BEFORE THE U.S. INTERNATIONAL TRADE COMMISSION

Hot -Rolled Steel Flat Products from Australia, Brazil, Japan, Korea, The Netherlands, Turkey, and the United Kingdom	)	Inv. Nos. 701-A-545-547 and 731-TA-1291-1297 (Preliminary)

Testimony of Dr. J. Malcolm Gray
President, Microalloyed Steel Institute

Good Afternoon, my name is Malcolm Gray and I am President and Founder of the Microalloyed Steel Institute Inc. I am also the President of ITI International, Inc. I was responsible many years ago for developing high strength microalloyed steels as used today for API 5L Line Pipe Grades. Our companies have continued to provide that expertise to steelmakers, pipe producers, and end users worldwide.

1. My role today is to speak to you based on my expertise in high yield large OD line pipe, both from a production point of view and also as a technical consultant to major pipe line projects throughout the world. I have written many specifications for the oil and gas projects and I have been in charge of approving vendors for those projects on a global basis. Our firm, ITI, also performs third party inspections for users of high strength line pipe produced by the DSAW and ERW processes. I understand that my resume is being distributed along with my testimony.

2. HRC Grade X-70 is used for approximately 90 percent of large diameter spiral weld production in the U.S. In the United States, U.S. Steel, ArcelorMittal, SSAB America can all produce to wall thicknesses less than 0.500 inch. For wall thicknesses that exceed 0.500 inch, the producers in the United States have great difficulty to produce this material to standards that meet the requirements of major oil and gas projects.
3. In fact, there are very few U.S. producers who can do so including U.S. Steel Gary and ArcelorMittal at their Calvert facility. SSAB also has some marginal capability, but their products have problems, including poor surface quality. U.S. producers have simply not made the investment in these heavy grade products.
4. Even the best U.S. producers cannot produce today in wall thicknesses that exceed 0.625 inch for Grade X-70. In my role as the technical advisor to the major oil and gas projects, I have never had pipe producers propose to use domestic HRC for any project requirement for wall thickness over .625. The limitations are simply practical, i.e., crop shear thickness capacity and maximum gage that can be coiled. The mini mills using thin slabs are limited to 0.50 inch, because they are not ideally configured to produce line pipe and there is insufficient rolling reduction to achieve grain refinement necessary to reach specified toughness values. (Based on Drop Weight Tear tests.) All of the

points above are based on a design temperature of 32 F (0 degrees C). When the design temperature is minus 20 C or Minus 50 C (ie above ground in Alaska), the maximum gage available is reduced further) Foreign producers with the capability to produce wall thickness above 0.625 inch include POSCO, Salzgitter, JFE, NSSMC, and several others.

5. Some examples where such large diameter heavy walled pipe is required include high pressure pipelines, pipelines running under rivers, and pipelines near heavily populated areas.

6. The line pipe business is very heavily regulated by DOT Office of Pipeline Safety (PHMSA) for all pipelines for the transport of hazardous materials such as oil and gas. The specific type of pipe required and weight and wall thickness of the pipe and method of manufacture are very relevant considerations for public safety.

7. In sum, very heavy walled material over 0.625 inch cannot be sourced here in the U.S. because it is not produced. While U.S. producers may think that they may be able to do so in the future, I have grave doubts about that because the required investment in rolling equipment does not appear to be forthcoming.

8. Even for wall thicknesses below 0.625", it is obvious that a spiral pipe producer needs a range of suppliers to reliably serve the market. Steel mills have predictable maintenance shut downs and they have unpredictable problems

like fires, or weather related production or raw material issues. If you do not perform on a project either because of timeliness or providing a sub-par product, projects will be very reluctant to grant you repeat business. Oil and gas pipe line projects can't risk that kind of liability or delay.

