PLASTIMACH CORP.

A HISTORY OF THE GROWTH OF THE THERMOFORMING INDUSTRY

Chapter I
Thermoforming Pioneers 1930-1950

Stanley R. Rosen

thermoipp@earthlink.net

702-869-0840

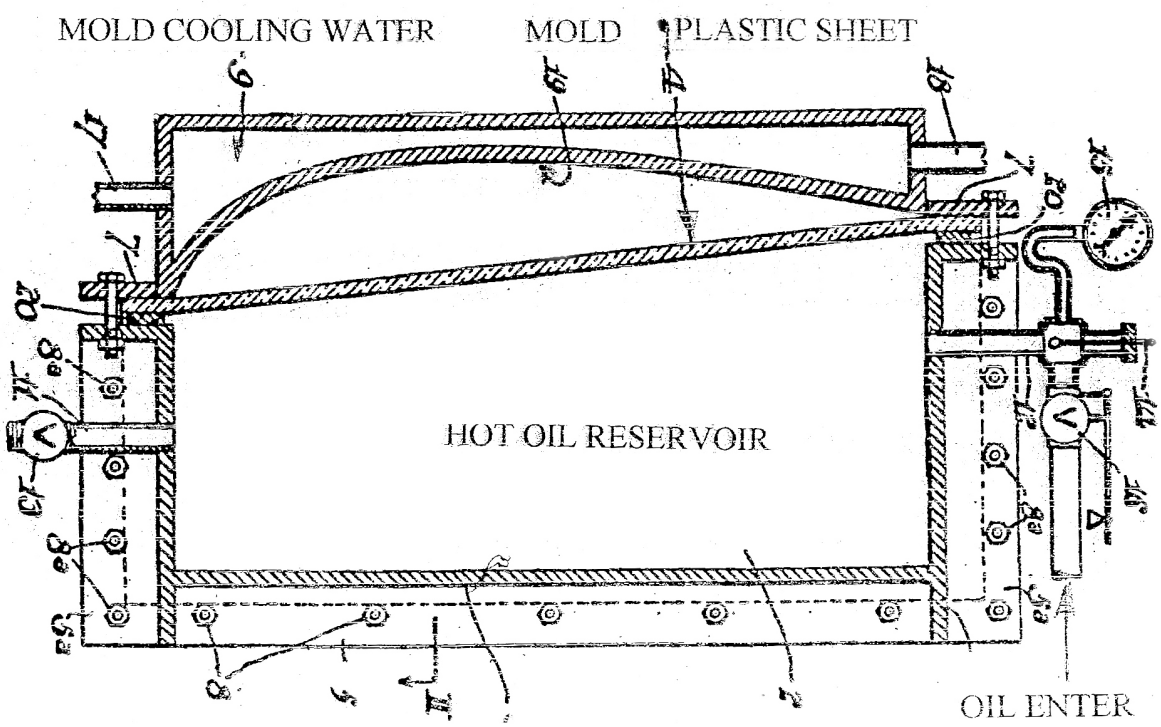
Early experiments which led up to the commercialization of thermoforming techniques.

Chapter 1

THERMOFORMING PIONEERS 1930-1950

The development of modern machinery for the thermoforming industry took place on the shoulders of very perceptive pioneers during the years 1930-1950. These experimenters did not have our modern tools or hindsight yet they developed many of the processes we currently employ. Information contained in this article was abstracted from periodicals, patents, and conversations with industry innovators. Other firms may have developed proprietary equipment to thermoform during this period.

A great deal of development effort pre-World War II went into forming airplane acrylic canopies free of flaws. E. L. Helwig of Rohm and Haas Company in Philadelphia, an acrylic resin manufacturer, has two patents using different techniques which when modified are used today.



Ill.- A H.E. Helwig of Rohm and Haas Corp. filed for a patent 11-27-1936 using hot oil pressure for forming acrylic.

ILL.-A. Helwig's patent filed on 11-27-1938 illustrates the forming of a canopy from a pre-heated sheet of acrylic forming which utilizes a hot fluid under variable pressure. The mold was water cooled so that sheet surface facing the cavity would chill and become hard enough to avoid being marred against the mold surface. The inner surface sheet would be free of blemishes since it only has contact with the hot fluid. This process is similar to a modified method used today where air pressure forms sheet against a temperature-controlled mold producing high quality parts.

