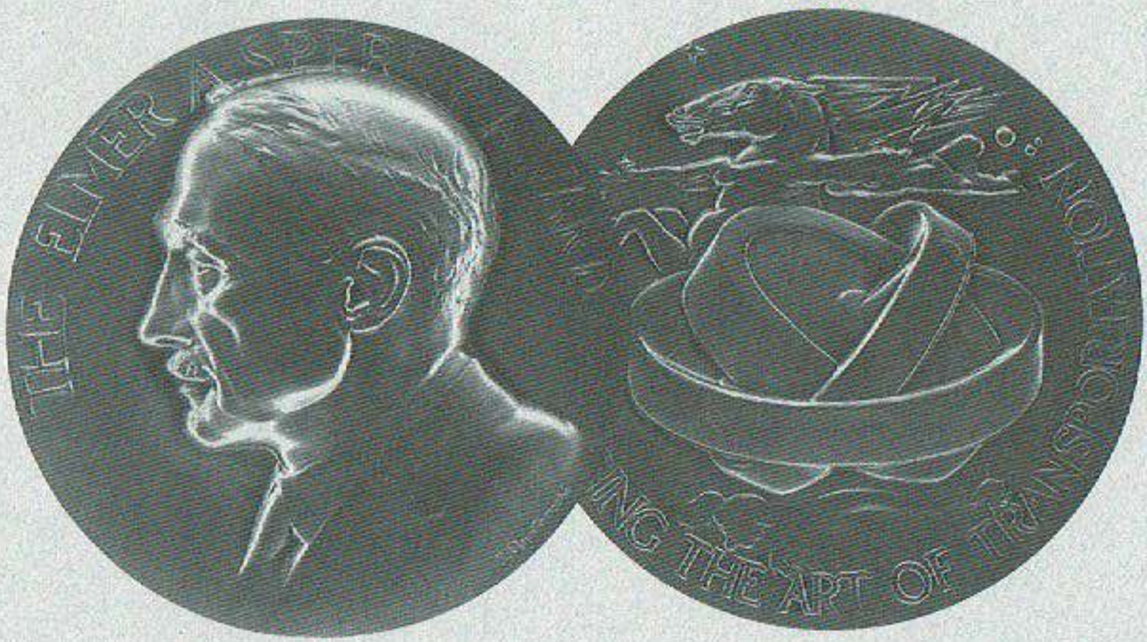


The Elmer A. Sperry Award 1994

for advancing the art of transportation

The Elmer A. Sperry Award

The Elmer A. Sperry Award shall be given in recognition of a distinguished engineering contribution which, through application, proved in actual service, has advanced the art of transportation whether by land, sea or air.

In the words of Edmondo Quattrocchi, the sculptor of the Elmer A. Sperry Medal:

"This Sperry medal symbolizes the struggle of man's mind against the forces of nature. The horse represents the primitive state of uncontrolled power. This, as suggested by the clouds and celestial fragments, is essentially the same in all the elements. The Gyroscope, superimposed on these, represents the bringing of this power under control for man's purposes."

Presentation of

The Elmer A. Sperry Award for 1994

to

Russell G. Altherr

for the conception, design and development of a slackfree connector for articulated railroad freight cars

by

The Board of Award under the sponsorship of the:

American Society of Mechanical Engineers
Institute of Electrical and Electronics Engineers
Society of Automotive Engineers
Society of Naval Architects and Marine Engineers
American Institute of Aeronautics and Astronautics
American Society of Civil Engineers

at the
1994 ASME International Mechanical Engineering Congress and Exposition
November 9, 1994 - Chicago, IL

Russell George Altherr

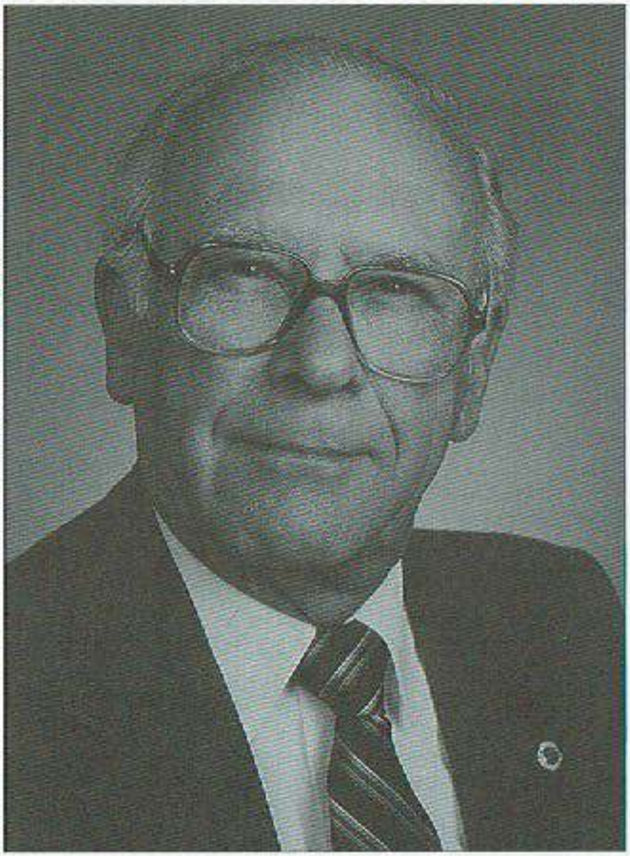
As a native of Lafayette, Indiana, Russ entered Purdue University in 1946 immediately after 2-1/2 years of military service during World War II. Upon graduation in 1949 with a BS degree in Engineering Mechanics, he joined Babcock & Wilcox Research where he was involved in tests of pressure vessels and coil spring fatigue. Contact was made with American Steel Foundries because of their extensive research and publications on spring design and testing. He joined the American Steel Foundries Product Engineering Department in 1951 and was involved in the design of brake mechanisms, brake shoes, fifth wheels and railroad coupling systems.

