The History of Corrugated Fiberboard Shipping Containers

Diana Twede, Michigan State University, East Lansing MI, USA

Papermaking inventions in the 1800s gave birth to the corrugated fiberboard shipping container in the 1900s. This paper tells the story of the technology development of the material. It showcases the strategic alliances between the corrugated industry and railroads, as well as the anti-trust collusion among the corrugated box manufacturers. These alliances institutionalized the new container which has, for the past 100 years, been indispensable for modern physical distribution.

Three key technological inventions in the 1800s set the stage for the mass production of paper based packaging by the end of that century: the paper making machine, the process for pulping wood and lithographic printing. The paper-making machine and the process for pulping straw, wastepaper and wood provided the cheap materials. (Twede 2005b)

By the early 1900s, these inventions reduced the cost of paper enough to make it useful for a wide range of disposable packages. They stimulated the invention of many paper-based packaging forms and processes. Most notable among them is the (now) ubiquitous corrugated fiberboard shipping container. This invention came at the right time to supply the growing demand for packaging due to the growth of manufacturing and distribution of consumer goods.

The corrugated box came to play an essential role in developing mass marketing and distribution. But the story of its invention pales in comparison with the story of how the corrugated box was to become ubiquitous. This is a story of strategic alliances and anti-trust collusion between powerful transportation and timber industries and their customers, as well as with powerful manufacturers with national (now global) distribution.

For almost 100 years, corrugated fiberboard shipping containers have almost invisibly carried almost all goods in commerce. One might argue that modern marketing would not have been possible without such inexpensive and yet sturdy shipping containers. One might also argue that we've had precious little opportunity to explore alternatives.

Corrugated boxes continue to play a key role in marketing systems today: corrugated boxes represent almost 80% of the mass and over half (54%) of the value of packaging materials in the US (Rauch 2002 and EPA 2003).

INVENTION OF CORRUGATED FIBERBOARD

[Reference note: The sources for much of this paper are Bettendorf (1946) and Howell (1940), unless otherwise noted. They were eyewitnesses to some the industry=s early development. Howell was secretary to the Robert Gair Company, and Bettendorf was a writer for the trade press and industry association staffer. Koning (1995) presents a more complete bibliography.]

In 1856 in England, the first patent was issued for making corrugated paper. It was formed on the same kind of fluted irons used to make ruffled Elizabethan collars, and was used in men=s hats as cushioning for the hat=s sweat band.

The first patent issued for corrugated paper as a packaging material was granted in 1871 to an American, Albert L. Jones. It was a textured cushioning material for wrapping glass bottles to protect against breakage. In 1874, Oliver Long=s patents added the single and double facings to prevent stretching.

The British hatband patent was used as evidence of prior art in a patent infringement settlement that led to an alliance of three entrepreneurs: Robert H. Thompson, Henry D. Norris and Robert Gair. They maintained a manufacturing and sales monopoly on corrugated bottle-wrapping paper for the life of the patents, until the1890s. The Thompson Norris Company and Gair developed machinery, processes, and various forms of wrappers.

The early corrugated wrapping materials were made from thin straw sheets, like the straw wrapping paper of the period. A sheet was dipped in water and then passed through heated fluted rollers. A typical bottle wrapper was single-faced with the facing extending past the corrugated paper to fold in neatly around the neck and at the bottom. Some were gummed for convenience, and some were pre-made into cylinders. The material was also used for nests and pads as dunnage (void filler) inside wooden boxes.

When the bottle wrap patents ran out in the 1890s, Thompson and Norris developed the first double-faced board. Single-faced board would be unrolled, glue was

applied to the second liner by a series of brushes, and the plies would be combined as they were pulled through the machine, which was stopped to cut off the sheet; in later machines, glue would be applied only to the tips of the flutes. They invented a rudimentary process for setting the glue under pressure: the machine operators piled up several sheets, covered them with boards and Awould tramp around this board to give the necessary weight to make the liners adhere@ (W. G. Chapin, quoted by Howell 1940).