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Education:

A. Met.	1961	Metallurgy, University of Sheffield
M. Met.	1962	Metallurgy, University of Sheffield
Ph.D.	1965	Metallurgy, University of Sheffield
Diploma	1974	Advanced Management Training, (Compressed MBA) University of Western Ontario

Major Project Involvement:

- Alaska Gas Development (ASAP Project) 2014 – Present
- Spectra Canada, LNG Pipeline 2013 – Present
- Dominion Gas Transmission – 2008 – 2011
- Equitable Gas – 2007 – 2011
- Arrow Energy [Australia] (Coal Seam Gas) – 2008 – 2011
- Queensland Gas – 2009 - 2011 (Coal Seam Methane Pipeline).
- Kern River Gas – 2007 – 2011
- China National Petroleum 2004 – Present. Second and Third West East Pipeline.
- Colorado Interstate Gas – 2003 – 2005. (El Paso) Cheyenne Plains 380 mile 36" OD X-80 Pipeline – Lead Materials Engineer.
- Trans Canada Pipeline – 1998 – 2011. Lead Materials Engineer – Developments of NCF composite reinforced pipe technologies for compressed natural gas modules..
- BHP Billiton – 2003. Angostura Project (Trinidad & Tobago). Audit of pipe mills in India and Brazil.
- CIG (El Paso) – 2000 – 2001. Medicine Bow Lateral (163 miles). Lead Materials Engineer.
- Chevron – Texaco – 2003. Benguela-Belize Compliant Tower. Procurement Support: Critical Steel API 2W and EN 10225.

- Shell's TLP Program - 1990 - 1999 Auger, Mars, Ram Powell and URSA Projects. Specifications, vendor qualification, alloy development for TLP forged connectors, plate mill qualification and inspection.
- Amerada Hess-Bald Pate Compliant Tower - 1995- 1999 Lead Materials Engineer.
- Hibernia - 1994. Review MPS for critical plate. Approval of vendors, weldability prequalification.
- Florida Gas (Enron) Phase III Expansion - 1993-1995. Lead Materials Engineer. Linepipe procurement.
- Northern Borders Pipeline Expansion (Enron) - 1996-1998 Lead Material Engineer. Linepipe, hot bends, accessories.
- Markwest Hydrocarbons - 1996 to 1999 Slocum to Victory Sour Gas Pipeline, Lead Materials Engineer.
- East Australian Pipeline - 1994-1996. Ethane Pipeline. Technical Advisor. Pipeline materials and design. Approval of vendors.
- Mobil Oil Indonesia - 1995-1997. Offshore Sour Service Pipeline. Review of specification, approval of vendors, third party surveillance.

Employment History:

2008 – Present	President, Microalloyed Steel Institute Inc. Houston, Texas
2003 – 2008	Partner, EWI/Microalloying International LP Houston, Texas
1991 – Present	President, ITI International, LLC Houston, Texas
1977 - 2003	President, Microalloying International, Inc. (Formed Partnership with EWI) Houston, Texas
1971 - 1976	Assistant Vice President, Molycorp, Inc. (Became a Division of UNOCAL) White Plains, New York
1970 - 1971	Research Manager, Cameron Iron Works (now Wyman-Gordon) Houston, Texas

1966 - 1970	Senior Research Engineer, U.S. Steel Research Center Monroeville, Pennsylvania
1956 - 1966	Various Technical Positions, Park Gate Iron & Steel Company (now British Steel Corporation) Rotherham, England

Dr. Gray has extensive experience in all phases of steel melting, deoxidation, casting, thermo-mechanical processing and welding and has authored over 125 papers in the field. He was employed by British Steel Corporation until 1966, when he joined U.S. Steel Research Center in Monroeville, Pennsylvania where he carried out pioneering research on HSLA steels. He left U.S. Steel in 1971, to join the Molycorp Division of Union Oil where he acted as Assistant Vice President of the Metallurgical Division. In that capacity he was responsible for worldwide sales of the company's products to the steel industry. Dr. Gray founded Microalloying International, Inc. in 1976 (now Microalloyed Steel Institute Inc.) and has served as its President for 39 years. He has been involved in the worldwide development and application of HSLA (Microalloyed) steels since their inception in the early 1960's. His expertise in the production and specification of heavy plate, linepipe forgings and other HSLA steels is globally acknowledged.

The company is involved in development of industry standards and practices, materials testing, development of proprietary specifications and qualification of vendors with varied assignments for API/ISO, PRCI, U.S. Navy, Shell Deepwater, Exxon Mobil, Chevron-Texaco, BHP Billiton, Amerada Hess, El Paso, Trans Canada Pipelines, Enron, Duke Energy, BP-Amoco and others. Dr. Gray is also an advisor to the pipeline industry regulator, DOT-OPS (PHMSA).