March 5, 1951 to November 8, 1954	Analyst
November 8, 1954 to January 6, 1958	Mechanical Designer
January 6, 1958 to February 3, 1964	Design Engineer
February 3, 1964 to November 1, 1966	Test Engineer
November 1, 1966 to June 1, 1967	Mechanical Engineer II
June 1, 1967 to June 17, 1968	Mechanical Engineer - Analytic
June 17, 1968 to March 1, 1969	Mechanical Engineer - Couplers
March 1, 1969 to May 1, 1976	Product Design Manager - Couplers
May 1, 1976 to January 1, 1990	Manager - Coupler Engineering
January 1, 1990 to June 30, 1990	Manager - Advanced Coupler Engineering

On June 30, 1990 Russ retired from American Steel Foundries with over 39 years of service. Russ is now a consultant in his field.

Russ is a registered Professional Engineer in Indiana and is the sole or joint inventor of 52 patents on subjects ranging from spring suspension systems, disk brakes and slack adjusters to a variety of highway and railroad vehicle coupling systems. He is a member of ASME and was an active contributing member of the Mechanical Committee of the Standard Coupler Manufacturers. In the past he has held membership in the Air Brake Association, American Society for Testing & Materials, Society of Automotive Engineers and Society for Experimental Stress Analysis.

Russ is married with 3 daughters and 6 grandchildren. He is an active member of Lions International and, since retiring in 1990, has worked with the Habitat for Humanity and on renovation and operation of a local warming shelter.



Russell George Altherr

Historical Background

Introduction - To appreciate the significance of the reduced slack development of alternate railroad coupling systems it is important to discuss the railroad situation during the early 1980's. The articulated car was introduced at a unique moment in railroad history. Several diverse forces mitigated toward a favorable climate for the introduction of this innovative car type.

Container Movement - In the early 1980's the North American freight car fleet required major transportation improvements for the railroads to be in a position to tap the growing demand for handling containers across the country. Greater productivity and reduced lading damage with more reliable handling were required. Articulation of multiple car units, each capable of carrying two containers, was a means to achieve this productivity improvement and the reduction of handling damage. The primary component to permit economic articulation was the unique slackless articulated connector designed by Russ Altherr.

Railroad Facilities - Three major facility changes had solidified in the early 1980's to establish the transportation climate for the introduction of new equipment. *Significant routes* had been upgraded to permit trains to operate at higher speeds between the terminals and clearances had been improved to permit double stacking. *Major terminals* had been established at strategic locations throughout the country. Many of these terminals were at ports where import containers were unloaded. *Efficient handling equipment* had been installed in the container terminals, see Figure 1.

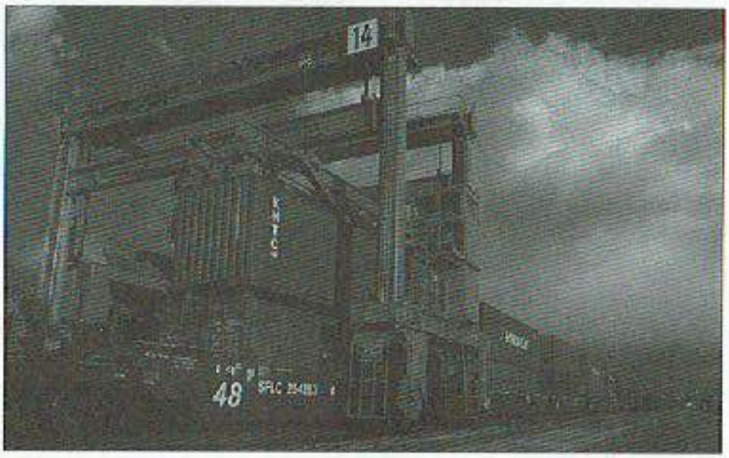


Figure 1 *(photo courtesy of Greenbrier Intermodal)*

"Contract" Operation - The vast majority of cars operating on the North American railroad system are freely interchanged between carriers subject to AAR (Association of American Railroads) regulations and standard practices. The early articulated car designs did not conform to AAR requirements. In addition, the mergers and consolidations had resulted in fewer railroads operating across the country. Fortunately, the alternate practice of interchanging cars under contract had become well established, negating the necessity of operating under AAR practices. Later, after articulated cars were established in the fleet, the AAR established practices to cover varying car types, including articulated cars.

Slack in Train Operation - For over a century, railroads operated with steam locomotives as the major freight motive power. The characteristics of a steam locomotive provided little torque at starting and low speeds. When the wheel/rail adhesion was exceeded the wheels slipped causing the train to loose power. This characteristic was overcome by the engineman backing into the train and "gathering slack". When he started forward again the cars were serially accelerated and eventually the entire train would begin to move. This established a deep set paradigm, "slack is required to start a train."

Even with the dieselization[1] of the freight railroads complete, the paradigm persisted. Several experiments were performed to shatter the concept and demonstrate that a diesel could, in fact, start a heavy train on an ascending grade with no slack.

After the "slack is required for starting a heavy train" concept was left behind, the railroads began to examine the damaging effects of in-train slack. As trains operate over undulating territory the run-in and run-out of slack results in high coupler forces between cars in the consist. Thus, it became apparent that the reduction of slack would be beneficial to the train operation and the lading would experience a smoother ride quality if all slack could be eliminated. A secondary benefit was the significant reduction in over-the-road train partings and in-train air hose partings realized after the reduction of slack.

Freight Car Reliability - Freight car reliability had improved significantly through the 1970's and early 1980's. The plain bearings[2] had been phased out of service, center plate designs had improved, tougher couplers were in general service and freight car wheels were more reliable.[3] Further through the efforts of AAR research and test programs, often with federal governmental assistance, the railroad environment was better understood and accompanying improvements in design and testing techniques had permitted car builders to produce more reliable structures. These significant improvements in freight car reliability permitted an escalation of the miles a car could operate per year. It is not uncommon for a modern articulated well car to operate over 200,000 miles in a year.