In 1894 Thompson and Norris produced the first double-faced corrugated boxes for light express deliveries in New York City. The new box was tested by a Wells Fargo office that was Apleased to say has borne without damage, such handling as it would probably be called upon to stand in ordinary transportation,@ and their agent recommended them to other Wells Fargo shippers. (W. B. Lindsay, quoted by Bettendorf 1946)

ALLIANCES WITH RAILROADS

Throughout history, the makers of shipping containers have always had a strong relationship with the transport industry (eg. Twede 2003 and 2005a). But the marriage between the US fiberboard shipping container industry and the railroads, which came to ensure the success of corrugated board, did not start out as a love affair.

The first serious effort to use corrugated fiberboard boxes for rail transport was about 1903, when a cereal manufacturer secured an exception to the wooden box requirement of the railroads in the Central Freight Association territory. This motivated nine manufacturers to unite in 1905 in a remarkable cooperative effort between competitors. The members were Thompson & Norris, Hinde & Dauch, J. W. Sefton, McPike Paper, Charles Boldt, Hunt & Crawford, J. N. Hahn, Modes-Turner Glass and Lawrence.

The first association was called The Progress Club and became the Corrugated Paper Patents Company. Their goal was to standardize the material and make it fully acceptable to all of the railroads. Through a series of trade associations (culminating in today's Fibre Box Association) they drafted specifications, and in 1906 they applied to the Western Classification Committee of the railroads to permit the use of corrugated fiberboard boxes.

At the same time (1904), the solid fiber shipping container was being developed by the Illinois Fibre Box Company in Chicago. Solid fiber boxes were made from 3 or 4 sheets of flax or jute board pasted together with animal glue. The first ones had wooden frames, because the material was hard to crease, until George Swift developed a creasing machine in 1909. The W. K Kellogg Toasted Corn Flake Co. was the largest user of the boxes produced by the Illinois Fibre Box Co., which moved its manufacturing operations to Battle Creek, Michigan in 1907 in order to better meet Kelloggs= demand.

The Illinois Fibre Box Company also petitioned the Western Classification Committee in 1906, and joined the corrugated manufacturers in a July hearing at Frankfort, Michigan. As a result, the Western Committee accepted both kinds of boxes, as did the Eastern Committee in the same year, but they also authorized a 10% higher freight rate.

The railroads argued that the higher rate was justified because fiberboard quality was considered to be mostly poor, and if goods were damaged in transit, the railroad was liable. They also argued that they would lose freight revenue because of the corrugated box=s lighter weight and smaller size.

In defense, quality standards were developed by the Corrugated Paper Patents Company and the Illinois Fibre Box Company, which joined other solid fiber box makers in 1909 to form the Fibre Shipping Container Association. Thirteen years later, the two industries joined to form one organization: The National Association of Corrugated & Fibre Box Manufacturers.

They standardized corrugated board properties and box weight limits, based on the thickness of facings and bursting strength. Bursting strength was based on the MullenJ tester. It had been developed in 1887 by John W. Mullen for testing paper, and by 1907 a jumbo sized version had been adopted by the Government Printing Office for testing book cover boards (Bettendorf 1946). It was also used by the textile industry for testing knit fabrics. The standards appeared in all three freight classifications in 1910, and when the three were merged in 1919, it was published as *Rule 41,* which exists to this day.

More and more types of goods began to be shipped in fiberboard boxes. Mass production and distribution were multiplying markets. Besides cereal and lamp chimneys, RSCs were used in 1906 for glass-packed goods, starch, sugar, baking powder, candy, hardware, housewares, drugs, stationery, rubber goods, shoes and soap. In 1910, the US Bureau of Explosives approved fiber boxes for packaging Strike Anywhere matches. By 1916 they were also used for canned foods, matches, cigarettes and other tobacco products, blankets, clothing, chewing gum, chemicals, kitchen cabinets and other furniture. In the 1920s their use would extend to products like radios, paint and department store goods. (Browder 1935)

But the railroads continued to charge a higher freight rate. The Western railroads were especially resistant, charging on an Aexception@ basis as much as a 400% premium for shipments eastbound from California. They were concerned about more than damage. Due to federal land grants, the Western railroads had enormous timber holdings and investments in box-making sawmills, and therefore had an financial interest in favoring the use of wooden boxes in the West.