ILL.-B. Helwig patent filed on 8-28-1942 describes a male snap-back technique using an oven-heated acrylic sheet which is clamped to the device with quick-acting clamps or bolts.

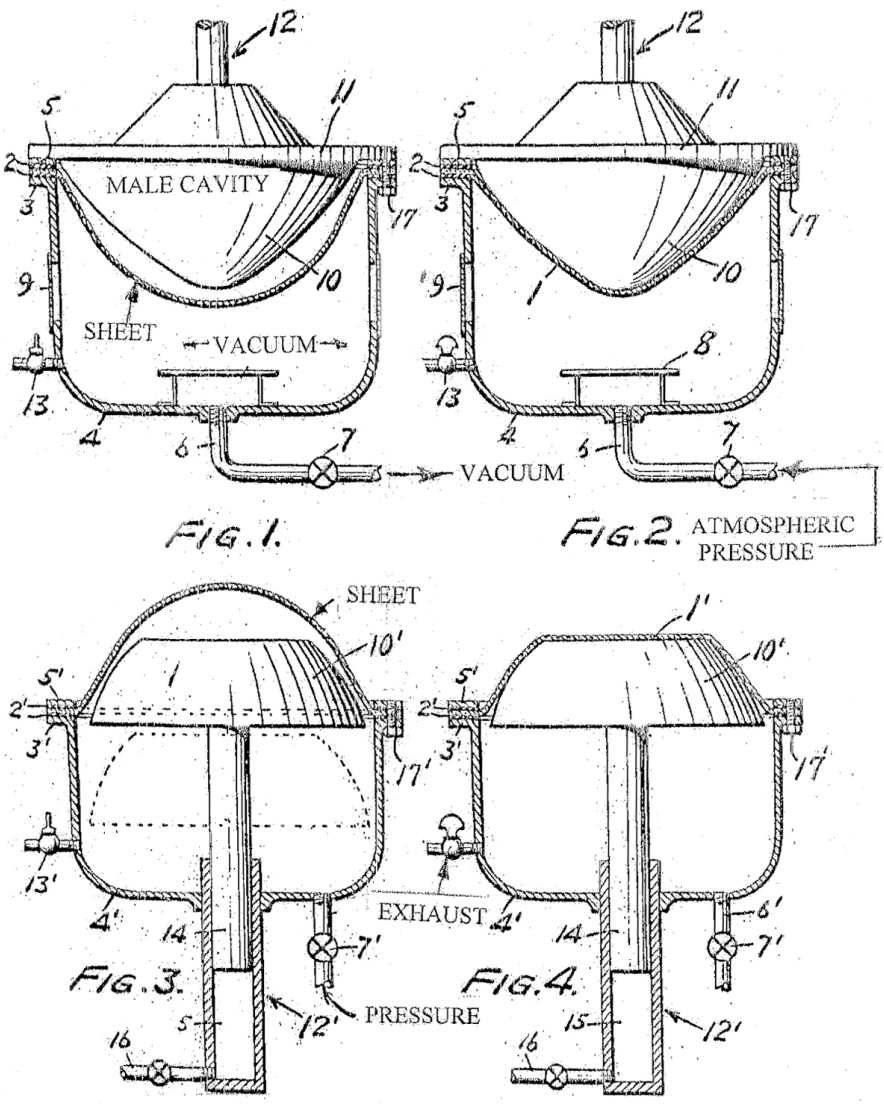


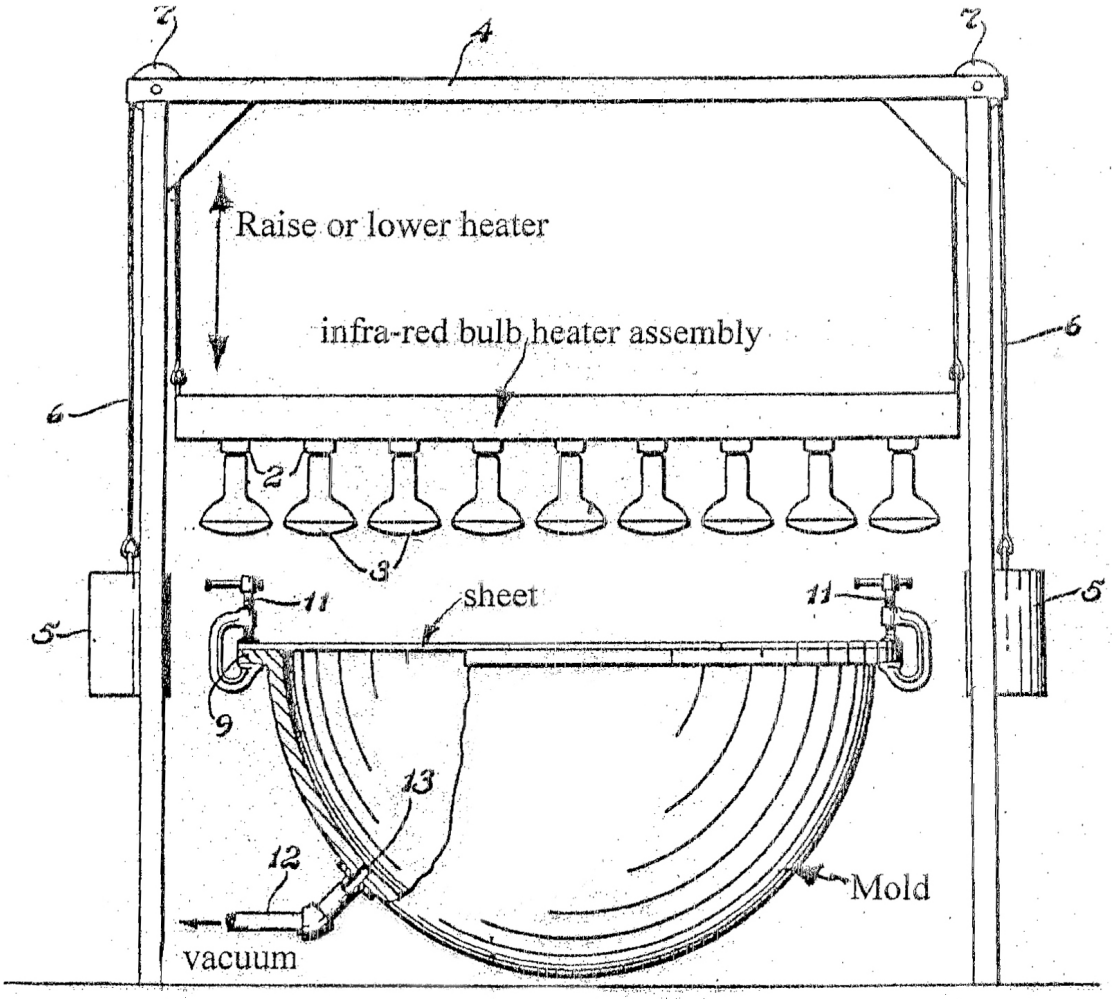
FIG. 1. FIG. 2. FIG. 3. FIG. 4.

ILL -B H. E. Helwig filed for a patent 8-28-1942 using snapback forming

Figs. 1-2 Illustrated the use of vacuum to pre-stretch the hot sheet and then allows atmospheric pressure to force the hot plastic against the male cavity.

Figs. 3-4 Air pressure creates a bubble of hot plastic which, after the air is exhausted from the chamber, the plastic sheet then snaps back to the cavity. The expansion of the surface of the hot sheet before forming is utilized to assist in producing uniform wall thickness on the finished part. This process appears to be the first patent in which a male cavity is thermoformed.

ILL.-C. R. E. Leary of Dupont Corp. patent filed 12-27-1940 illustrates vacuum forming using two methods of controlling a radiant heat source to achieve a uniform wall thickness.