Microalloyed Steel Institute, frequently acts as the technical interface between producers and consumers of steel and long-standing relationships exist involving major producers and end users in the steel industry including China, S.E. Asia, North America, Europe and the CIS (formerly USSR). These contacts, informational channels, and international experience are the foundation and resource on which the company's business is based.

Significant metallurgical achievements have included successful reformulation of ASTM 707 forging alloys for Shell TLP tendon connectors, sour service forgings for Saga Petroleum riser flex joints, and participation in development and qualification of plate manufacturing technology to meet the HAZ prequalification schemes for the Hibernia, Shell, BPX and Amerada Hess deepwater projects. A recent achievement has been the invention of a very low manganese HIC resistant pipeline steel for severe service applications.

Professional Accomplishments:

- 2012 Sir Robert Hadfield Medal IOM^3 UK
- 2010 Charles Hatchett Medal for Lifetime Achievement IOM^3
- Inventor, "Sour Service Linepipe and Structural Steel Produced by High Speed Continuous Casting". US Patent 5993570, November 30, 1999

- 1990 Chairman, AWS-Microalloying Int'l Conference, "The Metallurgy Welding and Qualification of Microalloyed Steel Weldments," Houston, TX
- 1990 Elected Fellow of the Institute of Metals, Minerals and Materials (UK) Now IOM^3
- 1987 Elected Fellow ASM International
- 1987 Co-Sponsor with AIM (Italy), "Pipeline Technology," Rome, Italy, 17-19 November, 1987
- 1985 Advisor & Proceedings Editor, Chinese Society of Metals, "HSLA 85," Beijing, China, 4-7 November, 1985
- 1984 Chairman & Editor, CBMM Symposium, "Fracture in Gas Pipelines," Moscow, USSR
- 1982-1985 Coordinator, AGA Cooperative Program, "Ductile Fracture of Gas Pipelines - Correlations Between Fracture Velocity and Plastic Zone Defined from Tension Test Parameters"
- 1978-1980 Coordinator Group Program, "Development of Superior Notch Toughness in High Dilution Weldments of Microalloyed Steels"
- 1979 Co-Organizer, "AIME/SFM Conference, HSLA Steels - Experience in Applications, Versailles, France
- 1976 Chairman & Editor, "Weldability of High Strength, Low Alloy (Microalloyed) Structural Steels," ASM/AIME Conference, Rome, Italy
- 1975 Co-Organizer & Editor, "Microalloying 1975," Washington, D.C.
- 1974 Chairman, AWS/WRC Conference, "Recent Developments in the Welding of High Strength Pipeline Steels," Houston, Texas
- 1973 Chairman, ASM/AIME Symposium, "Cold Rolled Steel for Automotive Use," Detroit, Michigan
- 1973-1975 Member, American Deep Drawing Research Group (ADDRG)
- 1973-1975 Chairman, WRC Pipeline Welding Sub-Committee
- 1972 Chairman & Editor, Conference Proceedings, "Proceedings & Properties of Low Carbon Steels," Cleveland, Ohio

- 1968-1972 Member, AIME Nickel Base Superalloy Committee
- 1967-1973 Chairman, AIME Ferrous Metallurgy Committee
- 1970 Inventor (with P.R. Mould), "Method for Producing Non-Strain-Aging Low-Carbon Steel"
- 1969 Inventor, "Improved Hot Rolled Steel," (Nb-Mo-B ULCB Type)
- 1965 Chairman, Institute of Metals, Younger Members Committee, London

Publications:

J. Malcolm Gray, "Development of X-80 HTP Linepipe Steel Over 40 Years" 69th ABM International Annual Congress and to the ENEMET, July 21-25, 2014, Sao Paulo, SP, Brazil.

A. Fonzo, G. Mannucci, J. M. Gray & S. Mishael, "Assuring Safety Against Propagating Cracks in Gas Pipelines Made from Modern Steels with High Upper Shelf Charpy Energy", APIA PRCI, Sydney, Australia, 29 April - 3 May, 2013.

J. Malcolm Gray, "Metallurgical Concepts and Status of High Temperature Processed (HTP) Steel Development", Microalloyed Pipe Steels for the Oil & Gas Industry, Moscow, Russia, April 2-4, 2013.

J. Malcolm Gray, "Ultra Low-Manganese High Toughness HTP Sour Service Linepipe Steel", CBMM Russian Pipe Steels Seminar, Moscow, April 2-4, 2013.