So an angry Pacific Coast boxmaker, R. W. Pridham, sued the eastbound railroads for discrimination. The Interstate Commerce Commission=s landmark *Pridham*

Decision in 1914 was a complete victory for fiberboard boxes: the ICC found that there were no transportation differences between the wood and fiber boxes, and it prohibited all tariff discrimination. The decision moved fiber boxes out of the position of being a substitute container. Howells (1940) calls it Athe Fourth-of-July of the industry.@

The ensuing cooperation gave the corrugated box the status it has today. The shipping container manufacturers and the rail, and later trucking, associations standardized corrugated fiberboard, and institutionalized it. In 1968, motor carriers adopted Item 222, similar to the railroads= Rule 41, for items carried by truck. The cooperative relationship between the corrugated board and transport industries continues today.

In the 1920s, corrugated containers overtook solid fiberboard as the packaging of choice (Fibre Box Assn. 1991). Except for a short increase in demand during WWII, solid fiber and wooden boxes gradually conceded markets to boxes made from the now ubiquitous corrugated board.

THE COMMODITY RSC

From its outward appearance, the corrugated regular slotted container (RSC) that is still the most common box style used today has changed little from that used in 1914. But in the following decades there were many changes in materials and technology and, as a result, in the structure of the industry. There were new sources of pulp, changes in the process for making the containerboard, and new processes for combining the board and converting it into boxes.

Thompson and Norris= first board were made from a thick stiff strawboard corrugated medium. Their first liners made from thick Aboiled wood pulp.@ They developed the economical one-piece regular slotted container (RSC). It is based on the idea of straight line folding and gluing similar to that used in tube style bag and carton folder-gluer machines. Experimentation with different liner stocks continued until about 1906 when jute liners were first made. From then until 1936, so called jute linerboard was most common, made from wastepaper reinforced at first with jute and later with kraft fibers.

After 1895, corrugator machinery developments quickly multiplied. The first independent machinery manufacturer was S. F. Langston in Philadelphia; his first machine, in 1895 was a singlefacer. The first machine to corrugate the medium and affix both faces was invented by in 1895 by Jefferson T. Ferres for the Sefton Manufacturing Company in Anderson, Indiana; he improved it in 1900 by adding steam-heated hot plates for drying the board and setting the glue. His machine, although it operated at only 10 feet/minute, is the basis for the corrugating machines used today.

The first board combining adhesives were simple cooked starches and flours, which were capable of producing a good bond, but limited the corrugator speed. Between 1910 and 1920, the industry switched to a quicker-drying silicate of soda based adhesive, which required less water and heat to cure than starch. Machine speeds increased to over 300 feet/minute. But silicate of soda is abrasive and over time ruined corrugating rolls, so in 1934, Jordan C. Bauer of the Stein-Hall Company developed a starch-based adhesive that would cure more quickly. The *Stein-Hall Formula* uses cooked starch as a carrier agent to keep the remaining raw starch suspended as heat at the glue line solidifies it and creates an instant bond; it is the basis for the adhesive used for corrugated board today.

RSC box-making equipment was also developed in the early 1900s. Rotary slitters and scorers were developed in 1905 by George Swift for making the blanks into tubes. Slotting was mechanized by using saws in 1902, by the Sefton Manufacturing Company, a dusty practice that continued into the 1920s along with the up-and-down slotter developed in about 1905.

In 1910, the invention of the printer-slotter by James Jones and Henry Gores, employees of the American Paper Products Company, simplified the manufacturing process. The concepts were based on rubber printing plates (developed by John Kerr in 1900), a Along way@ slitter and scorer that also printed the blank (developed by George Swift in 1905), and Samuel Langston=s 1908 printing press, which for the first time fed blanks the short way. Feeding blanks in the Ashort@ direction would come to simplify folding and gluing, too.