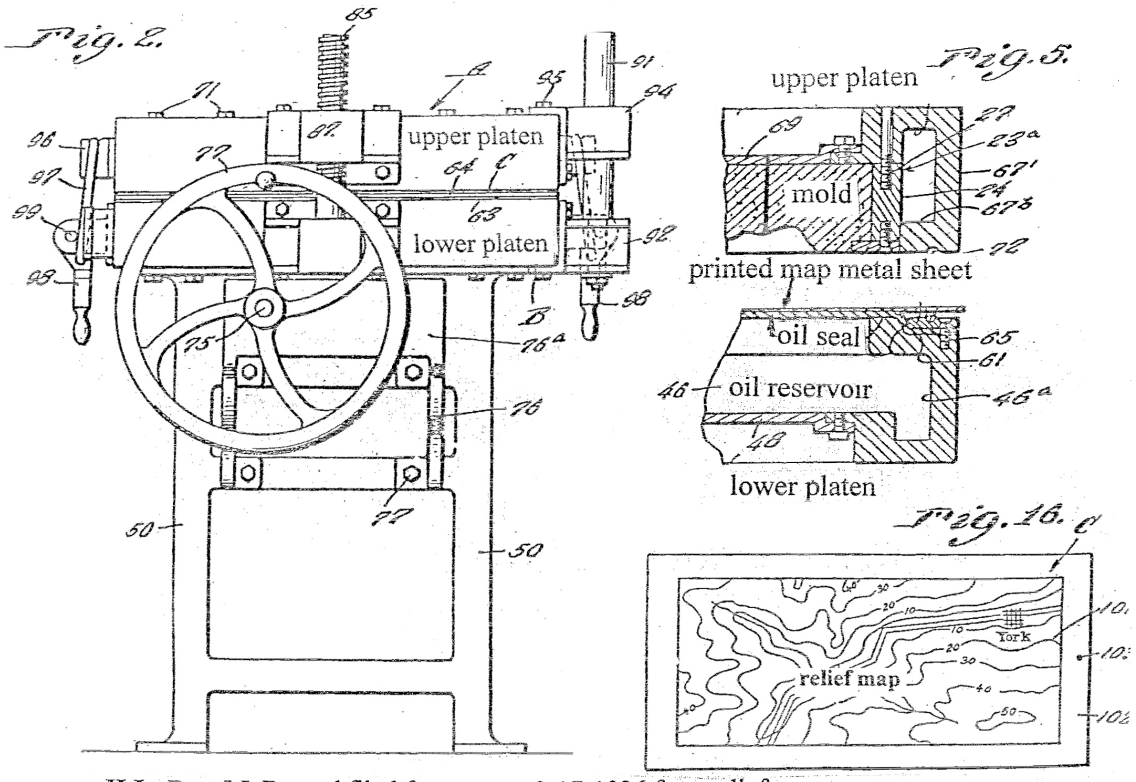


ILL.-C R.E. Leary of Dupont Corp. filed for a patent 12-27-1940 for a vacuum forming apparatus

The heater assembly can be raised or lowered relative to the plastic sheet line. Moving a heat source away from or toward the sheet is a powerful method of heat control. The distance of a radiant source to its receptor is not a linear function and a small movement can create big differences in temperature distribution across a sheet surface.

Each lamp in the heater assembly is individually controlled so that the heating pattern can be zoned to promote a uniform temperature distribution across the sheet. This patent suggests the use of radiant heating at the forming site rather than preheating the sheets in an oven and later transporting them to a mold.