J. Malcolm Gray, "Low Manganese Sour Service Linepipe Steel", Proceedings of the Microalloyed Steels for Sour Service International Seminar, Sao Paulo, Brazil, 20-22 August 2012, p. 165.

J. Malcolm Gray and C. Fowler, "The History and Development of a New SOHIC Test Method", Proceedings of the Microalloyed Steels for Sour Service International Seminar, Sao Paulo, Brazil, 20-22 August 2012, p. 47.

J. Malcolm Gray, "Welding of Niobium Microalloyed Linepipe Steels: 50 Years of History and Experience" International Seminar, Araxa, Brazil, November 28-30, 2011.

F. Barbaro, L. Fletcher, C. Dinnis, J. Piper and J. Malcolm Gray, "Design and Specification of Line Pipe and Line Pipe Steels for Weldability, Constructability, and Integrity", Joint Technical Meeting on Pipeline Research, San Francisco, CA, May 2011.

J. Malcolm Gray, "High Strength Microalloyed Linepipe: Half a Century of Evolution", Krakatau, Indonesia, Oct 29, 2011.

J. Malcolm Gray, "Application of Niobium-Molybdenum Strengthening Mechanisms in High Strength Linepipe Steels" Symposium on Fundamentals and Application of Mo & Nb Alloying in High Performance Steels, Taipei, Taiwan, November 2011.

J. Malcolm Gray "Chinese Metallurgical Development: Ancient to Modern" IOM^3 Charles Hatchett Seminar, London, UK, July 13, 2011.

J. Malcolm Gray "Ductile Fracture Propagation in High Strength Pipelines". CNPC/TGRI Seminar, Xian, August 2011.

S. Subramanian, H. Zurob and J. Malcolm Gray, "Studies on Softening Kinetics of Low Manganese Steel Microalloyed with Niobium for High-Strength Sour Service ERW Linepipe" 2011 International Symposium on Recent Developments in Plate Steels. AIST Symposium, Winter Park, CO, May 2011.

J. Malcolm Gray, "Linepipe Steel Integrity in Alaskan Pipelines" PHMSA Conference. "Risk, Consequences and Mitigation and Proximity Meeting", Anchorage, Alaska, October 19-20, 2010.

J.M. Gray, Fulvio Siciliano, "High Strength Microalloyed Linepipe Half a Century of Evolution" "Pipeline Technology" Oostende 2010.

J. Malcolm Gray, Marcus Stuart and Jitendra Patel "Manufacturing and Application Experience for Low Carbon Nb-Cr (Near Stoichiometry) HTP Linepipe Steel, the 2nd South-East European IIW International Congress, 21-24 October 2010, Sofia, Bulgaria.

J. Malcolm Gray and Fulvio Siciliano "Production of Modern X-80 Nb-Cr Linepipe Steel on a Industrial Scale - History, Metallurgical Concept and Practical Application" IIW Commission IX Meeting Oct. 22, 2008.

J.M. Gray, Fulvio Siciliano, S.S. Nayak, R.D.K. Misra, and J. Hartmann, "Microstructure an Properties of Low Manganese and Niobium Containing HIC Pipeline Steel" China June 23-24, 2008

J.M. Gray "X80 Linepipe; Alloy Design and Application Experience" GAZPROM Seminar, Moscow February 12, 2008

J.M. Gray, Fulvio Siciliano, and Douglas G. Stalheim, "Modern High Strength Steels for Oil and Gas Transmission Pipelines"

J.M. Gray, Fulvio Siciliano, and Douglas G. Stalheim, "Alloy Design Concepts for High Strength Coil for Gas Transmission Spiral Pipe"

J.M. Gray, "Development, Specifications, and Application Experience with 80ksi (552MPa) Linepipe Beijing Aug 20-22, 2007

J. M. Gray, "A Guide for Understanding & Specifying Chemical Composition of High Strength Linepipe Steels." June 2007.

J.M. Gray, "Recent X-80 Pipelines in the United States." Presented at the TGRX Seminar of Fracture Control Technology for X80 Pipeline. Steel, Xian, China. 22-23 January 2007.