Automatic tapers were invented in the 1920s for making the manufacturer=s joint, but the blanks were still manually folded and fed into the machine. Once folding machines were developed and glues were improved, a gluing operation was added in the 1950s. Up until then, most manufacturers= joints were taped or stitched (stapled). One of the earliest folder-gluer machines was the Universal Comet. (Shulman 1986)

The first boxes were closed with string, which was replaced by the 1920s with case sealing glue made from silicate of soda. But as it dried, it seeped out and hardened with sharp edges that cut the fingers of workers. Later, vegetable based adhesives were used which could be automatically applied, but the slow setting speeds required 50' long compression belts. (Personal Touch 1977)

The first printing on corrugated board was with oil-based inks by letterpress. The development of flexography made possible the use of faster drying low viscosity inks. Water-based inks have the advantage of being quickly absorbed by the porous board. Flexography also had the advantage of not crushing the flutes as much as letterpress.

In 1957-60, a flexographic printing press was first added to a folder-gluer machine under the direction of Henry Kulwicki at Hooper-Swift (later Koppers). By 1970 there were approximately 2000 flexo folder-gluers in use worldwide. Flexo folder-gluers greatly improved productivity, and were able to run at speeds up to 32 times

faster than letterpress (Shulman 1986). Just as the development of lithography led to an extravaganza of color on labels and cartons, the development of flexography has led to an increasing emphasis on printing for corrugated fiberboard containers. Today, most corrugated boxes are formed and printed in flexo folder-gluer machines.

Containerboard pulp and papermaking processes have changed too. In 1924 all-kraft cylinder machine liners first appeared in Rule 41. The jute linerboard and strawboard medium had been produced on multi-ply cylinder machines, and so was the first kraft linerboard. It was made in a Bogalusa, Louisiana, juteboard mill in 1915, and in 1923 the Hummel-Ross Fibre Corporation in Hopewell, Virginia first produced kraft linerboard commercially.

In 1922 a variation on the kraft process was developed in the South that made the pulp stronger, less expensive and easier to drain, making it possible to form board on a fourdrinier machine. In 1927, the Brown Paper Mill in Monroe, Louisiana, was the first mill to produce kraft board on a fourdrinier machine. The invention of the double flow headbox for the fourdrinier machine, in 1934 by John Sale of Hummel-Ross Fiber Corp., made it possible to put a smoother (or white) surface on the linerboard or a layer of virgin kraft atop a recycled layer (as had been done by cylinder machines for many years), and this is the process still used today. A smoother and/or whiter surface improves print quality.

The introduction of fourdrinier kraft board ignited a paper industry expansion in the South which fiercely competed with the cylinder-made jute linerboard producers in the North. From 1925 to1952, as linerboard production overall quadrupled, annual juteboard production remained relatively steady and kraft=s share increased to 80% (Gates 1954).

Kraft linerboard, since it was stronger than juteboard, could be used at a lower basis weight. Whereas the original jute liners needed an 80 lb basis weight to pass the 200 lb burst test, A200 lb test@ board made from today=s kraft liners has a basis weight of half that.

The standard 0.009" corrugated strawboard medium began to be replaced in 1927 by one made from semichemical hardwood pulp. The first source was another waste product, spent chestnut chips which had been leached to extract tannin for the leather tanning industry. Chestnut pulp, like that made from straw, made a good stiff medium. This would prove to be true for other hardwoods as well, and neutral sulfite semichemical (NSSC) hardwood pulp is still used in some corrugated medium.

Once there were enough old corrugated containers (OCC) with high kraft content in service, it began to make economic sense to recycle them to reclaim their long fibers. In 1930, *bogus* medium made from OCC began to be used. (The term *bogus*, though rarely used today, refers to paper made from recovered pulp.) The recycled pulp was also used in juteboard, to replace imported virgin kraft and some of the wastepaper.

World War II was instrumental in the development of wet-strength board. There was a shortage of wooden boxes, and the regular fiberboard boxes that were sent as substitutes failed in the South Pacific where they were stored outdoors. In 1942, the paperboard mills came up first with AV@ (for AVictory@) water-resistant solid fiberboards: V1, V2 and V3. When demand quickly outstripped the capacity for solid fiberboard, the Southern kraft board mills and box makers developed *V3c* corrugated board, with heavy kraft medium and liners, glued with water-resistant urea formaldehyde resin. Its lighterweight cousin, *W5c*, was first used for inner packing of wooden boxes, but later came to be used for lighter duty water resistant boxes (Lincoln 1945). After the war, the water-resistant boxes were found to be too costly for most domestic uses (Daly 1971).