[1] The 1957 Sperry Award was for the diesel-electric locomotive
[2] The tapered roller bearing won the 1977 Sperry Award
[3] The curved plate railroad wheel won the 1987 Sperry Award

Freight Car Repair Shops - In the past the freight car repair shop operations consisted of placing the cars to be repaired on long shop tracks. Each car was separated and the mechanics hauled tools to the car and performed the repair. The inclusion of multi-platform cars to these older repair shops would have drastically reduced the efficiency of the facility. The newer repair facilities are "one-spot" operations where the cars are pulled through a location where the repairs are performed. This operation permits the articulated cars to be repaired without taxing the entire facility for changeout of one wheel set in a five platform car.

Classification Yard Operation - The use of central container and trailer handling hubs has essentially eliminated classification or sorting of cars in hump yards. This eliminates the requirement to provide equipment on the articulated car to absorb the coupling energy.

Computer Aided Utilization - The utilization of freight cars has been significantly improved with the application of computer control to keep the car moving as much as possible. The reduction of out-of-service time achieved with the reduction of damaging slack further improved the utilization. The increased utilization makes the cars more efficient and leads to a rapid recovery of the cost of capital equipment.

Summary - These factors provided a favorable climate for the introduction of new technologies, and particularly the slackless articulated freight cars.

Quest For The Articulated Car

In mid-1958 the Santa Fe Railway decided to experiment with articulated cars to haul trailers. Russ Altherr and others at ASF worked with John Angold and his team at the Santa Fe to develop the coupling systems for these vehicles. The first two unit prototype was completed in March 1959. The favorable response to the prototype led to the introduction of 100 more cars in 1960. The experiment was expanded when four additional cars equipped to handle containers were placed into service in February 1960.

The early connection design developed problems and eventually the cars were removed from service. In spite of the component difficulties, the success of articulation had been established.

In 1966 the Santa Fe built 100 more articulated cars at their Topeka Shops. These cars had conventional couplers that were disabled to prevent separation. Unfortunately the cars were separated and individual units began to appear at various destinations across the country. Further, the ICC objected to the disabling of the AAR Standard coupling systems. By the late 1960's the success of articulation had been established coupled with the knowledge that a unique coupling system designed for the rigors of high speed, high mileage service was required.

In 1968 a team composed of Gus Holabeck, Chief Engineer of Bethlehem Steel Car (the predecessor of Johnstown America), Russ Altherr at ASF and Sergei Guins at the C&O Railroad (one of the predecessors of CSX), along with many others from their respective organizations, developed an articulated coal hopper car. The coupling system for the C&O hopper car bore many resemblances to the present articulated connector.

In 1970 an ASME paper was published announcing to the world that a unique connector design was available to permit the articulation of freight car bodies. The system still lacked the reliability of a slackless connection.

In August 1971 a patent application was filed in Russ Altherr's name for the slackless feature and on February 13, 1973 the patent issued describing the wedge system that has been used in over 44,000 connectors.

Slackless Articulated Connector

On February 13, 1973, patent number 3,716,146 was granted to Russ Altherr for the slack adjuster for the railroad freight car articulated connector, see Figure 2. The addition of this slack reduction feature made the use of the articulated connector in freight cars feasible.

Free Slack - Before the arrival of the articulated connector, individual freight cars were connected with AAR standard couplers. These couplers permitted connection and release between each individual car body. The couplers and associated draft gears, energy absorbing devices to reduce the effect of impact during coupling, had a considerable amount of free slack. For example, one railroad reported 135′ of free slack in a train of 120 cars. As the couplers and their associated equipment wore, the amount of free slack increased.

This free slack was an impediment to train handling as trains got longer. Often the run-in and run-out of free slack in a train generated higher forces than yard impacts. Since the articulated connector permanently connects up to ten individual platforms, Figure 3, the reduction of free slack is significant. The damage to lading caused by forces generated from in-train forces, derailments induced by train action and injuries to train crews from violent run-in and run-out forces were reduced with introduction of reduced slack in trains.

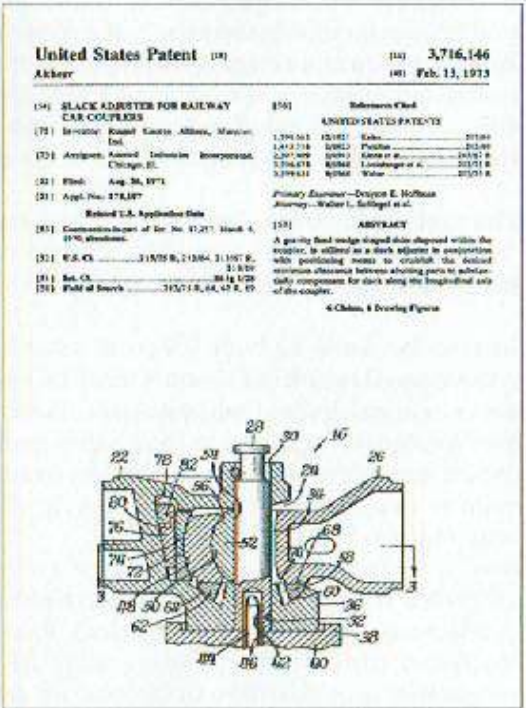

United States Patent [19]
Altherr
[11] 3,716,146
[45] Feb. 13, 1973
[54] SLACK ADJUSTER FOR RAILWAY CAR COUPLERS
[56] References Cited
UNITED STATES PATENTS
[57] ABSTRACT

Figure 2-Copy of the Patent Cover

Figure 3-APL Car *(photo courtesy of Thrall Car)*

The Articulated Connector - The articulated connector couples the platforms and supports one end of each platform in multiple-unit freight cars. Referring to Figure 4, one platform of the freight car is welded to the male end of the connector, see part "A", and the female end of the connector, part "B", is welded to the adjacent platform. The pin, part "F", connects the platforms. A pair of rings, parts "D" and "M", and pin bearing block, Figure 4 part "E" and Figure 5, accommodate the relative motions between the platforms. The follower, part "C", and the gravity wedge, part "G", compensate for the wear of the parts.