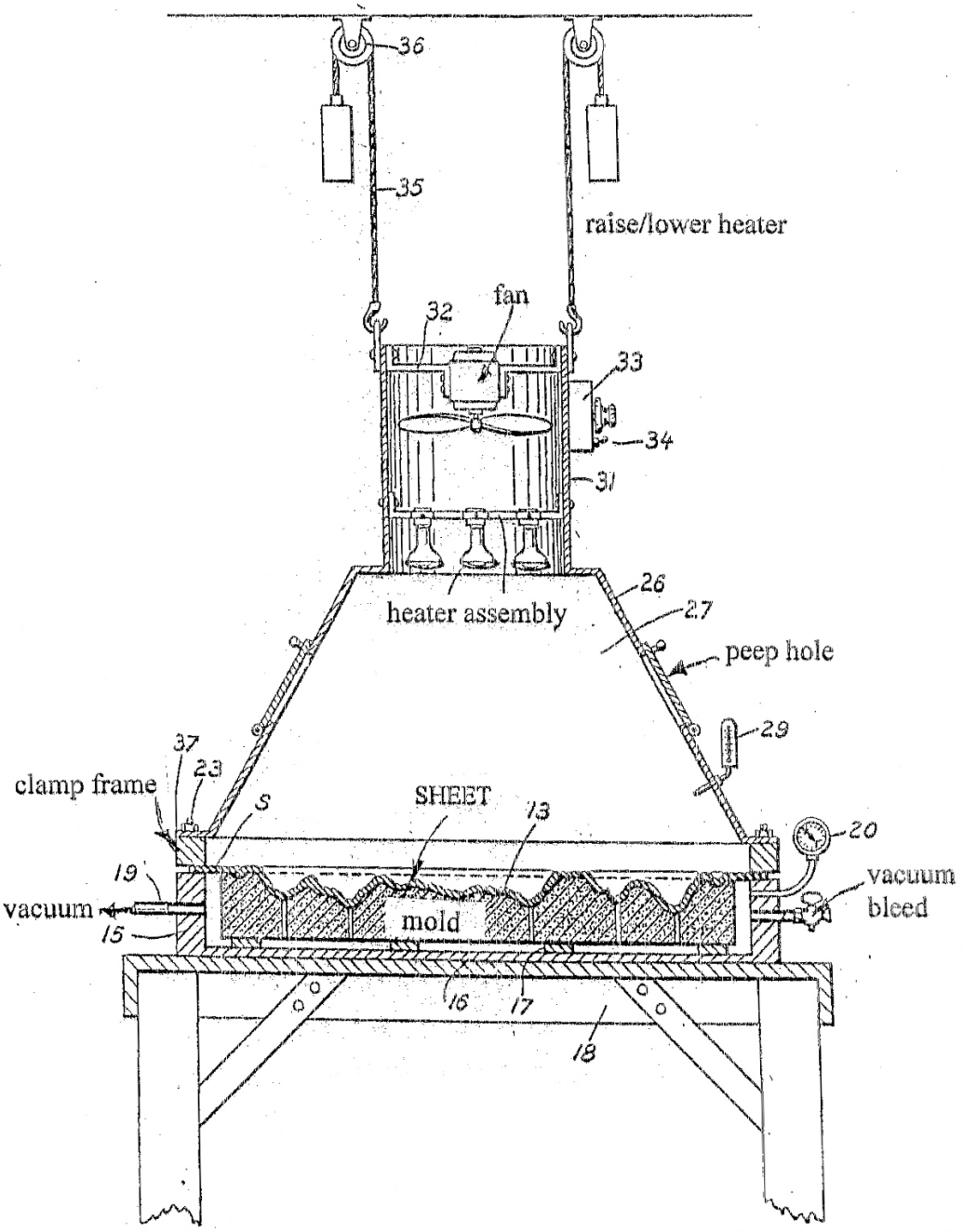
ILL.-D. J. J. Braund patent filled on 2-17-1936 is not a plastics patent but it has an interesting concept. Braund in the early 1930s started to develop a process to produce inexpensive three-dimensional relief maps for the U.S. Coast and Geological Survey.



ILL.-D J.J. Braund filed for a patent 2-17-1936 for a relief map duplicating machine

A relief map copper sheet is distortion printed with each color referring to a specific elevation. When formed, the map might use green for sea level at the sheet line and white for the tips of the mountains in the deepest part of the female mold. This technique registers a pre-printed sheet of ductile metal facing a female mold mounted above the blank. The back face of the sheet is sealed to a shallow box and the whole assembly is locked within a clamp frame. Hydraulic oil under high pressure is pumped into the box, forcing the metal sheet to flow into the mold. If the date of the above patent was 1946 instead of 1936, Braund would have been able to substitute a plastic sheet instead of metal and use air instead of oil pressure.