COMPETITION AND COLLUSION

The ballooning demand for corrugated board during and after the War stimulated the building of more virgin kraft mills. This new kraft supply ultimately crowded out the juteboard and solid fiber box suppliers. From that time forward, corrugated board, in the U.S., has been made with a high virgin kraft content.

The ascension of kraft linerboard dramatically changed the structure of the industry. The kraft manufacturers, corrugators and box-making industries grew increasingly integrated. Further breakthroughs in the pulping of hardwoods and pine, and the ability to make containerboard on a fourdrinier machine, brought corrugated board into the heart of the forest industries.

There has always been a powerful incentive to fix prices in the industry. Corrugated board is largely a commodity, and when the market is left to pure competition and inventory levels are high, prices can fall below variable costs. The integrated kraft/board/box producers have, since the 1930s, attempted to use their power and affiliation to maintain prices of linerboard, boxes or both. Serial offenders, they have been accused in anti-trust actions several times.

In 1939 the integrated producers were first accused of violating the Sherman Antitrust Act. They were sued for price fixing and allocating markets among themselves. In the 1930s, most of the producers did not know how to use their accounting systems to determine variable costs, and much of the early collusion was claimed to be based on attempts to standardize accounting principles. The suit was settled by a Consent Decree in which the independents agreed, without admitting guilt, to abstain from collusion. (Daly 1971)

Mergers in the 1950s further increased the market power of the large producers. The incentive to fix prices continued, and corrugated box salemen developed the informally agreed upon practice of asking their customers for a competitor=s priceBand meeting it because beating it caused the retaliatory threat of reciprocal price cutting. In

1967 the government again clamped down, suing the industry under the Clayton Antitrust Act. The result was an order to divest and the industry was ordered not to communicate between competitors about prices. (Daly 1971)

In 1976 one of the largest antitrust class action civil cases in history (brought by 58 companies on behalf of a class of over 200,000 purchasers of sheets and boxes) was brought against 37 corporations for exchanging price information, resulting in a record $550,000,000 in settlements. The most certain violations were by the integrated producers who allegedly conspired to fix the price of linerboard, although they were also accused of fixing prices for their largest multi-plant customers (Goldberg et al 1986). This coincided with an anti-trust indictment of 23 producers in the folding carton industry. (Arzoumanian 1986)

In the 1990s, when the price of linerboard doubled in two years, it happened again! Another class action suit was brought by a group of independent converters and end users. The suit alleged that the president of Stone Container, the largest of the integrated producers, had orchestrated a plan in which his fellow linerboard manufacturers would close plants and idle mills, in order to drive up the price of linerboard. Then they could charge the independents an inflated price for the linerboard as well as undercut the independents= box prices in the market. By 2003, the case=s combined settlement was $210,000,000, not including several of the end users who opted out of the class action to pursue independent lawsuits. (Duffy 2003).

Much of this litigation stems from the fact that the integrated producers control the kraft linerboard production. During the 1950s, they perpetuated the legend of the virtues of virgin kraft linerboard, which enhanced their power.

The increase in recycling in the 1990s has changed the materials again. Now most US corrugated fiberboard is still 100% kraft, but the OCC (old corrugated container) content varies depending on the state of recycling.

By the 1970s, almost every product in the US was shipped in a corrugated fiberboard shipping container. Wax impregnating, introduced in the 1960s, even made them suitable for agricultural products with high moisture contents, from fruits and vegetables to fish and meat.

Some of the first tests for corrugated board and boxes were developed by the fiberboard associations from 1916 to 1927 through the Mellon Institute of Industrial Research in Pittsburgh. In 1913 the Forest Products Laboratory in Madison, Wisconsin, started research and developed the revolving drum test, which was a little like kicking a box down an endless set of stairs. (Plaskett 1935) In 1950, TAPPI (Technical Association of the Pulp and Paper Industry) developed a Corrugated Containers Division that has been responsible for developing most of the material test methods used today. (Coleman 1990).

CONCLUSION

The low cost and light weight of corrugated boxes enabled more producers to economically employ wider distribution than ever before in history. Indeed, the exponential expansion of distribution throughout the 1900s would not have been possible without the help of the self-effacing brown corrugated RSC.