The two adjacent, coupled platforms set upon one truck, see Figure 6 and the female bowl at the bottom of the female end of the articulated connector, Figure 4 part "B". A truck center pin, part "H", is inserted into a hole in the connector pin, "F".

Thus, the articulated connector serves to connect two adjacent platforms and provide support for the two platforms. The gravity wedge system compensates for wear in the coupling, assuring a slackfree connection for years of service.

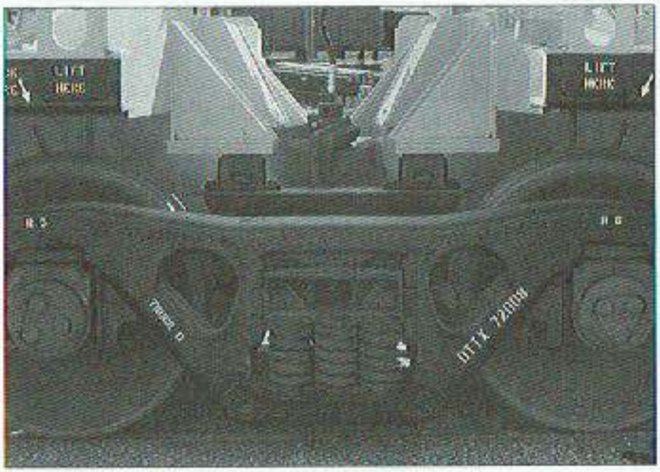
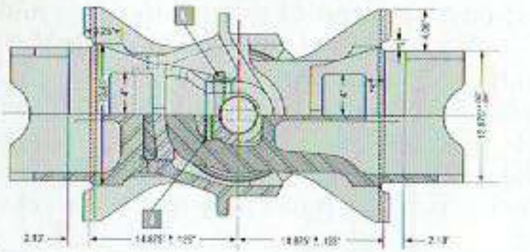


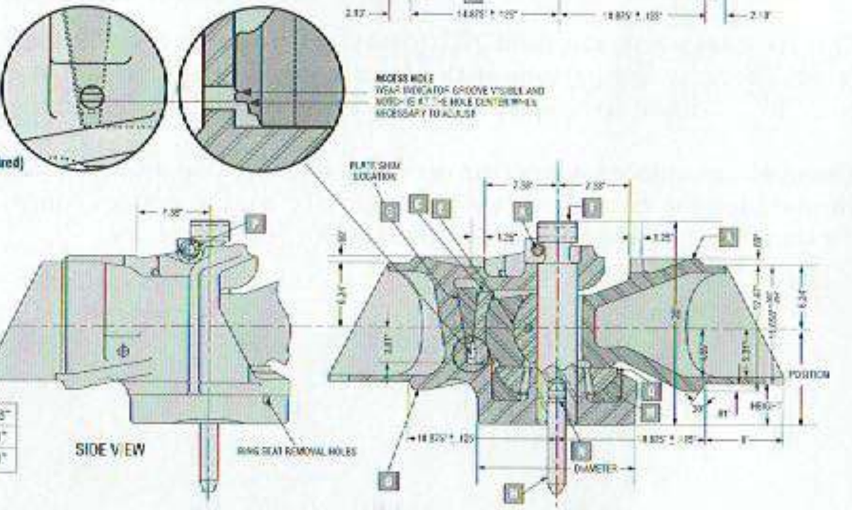
Figure 6 *(photo courtesy of TTX Company)*

Nomenclature - The use of articulated connectors has created a new language for historic railroad terms. What was a single "car" is now a set of "units" or platforms. A platform designed for doublestacked containers may be called a "well".

The ASF® articulated connection assembly is a system that contains a wedge that provides for initial assembly clearance and drops by gravity to maintain zero longitudinal slack.
Automatic adjustment for seating and any wear that accumulates is provided by wedge (G) to maintain a slack-free connection. After longitudinal wear, wedge travel may be restored by adding a plate shim. Wedge travel is visible through access holes which also permit insertion of a pry bar to raise wedge for ease of assembly and disassembly.

A. **Male Articulated Connector**
B. **Female Articulated Connector**
C. **Follower**
D. **Spherical Ring**
E. **Pin Bearing Block**
F. **Primary Pin**
G. **Wedge**
H. **Special Center Pin**
J. **Pin Bearing Block Spring**
K. **Retaining Pin**
L. **Cotter .31"x1.75" (2 required)**
M. **Ring Seat**
N. **O-Ring (120 R1-I-325)**
P. **1" Nom. Washer (2 Required)**





Diameter	13.85"	15.53"
Height	2.62"	3.31"
Position	8.75"	9.44"

Figure 4 Articulated Connector with parts list

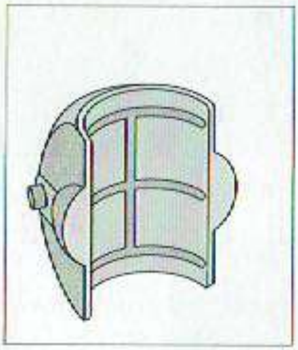


Figure 5 Pin Bearing Block

Advantages Realized With The Introduction Of The Slackless Articulated Connector

Slackless Articulated Connector - The application of new technology often involves the balancing of design advantages against disadvantages. Seldom has a revolutionary new technology been adopted into freight railroad service with so many significant advantages accompanied with so few disadvantages.

Reduced Cost - Each coupling of two car bodies, or platforms, was above a truck, reducing the number of trucks required. Since the trucks have a significant first cost, represent a high maintenance component and contribute to train resistance, the railroads realized a savings operating the articulated cars.

