting.

- All results will be communicated to participants at this conference, and I am sure input to this task force will be most welcome.

*ASCE—American Society of Civil Engineers; SNAME—Society of Naval Architects and Marine Engineers.