J. Malcolm Gray "Metallurgy and Application of ASTM A707 Forgings" Araxa, Brasil January 2006.

Yuri Matrosov, J.M. Gray, O.V. Nosocheno and O.A. Bagmet, "Trial Commercial Production and Research into Structure Formation Processes of High Strength Steel Plates for Pressure Vessels.

J.M. Gray and Douglas G. Stalheim, "Ferrite/ Acicular Ferrite Alloy Designs for API X80 Gas Transmission Linepipe Steels"

J.M. Gray, "Development of International Standards for High Strength Linepipe"

J. M. Gray, "Quantitative Measurements of Segregation during Concasting: Correlations with Field Welding and Macro Etch Results". International Technology Conference - Azov Stal 2000 Rolled Steel Plates for Large Diameter Oil and Gas Pipelines and Critical Structural Applications". Mariupol, Ukraine. September 23-27, 2002.

J. M. Gray and Peter A. Peters, "Technical Demands and Specifications for Linepipe During the Past Decade". CBMM/TSNIICHERMET Seminar - 25 Years of Cooperation. Moscow Russia. September 5-6, 2002.

J. M. Gray, "An Independent View of Linepipe and Linepipe Steel for High Strength Pipelines: How to get Pipe that's Right for the Job at the Right Price". API X-80 Pipeline Cost Workshop. Hobart, Australia. October 20, 2002.

J.M. Gray, and Klaus Hulka, "High Temperature Processing of Line-Pipe Steels." Niobium Science & Technology. Proceedings from International Symposium Niobium 2001, Orlando, FL. December 2-5, 2001.

J. M. Gray, "Niobium Bearing Steel in Pipeline Projects". Niobium 2001 Orlando, FL, ibid

J. M. Gray, "Offshore Plate and High Strength Linepipe - A Unified Metallurgical Analysis of Manufacturing Options". ABM Annual Meeting, Rio de Janeiro, Brasil. July 24-28, 2000.

J. M. Gray, "Modern Pipeline Technology - Specification Trends and Production Experience"

J. M. Gray, "Recent Developments in Plate and Linepipe Steels", Joint CBMM-CISRI Symposium; Beijing, China; September 28, 1999.

J. M. Gray & W. J. Fazackerley, "The Use of Electric Furnace and Thin Slab Cast Steels and Their Effects on Welded Construction", Pipeline Welding & NDT in the New Millennium; Wollongong, NSW; March 3 & 4, 1999.

J. M. Gray & W. J. Fazackerley, "Technical Challenges and Metallurgical Aspects of High Strength Linepipe", 37th Annual Conference of Metallurgists; August 16-19, 1998.

M. W. Hukle, W. J. Fazackerley & J. M. Gray, "Weldability of Microalloyed Steel for Potential Tank Car Applications", Iron & Steel Society International Symposium on Railroad Tank Cars; September 1997.

J. M. Gray & James D. Smith, "Critical Plate Steel for Offshore Structures: Metallurgical Approach and Prequalification", International Conference on Advances in Welding Technology; Columbus, Ohio; November 6-8, 1996.

J. M. Gray, "Full Scale Testing of Linepipe for Severe H_2S Service – Review of Recent Results", Canadian Region Western Conference; Anchorage, Alaska; February 19-22, 1996.

J. M. Gray, "Microalloyed Plate, Pipe and Forgings: Critical Materials in Oil and Gas Production", The Third International Conference on High Strength Low-Alloy Steels, HSLA '95, Beijing, China; October 25-29, 1995.

J. M. Gray & D. H. Stone, "Application of Modern Steels in tank Car Construction", ASME ME '95 Congress & Exhibition; San Francisco, CA; November 12-17, 1995.

J. M. Gray, J. T. Hickey & B. L. Jones, "Metallurgical Considerations in the Application of Line Pipe in Corrosive Service" The International Corrosion and Pipe Protection Conference and Exhibition; Houston, Texas; September 12-14, 1994.

J. M. Gray, "Opportunities for Fabrication in a Global Environment: Steel Production and Purchasing Issues", ASME Workshop and Panel Discussion; ASME Pressure Vessels and Piping Conference; Minneapolis, Minnesota; June 20-23, 1994.

J. M. Gray & J. W. Post, "Steels for Offshore Structures - Materials Engineering Concerns", OMAE 1994/Conference Workshop on Steel and Weldment Testing and Data Analysis, February 27 - March 3, 1994.