Improved Ride Quality - After the initial operations, the shippers realized a significant reduction in lading damage. The slackless feature produced notable improvements to longitudinal ride quality. The basic car design leads to improvements in lateral and vertical ride quality. The ride quality of the reduced slack five well articulated car was demonstrated by American President Lines in 1985[1] when they shipped a fancy table setting in a container from Los Angeles to New York, via Chicago without any damage to the place setting, see Figure 7.

[1] "Smooth Ride," American President Lines, April, 1990.

Weight Savings - The net-to-tare ratio is reduced. The savings is over 1,600 lbs. per connection compared with conventional draft gear, couplers, yokes and pins or keys.

Shorter Trains - Some railroads have limitations to the length of a train due to signal block dimensions and siding lengths, making it attractive to carry more containers in a given train length. Improved payload-to-length ratio of the articulated car permits shorter trains or more payload where train length is restricted.

Improved Train Handling - The tighter train with significant slack reduction is favored by railroad crews. They speak highly of the performance of a train of slackless articulated cars.

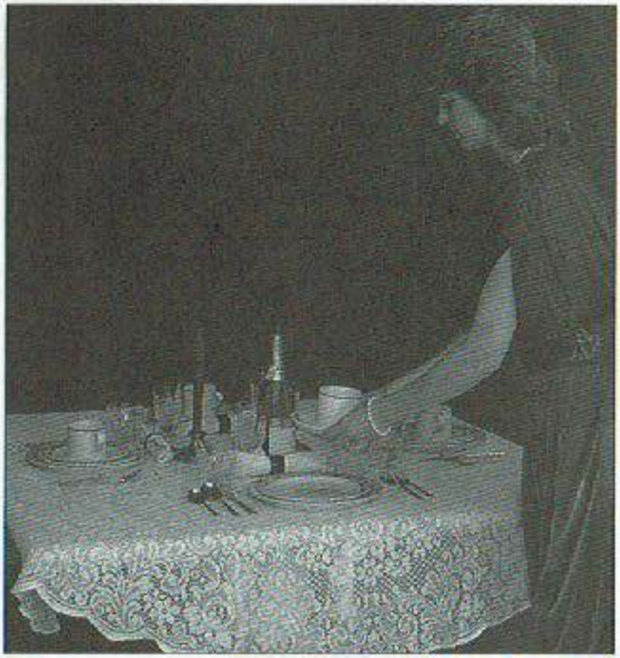


Figure 7 *(photo courtesy of American President Lines)*

Reduced Labor and Maintenance Costs - Railroad maintenance labor is reduced in the articulated car due to the reduction in air and mechanical couplings, handbrakes and other brake equipment and trucks.

Summary - These improvements enabled the articulated train to make rapid inroads into the operation of American railroads over the last decade[2].

[2] "Railway Age," September, 1993, page 70.

Railroad Freight Car Types That Use The Slackless Articulated Connectors

The slackless articulated connector has been applied to several car types:

Five and Ten Unit Spine Car, Figure 8 - The spine car is a lightweight freight car designed to haul containers or trailers. The car consists of a center beam that runs the longitudinal length of each platform. The beams are joined by articulated connectors and are supported by two axle trucks under each articulated connector. The spine car has been in service with either four, five, six, eight or ten platform units.

Five Unit Doublestack Container Well Car, Inset - The articulated five unit well car forms the backbone of the modern container freight car fleet.