Furthermore, the exponential expansion of RSC use can be attributed to strategic alliances between the corrugated industry and transport carriers, as well as collusion between competitors. This paper has described the historical context, technology developments and the alliances that were required for success.

REFERENCES

Arzoumanian, Mark. 1986. AHas Industry Learned how to Police Itself? *Paperboard Packaging*, v. 71, n. 8, August, 32-34, 37.

Coleman, Matthew J., ed. 1990. AForty Years of Corrugated, Tappi Journal, vol. 73, no. 11, 112A 1-32.

Bettendorf, Harry J. 1946. *Paperboard and Paperboard Containers: A History*. Chicago: Board Products Publishing. Originally published in *Fibre Containers*, 1945-46.

Browder, G. R. 1935. A Story of the Fibre Box and History of its Developments. *Fibre Containers and Paperboard Mills, vol. 20, no. 8,* Reprinted in ed. G. Maltenfort, *Performance and Evaluation of Shipping Containers*. Plainview, NY: Jelmar, 1989, pp.1-7.

Cornucopia of Processes. 1977. *Paper and Film Converter*, October, 64-71, 119-129.

Daly, Grover J. 1971. *The Corrugated Container Industry B A History and Analysis*. Oak Park, IL: Harry J. Bettendorf.

Duffy, Shannon P. 2003. AHouse of Cardboard, *The Legal Intelligencer*, November 212, vol 229, no 95, 1.

Environmental Protection Agency, *Municipal Solid Waste in the United States: 2001 Facts and Figures*, EPA530-R-03-011, Washington, D.C.:U.S. Environmental Protection Agency, 2003.

Fibre Box Association. 1999. *The Fibre Box Handbook*. Rolling Meadows, IL: Fibre Box Association.

Gates, James E. 1954. AThe Kraft-Jute Containerboard Controversy,@ *Fibre Containers and Paperboard Mills*, v. 39, no. 1, January. Reprinted in ed. G. Maltenfort, *Performance and Evaluation of Shipping Containers*. Plainview, NY: Jelmar, 1989, pp. 13-22.

Goldberg, Robert C., Craig S. Hakkio and Leon N. Moses. 1986. ACompetition and Collusion, Side by Side: The Corrugated Container Antitrust Litigation@ in ed. Ronald E. Grieson, *Antitrust and Regulation*. Lexington, MA: Lexington Books.

Howell, Wilber F. 1940. *A History of the Corrugated Shipping Container Industry in the United States*. Camden, New Jersey: Samuel M. Langston.

Koning, John. 1995. *Corrugated Crossroads: A Reference*

Guide for the Corrugated Containers Industry. Atlanta: TAPPI Press.

Lincoln, W. B. 1945. ADevelopment of >V= and >W= Board

Weatherproof Corrugated Shipping Containers, *Fibre Containers and paperboard Mills*, vol 39, no. 9, Reprinted in ed. G. Maltenfort, *Performance and Evaluation of Shipping Containers*. Plainview, NY: Jelmar, 1989, pp.8-12.

Plaskett, C. A. 1935. AForest Products Laboratory Launches
Investigation of Fibre Boards,@ *Fibre Containers*, vol 20, no. 6, 6-8.

Rauch Guide to the U.S. Packaging Industry, 2002-03 Edition. 2002. Manchester Center, VT: Impact Marketing Consultants.

Shulman, Joel J. 1986. *Introduction to Flexo Folder-Gluers*.
Plainview, NY: Jelmar Publishing.

Smith, Harry Allen. 1939. *Robert Gair: A Study*, with an Introduction by Lewis Mumford. New York: The Dial Press.

Twede, Diana. 2005a. The Cask Age: The Technology and History of Wooden Barrels, *Packaging Technology and Science* 18 (5): 253-264.

_____. 2005b. The Origins of Paper Based Packaging. In *The Future of Marketing=s Past*, Proceedings of the 12th Conference on Historical Analysis and Research in Marketing, ed. Leighann C. Neilson, 288-300. Long Beach, CA: California State University.

_____. 2003. AThe Packaging Technology and Science of Ancient Transport Amphoras,@ *Packaging Technology and Science*, vol 15, no 4, 181-195.