J. M. Gray, C. C. Chen & P. A. Peters, "Centerline Segregation of Continuously Cast Plate", 9th PRC/EPRG Biennial Joint Technical Meeting on Line Pipe Research, May 11-14, 1993; Houston, Texas.

P. A. Peters & J. M. Gray, "Genesis and Development of Specifications and Performance Requirements for Modern Linepipe - Strength, Toughness, Corrosion Resistance and Weldability", Australian Pipeline Industry Association, Inc. 1992 International Convention; Hobart-Tasmania, Australia; October 24-29, 1992.

J. Malcolm Gray, "The Influence of Steelmaking and processing Technology on the Formulation of Microalloyed Steels: A Historical Perspective.

J. Malcolm Gray, "Microalloyed Steels", *Advanced Materials & Processes*, January 1990.

J. Malcolm Gray, "Specification and Manufacturing Trends in High Strength Linepipe for International Projects: Capabilities of Local Suppliers versus the "Big Eight".

B. L. Jones & J. M. Gray, "Fracture Control in Large Diameter Pipelines".

J. Malcolm Gray, R. T. Hill and C. Moore, "Metallurgical Implications of Induction Bending", Advanced Pipe Fabricating Technology Conference, April 18-19, 1988; New Orleans, LA.

J. Malcolm Gray, "Fundamentals of Microalloying", Proceedings, CBMM-CISRI Commemorative Symposium, September, 1989, Beijing, China.

J. Malcolm Gray and Geoffrey Tither, "The Technology of Microalloying with Niobium in HSLA Steels", Proceedings, *International Symposium on Tantalum and Niobium*, p. 379, November 7-9, 1989, Orlando, Florida.

J. Malcolm Gray, "Alloy Design Options and Compositional Trends for HSLA Line Pipe", *Microalloyed HSLA Steels*, Proceedings, Microalloying 88", September 24-30, 1988, Chicago, Illinois.

J. Malcolm Gray, "Steelmaker & End User Inputs in the Evolution of New Steels", presented at Steel Processing - Product Integration Seminar, September 24-30, 1988, Chicago, Illinois.

J. M. Gray and M. Pontremoli, "Metallurgical Options for API Grade X-70 and X-80 Linepipe", International Conference, *Pipe Technology*, p. 171, November 17-19, 1987.

R. T. Hill, R. L. Hinn, J. M. Gray, "Metallurgical Considerations in the Design and Construction of the Celeron Sour Crude Oil Pipeline", ibid p. 423.

J. Malcolm Gray and Harry Stuart, "Microalloyed Steels-Current Status and Future Trends", AWI 35th Annual Conference, *The Challenge of Change,* October 27-30, 1987, Melbourne, Australia.

J. Malcolm Gray, "Trends in the Metallurgy and Application of Advanced Pipeline Steels", CRC Evans/VNIIST Symposium, May 1987, Moscow, USSR.

J. Malcolm Gray and Harry Stuart, "Trends in Microalloyed Line Pipe", Canacero Seminar, November 1986, Mexico.

J. Malcolm Gray and A. J. DeArdo, "Austenite Conditioning Alternatives for Microalloyed Steel Products", *HSLA 85*, November 1985, Beijing, China.

J. Malcolm Gray, et al, Editor *HSLA Technology and Applications*, November, 1985, Beijing, China. Published by American Society of Metal/Chinese Society of Metals.

N. Nozaki, T. Hasimoto, Y. Komizo, H. Nakate, and J. M. Gray, "A New Low-Carbon-Niobium Steel Designed for Accelerated Cooling", AIME, *Accelerated Cooling of Steel*, August 19-21, 1985.

J. M. Gray and B. L. Jones, "Application of High Strength Low Alloy Steel: Microalloying on a Macro Scale", University of Sheffield Centenary Conference; July 1984, Sheffield, England.

B. L. Jones and J. M. Gray, "Fracture Control in Large Diameter Pipeline", ibid.

J. Malcolm Gray, S. V. Subramanian and D. A. R. Kay, "Property Improvements in Bars and Forgings Through Microalloying and Inclusion Engineering", Proceedings, ASM Conference, Technology and Application of HSLA Steels (HSLA-'83), p. 967, October 3-6, 1983, Philadelphia, Pennsylvania.