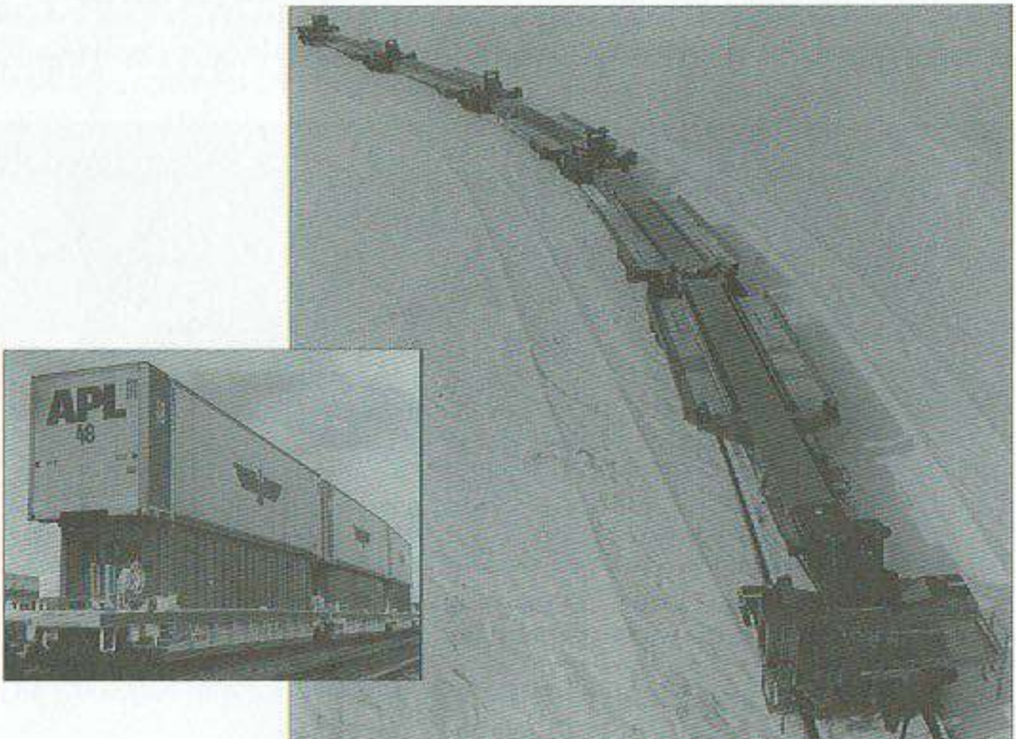


Figure 8 Spine Car *(photo courtesy of Johnstown America Corporation)*

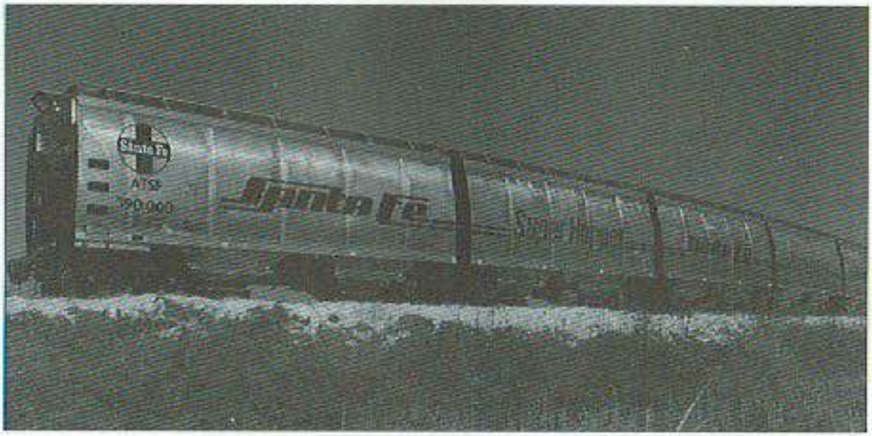


Figure 9 ATSF Covered Hopper Car *(photo courtesy of Thrall Car)*

Grain Cars, Figure 9 - The Santa Fe Railway has been experimenting with a five unit grain car.

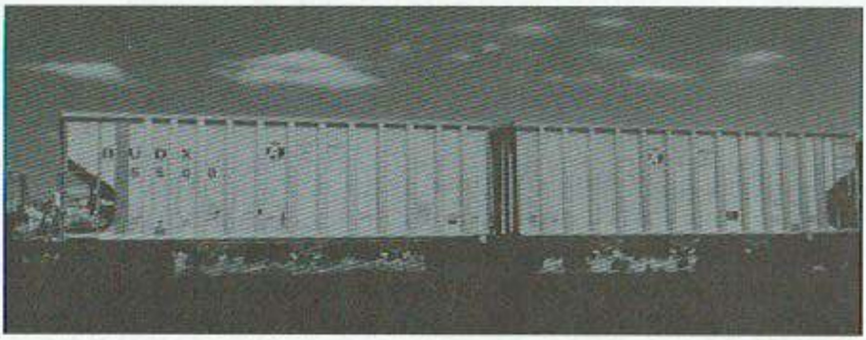


Figure 10 TransitAmerica Hopper Car *(photo courtesy of TransitAmerica Inc.)*

Coal Hopper Cars, Figure 10 - TransitAmerica, a freight car designer, has developed a prototype articulated coal hopper car.

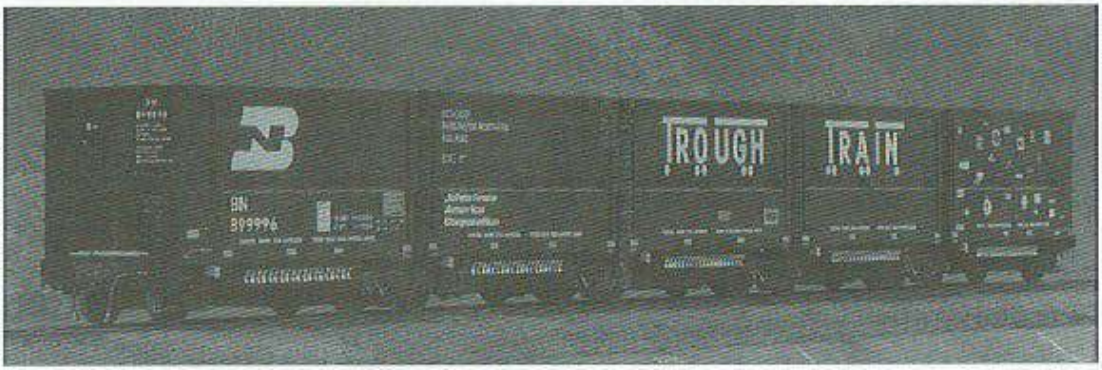


Figure 11 BN Trough Train *(photo courtesy of Johnstown America Corporation)*

Trough Coal Car, Figure 11 - A prototype trough coal car train has been in service on the Burlington Northern Railroad. The reception has been so successful that the railroad will purchase more trainsets next year.

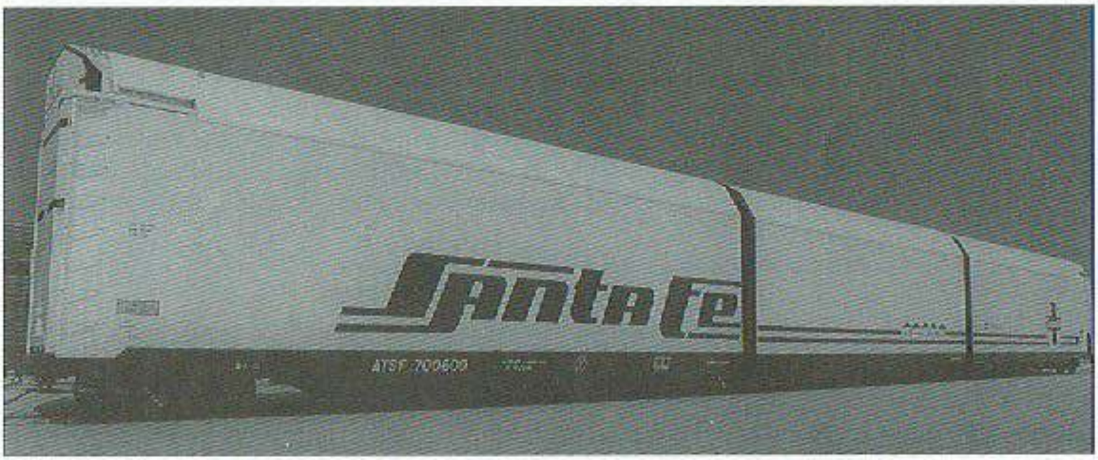


Figure 12 ATSF Autoveyor Car *(photo courtesy of Atchison, Topeka & Santa Fe)*

Articulated Autorack Car, Figure 12 - The Santa Fe Railway and TTX have been testing articulated autorack freight cars for handling automobiles.