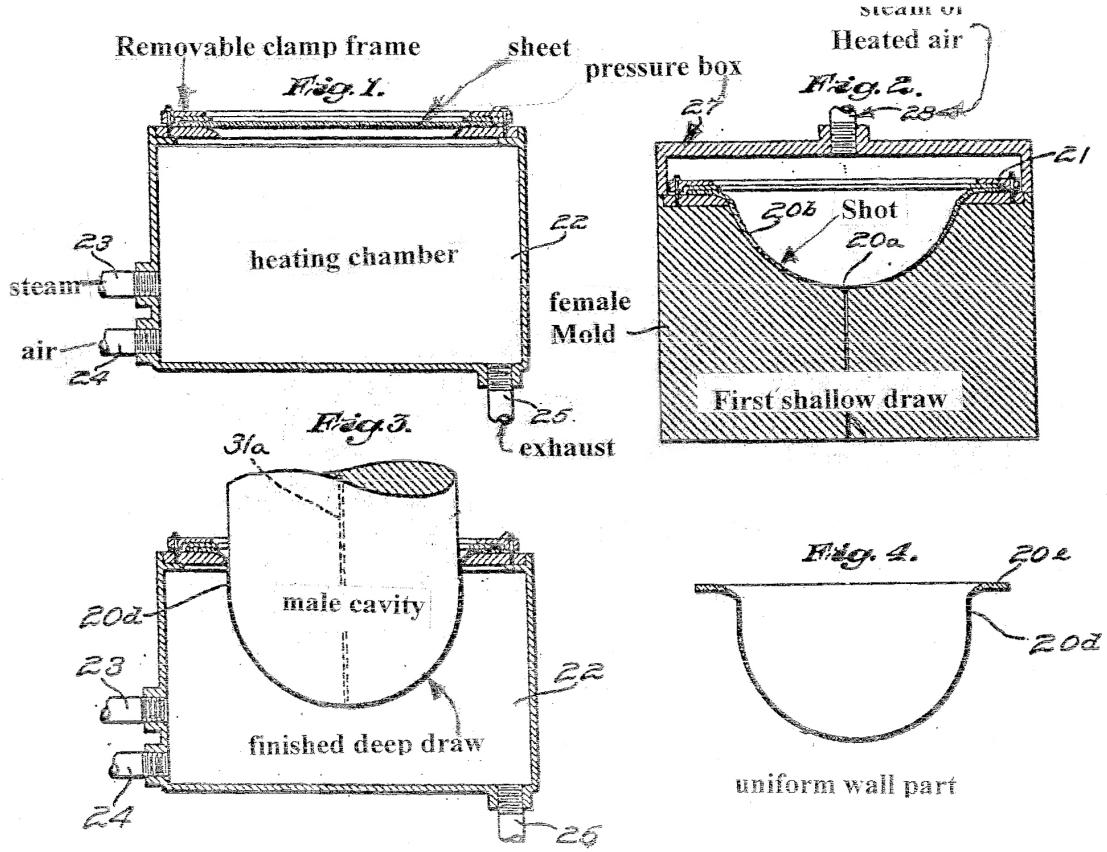
ILL.-E. J. J. Braund filed a patent on 9-24-1946 which describes a system for vacuum forming plastic relief maps similar to his earlier 1936 metal forming methods.



ILL. –E J.T.Braund filled for a patent 9-24-1946 for a relief map Vacuum Former using convection heating

This sheet heating system is analogous to R. E. Leary's radiant heat oven, except the heater fan provides convection heat transfer rather than radiant heating. The top fan creates an air flow through the bank of heat lamps which increases the air temperature within the hood and heats the plastic to forming temperature. Braund claims this method creates a uniform sheet temperature for accurate registration of pre-printed sheet to vacuum forming mold.

ILL.-F. F. E. Wiley of Plax Corp., Hartford, Connecticut, filed for a patent on 6-1-1944 concerned with forming techniques which produce a uniform wall thickness on deep drawn parts.