N. H. Croft, J. M. Gray and A. J. DeArdo, "Submerged Arc Weld Metal Toughness in Microalloyed Line Pipe Steels - The Effect of Post Weld Heat Treatment", ibid, p. 897.

S. A. Golovanenko, J. M. Gray, I.I. Frantov and F. Heisterkamp, "Base Plate, Pipe and Weldment Properties of Controlled Rolled Niobium Steel", IIW, Doc IX, p. 1356-83, 1983.

J. H. Bucher, H. Stuart and J. M. Gray, "Minimization of Embrittlement and Cracking Through Microstructural Refinement by Optimization of Alloy Design and Processing", First International Conference on Current Solutions to Hydrogen Problems in Steel, ASM, November 1982, Washington, D.C.

J. Malcolm Gray and Harry Stuart, "Fracture and Metallurgical Considerations in Developing High Toughness Pipeline Steels", ISTFA/82, October 25-29, 1982, San Jose, California.

J. M. Gray and T. V. Bruno, "Trends in the Technology and Specification of Pipeline Steels - Potential Problems for Steels in Sour Service", AISI Meeting, March 30, 1982, Houston, Texas.

J. Malcolm Gray and Harry Stuart, "Development Trends in High-Toughness Fracture-Resistant Pipeline Steels", Westec, March 22-25, 1982, Los Angeles, California.

J. Malcolm Gray and Brian L. Jones, "Trends in Technology and Weldability of Large Diameter Pipelines", *Interpipe '81*, February 24-26, 1981, Houston, Texas.

S. V. Subramanian, D. S. Ghosh, D. A. R. Kay, G. R. Purdy and J. M. Gray, "Process for the Production of Vermicular Cast Iron", U.S. Patent 4,227,924, October 14, 1980.

J. M. Gray, "Composition and Processing Alternatives in the Production of Large Diameter X-70 Pipe", AIME Mechanical Working Conference, October 29-20, 1980, Toronto, Ontario, Canada.

J. M. Gray and Harry Stuart, "Development of Superior Notch Toughness in High Dilution Weldments of Microalloyed Steels", CBMM Application Report #0100-1980, April 1980.

J. Malcolm Gray and A. Brian Rothwell, "How Welding Affects Pipeline Steels", *Pipeline Welding and Inspection*, AWS, February 25-26, 1980.

J. Malcolm Gray, "Microalloying in Critical Applications", ASM, New York Chapter, February 7, 1980.

F. Heisterkamp, J. M. Gray and H. Stuart, "Niobium as a Toughening Element in Pipe Steels: Influence on Weldment Properties", Second International Conference on Pipe welding, Welding Institute, November 20-22, 1979, London, England.

J. Malcolm Gray, "Physical Metallurgy of Microalloyed Steels", CISRI, July, 1979, Peking, Peoples Republic of China.

Harry Stuart, J. M. Gray and F. Heisterkamp, "The Control of Toughness in Submerged-Arc Weldments in Niobium-Containing Steels", *Trends in Steel and Consumables for Welding*, Welding Institute, November 13-16, 1978, London, England.

J. Malcolm Gray, "Alloying Possibilities for X-65 and X-70 Steel in Large Diameter Pipelines", L. P. Bardin Institute, (TSNIICHMET), September 1978, Moscow, USSR.

Harry Stuart and J. Malcolm Gray, "The Utilization of Niobium in Microalloyed Steel", ILAFA Conference, May 17, 1978, Acapulco, Mexico.

J. M. Gray, H. Stuart and F. Heisterkamp, "Development of Weldable Steels Containing 0.15 Percent Niobium", II Latin American Welding Congress, October 24-28, 1977, Santa Catarina, Brazil.

J. R. Goldsmith, Alec Mitchell and J. Malcolm Gray, "Preparation of Rare Earth and Other Metal Alloys Containing Aluminum and Silicon", U.S. Patent, 1976.

Anonymous, "Where Niobium/Columbium is Used and Why", Published by CBMM, 1976, Brazil.

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J. M. Gray, "Technology of Niobium Strengthened Steel", Paper presented at the 50th Anniversary of the Indian Metals Society, November, 1975, Rourkela, India.

J. M. Gray, "Use of Niobium in Concrete Reinforcing Bar Steel - A Review", Proceedings of ILAFA Congress, September 21-25, 1975, Lima, Peru.

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