Elmer A. Sperry, 1860-1930

After attending Cornell University in 1879-80, Sperry invented an improved electric generator and arc light and opened an electric company in Chicago. He invented electric mining equipment, locomotives, streetcars and an electric automobile. He developed gyroscopic stabilizers for ships and aircraft, a successful marine gyro-compass and gyro-controlled steering and fire control systems used on Allied warships during World War 1. Sperry also developed an aircraft searchlight and the world's first guided missile. His gyroscopic work resulted in the automatic pilot in 1930. The Elmer A. Sperry Award was established in 1955 to encourage progress in transportation engineering.

The Elmer A. Sperry Award

To commemorate the life and achievements of Elmer Ambrose Sperry, whose genius and perseverance contributed so much to so many types of transportation, the Elmer A. Sperry Award was established by his daughter, Helen (Mrs. Robert Brooke Lea), and his son, Elmer A. Sperry, Jr., in January 1955, the year marking the 25th anniversary of their father's death. An additional endowment to support the award was received in 1978 upon the death of Mrs. Lea. Additional gifts from interested individuals and corporations also contribute to the work of the Board.

Elmer Sperry's inventions and his activities in many fields of engineering have benefitted tremendously all forms of transportation. Land transportation has profited by his pioneer work with the storage battery, his development of one of the first electric automobiles (on which he introduced 4-wheel brakes and self-centering steering), his electric trolley car of improved design (features of its drive and electric braking system are still in use), and his rail flaw detector (which has added an important factor of safety to modern railroading). Sea transportation has been measurably advanced by his gyrocompass (which has freed man from the uncertainties of the magnetic compass) and by such navigational aids as the course recorder and automatic steering for ships. Air transportation is indebted to him for the airplane gyro-pilot and the other air navigational instruments he and his son, Lawrence, together developed.

The donors of the Elmer A. Sperry Award have stated that its purpose is to encourage progress in the engineering of transportation. Initially, the donors specified that the Award recipient should be chosen by a Board of Award representing the four engineering societies in which Elmer A. Sperry was most active:

The American Society of Mechanical Engineers
(of which he was the 48th President);
American Institute of Electrical Engineers
(of which he was a founder member);
Society of Automotive Engineers; and
Society of Naval Architects and Marine Engineers.

In 1960, the participating societies were augmented by the addition of the Institute of Aerospace Sciences. In 1962, upon merging with the Institute of Radio Engineers, the American Institute of Electrical Engineers became known as the Institute of Electrical and Electronics Engineers; and in 1963, the Institute of Aerospace Sciences, upon merger with the American Rocket Society, became the American Institute of Aeronautics and Astronautics. In 1990, the American Society of Civil Engineers became the sixth society to participate in the Elmer A. Sperry Board of Award.

Important discoveries and engineering advances are often the work of a group, and the donors have further specified that the Elmer A. Sperry Award honor the distinguished contributions of groups as well as individuals.

Since they are confident that future contributions will pave the way for changes in the art of transportation equal at least to those already achieved, the donors have requested that the Board from time to time review past awards. This will enable the Board in the future to be cognizant of new areas of achievement and to invite participation, if it seems desirable, of additional engineering groups representative of new aspects or modes of transportation.

The Sperry Secretariat

The donors have placed the Elmer A. Sperry Award fund in the custody of the American Society of Mechanical Engineers. This organization is empowered to administer the fund, which has been placed in an interest bearing account whose earnings are used to cover the expenses of the board. A Secretariat is administered by the ASME, which has generously donated the time of its staff to assist the Sperry Board in its work.

The Elmer A. Sperry Board of Award welcomes suggestions from the transportation industry and the engineering profession for candidates for consideration for this Award.

Previous Elmer A. Sperry Awards

1955 to *William Francis Gibbs* and his Associates for development of the S.S. United States.

1956 to *Donald W. Douglas* and his Associates for the DC series of air transport planes.

1957 to *Harold L. Hamilton, Richard M. Dilworth and Eugene W. Kettering* and Citations to their Associates for the diesel-electric locomotive.

1958 to *Ferdinand Porsche* (in memoriam) *and Heinz Nordhoff* and Citations to their Associates for development of the Volkswagen automobile.

1959 to *Sir Geoffrey De Havilland, Major Frank B. Halford* (in memoriam) *and Charles C. Walker* and Citations to their Associates for the first jet-powered aircraft and engines.

1960 to *Frederick Darcy Braddon* and Citations to the Engineering Department of the Marine Division of the Sikorsky Aircraft Division, Sperry Gyroscope Company, for the three-axis gyroscopic navigational reference.

1961 to *Robert Gilmore Letourneau* and Citations to the Research and Development Division, Firestone Tire and Rubber Company, for high speed, large capacity, earth moving equipment and giant size tires.

1962 to *Lloyd J. Hibbard* for application of the ignitron rectifier to railroad motive power.

1963 to *Earl A. Thompson* and Citations to his Associates for design and development of the first notably successful automatic automobile transmission.

1964 to *Igor Sikorsky and Michael E. Gluhareef* and Citations to the Engineering Department of the Sikorsky Aircraft Division, United Aircraft Corporation, for the invention and development of the high-lift helicopter leading to the Skycrane.

1965 to *Maynard L. Pennell, Richard L. Rouzie, John E. Steiner, William H. Cook and Richard L. Loesch, Jr.* and Citations to the Commercial Airplane Division, The Boeing Company, for the concept, design, development, production and practical application of the family of jet transports exemplified by the 707, 720 and 727.

1966 to *Hideo Shima, Matsutaro Fuji and Shigenari Oishi* and Citations to the Japanese National Railways for the design, development and construction of the New Tokaido Line with its many important advances in railroad transportation.

1967 to *Edward R. Dye* (in memoriam), *Hugh DeHaven and Robert A. Wolf* and Citations to the research engineers of Cornell Aeronautical Laboratory and the staff of the Crash Injury Research projects of the Cornell University Medical College.

1968 to *Christopher S. Cockerell and Richard Stanton-Jones* and Citations to the men and women of the British Hovercraft Corporation for the design, construction and application of a family of commercially useful Hovercraft.

1969 to *Douglas C. MacMillan, M. Nielsen and Edward L. Teale, Jr.* and Citations to Wilbert C. Gumprich and the organizations of George G. Sharp, Inc., Babcock and Wilcox Company, and the New York Shipbuilding Corporation for the design and construction of the N.S. Savannah, the first nuclear ship with reactor, to be operated for commercial purposes.

1970 to *Charles Stark Draper* and Citations to the personnel of the MIT Instrumentation Laboratories, Delco Electronics Division, General Motors Corporation and Aero Products Division, Linon Systems, for the successful application of inertial guidance systems to commercial air navigation.

1971 to *Sedgwick N. Wight* (in memoriam) *and George W. Baughman* and Citations to William D. Hailes, Lloyd V. Lewis, Clarence S. Snavely, Herbert A. Wallace, and the employees of General Railway Signal Company, and the Signal & Communications Division, Westinghouse Air Brake Company, for development of Centralized Traffic Control on railways.

1972 to *Leonard S. Hobbs and Perry W. Pratt* and the dedicated engineers of the Pratt & Whitney Aircraft Division of United Aircraft Corporation for the design and development of the JT-3 turbo jet engine.

1975 to *Jerome L. Goldman, Frank A. Nemec and James J. Henry* and Citations to the naval architects and marine engineers of Friede and Goldman, Inc. and Alfred W. Schwendtner for revolutionizing marine cargo transport through the design and development of barge carrying cargo vessels.

1977 to *Clifford L. Eastburg and Harley J. Urbach* and Citations to the Railroad Engineering Department of The Timken Company for the development, subsequent improvement, manufacture and application of tapered roller bearings for railroad and industrial uses.

1978 to *Robert Puiseax* and Citations to the employees of the Manufacture Francais des Pneumatiques Michelin for the design, development and application of the radial tire.

1979 to *Leslie J. Clark* for his contributions to the conceptualization and initial development of the sea transport of liquefied natural gas.

1980 to *William M. Allen, Malcolm T. Stamper, Joseph F. Suner and Everette L. Webb* and Citations to the employees of Boeing Commercial Airplane Company for their leadership in the development, successful introduction and acceptance of wide-body jet aircraft for commercial service.

1981 to *Edward J. Wasp* for his contributions toward the development and application of long distance pipeline slurry transport of coal and other finely divided solid materials.

1982 to *Jorg Brenneisen, Ehrhard Futterlieb, Joachim Korber, Edmund Muller,. Reiner Nill, Manired Schulz, Herbert Stemmler and Werner Teich* for their contributions to the development and application of solid state adjustable frequency induction motor transmission to diesel and electric motor locomotive in heavy freight and passenger service.

1983 to *Sir George Edwards, OM, CBE, FRS; General Henri Ziegler, CBE, CVO, LM, C; Sir Stanley Hooker, CBE, FRS* (in memoriam); *Sir Archibald Russell, CBE. FRS, and M. Andre Turcat, Ld'H, G*; commemorating their outstanding international contributions to the successful introduction and subsequent safe service of commercial supersonic aircraft exemplified by the Concorde.

1984 to *Frederick Aronowitz, Joseph E. Killpatrick, Warren M. Macek and Theodore J. Podgorski* for the conception of the principles and development of a ring laser gyroscopic system incorporated in a new series of commercial jet liners and other vehicles.

1985 to *Richard K. Quinn, Carlton E. Tripp and George H. Plude* for the inclusion of numerous innovative design concepts and an unusual method of construction of the first 1,000-foot self-unloading Great Lakes vessel, the M/V Stewart J. Cort, which revolutionized the economics of Great Lakes transportation.

1986 to *George W. Jeffs, Dr. William R. Lucas, Dr. George E. Mueller, George F. Page, Robert F. Thompson and John F. Yardley* for significant personal and technical contributions to the concept and achievement of a reusable Space Transportation System.

1987 to *Harry R. Wetenkamp* for his contributions toward the development and application of curved plate railroad wheel designs.

1988 to *J. A. Pierce* for his pioneering work and technical achievements that led to the establishment of the OMEGA Navigation System, the world's first ground-based global navigation system.

1989 to *Harold E. Frohlich, Charles B. Monsen, Jr. and Allyn C. Vine* for the invention, development and deployment or the deep-diving submarine, Alvin.

1990 to *Claude M. Davis, Richard B. Hanrahan, John F. Keeley and James H. Mollenauer* for the conception, design, development and delivery of the FAA enroute air traffic control system.

1991 to *Malcom P. McLean* for his pioneering work in revolutionizing cargo transportation through the introduction of intermodal containerization.

1992 to *Daniel K. Ludwig* (in memoriam) for the design, development and construction of the modern supertanker.

1993 to *Heinz Leiber, Wolf-Dieter Jonner and Hans J* and Citations to their colleagues in Robert Bosch GmbH for their conception, design and development of the Anti-lock Braking System for application in motor vehicles.

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