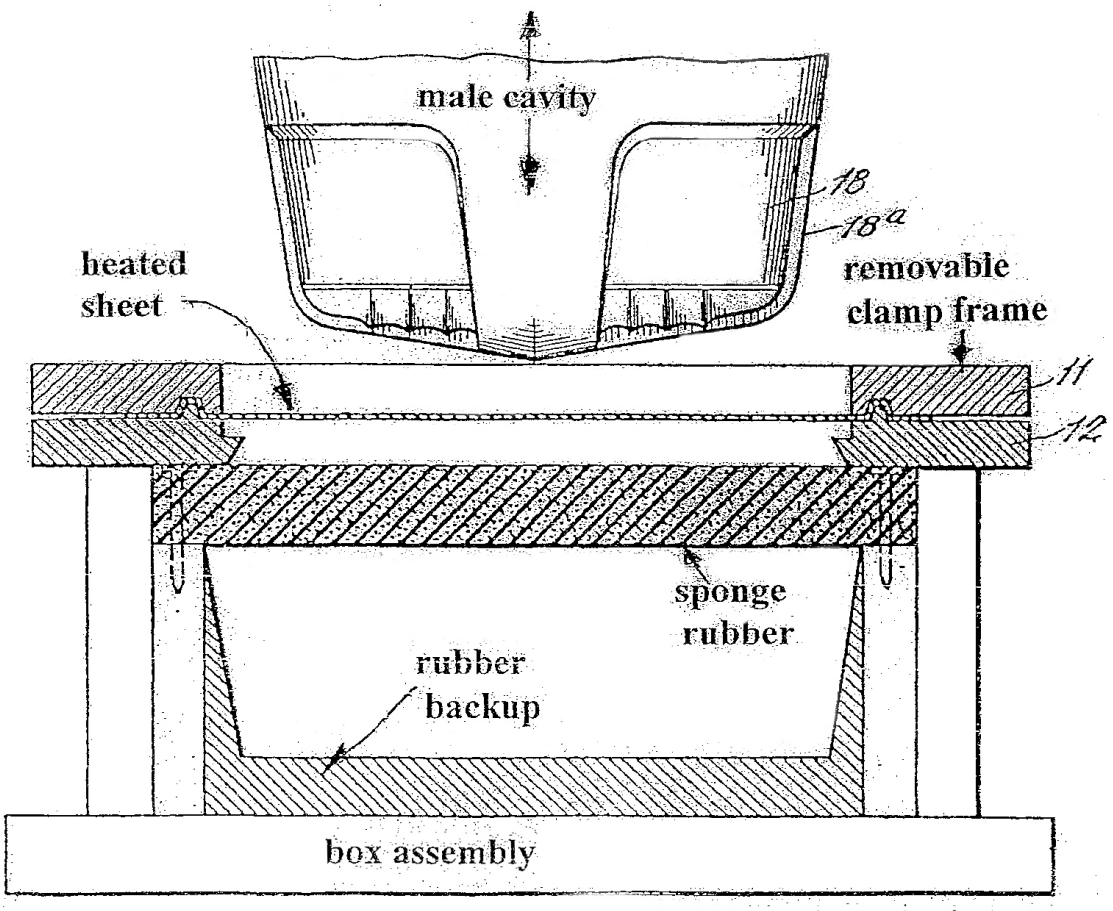


ILL. –F F. E. Wiley of Plax Corp. filed for a patent 6-1-1944 for a method of deep drawing plastics sheets.

This system is a three-step process in which the sheet is pre-heated, and in the second step is to form to a shallow depth in a female cavity. A third operation draws the sheet to the deeper finished size on the male cavity. The heating medium is steam, which raises the sheet to forming temperature in all the steps and the clamp which holds the pre-heated sheet frame is moved manually from step to step. Wiley has developed four similar variations of this technique. (Only one is illustrated as follows:)

(ILL.-F.) Fig.-1 is a steam heating chamber. In Fig.-2 a shallow female mold and sheet is heated and pressure-formed using steam and the part wall thickness is at a minimum at the bottom (***20a)*** and thickest at the sidewall (***20b)***. In Fig.-3 the formed shot is steam-reheated and male cavity (***31a)*** is extended into the shallow plastic formed part to stretch the part to full depth. After the male cavity is fully extended the steam is exhausted and the cavity (***31a)*** reaches its final depth, the cooling cycle commences. The male cavity draws material from the upper side wall ***(20d)*** and very little from the tip (***20a)*** which results in a fairly uniform wall thickness Fig.-4

(ILL.-G). G. W. Borkland of Borkland Lab, Marion, Indiana filled a patent on 10-2-1941 for forming a plastic lighting diffuser.

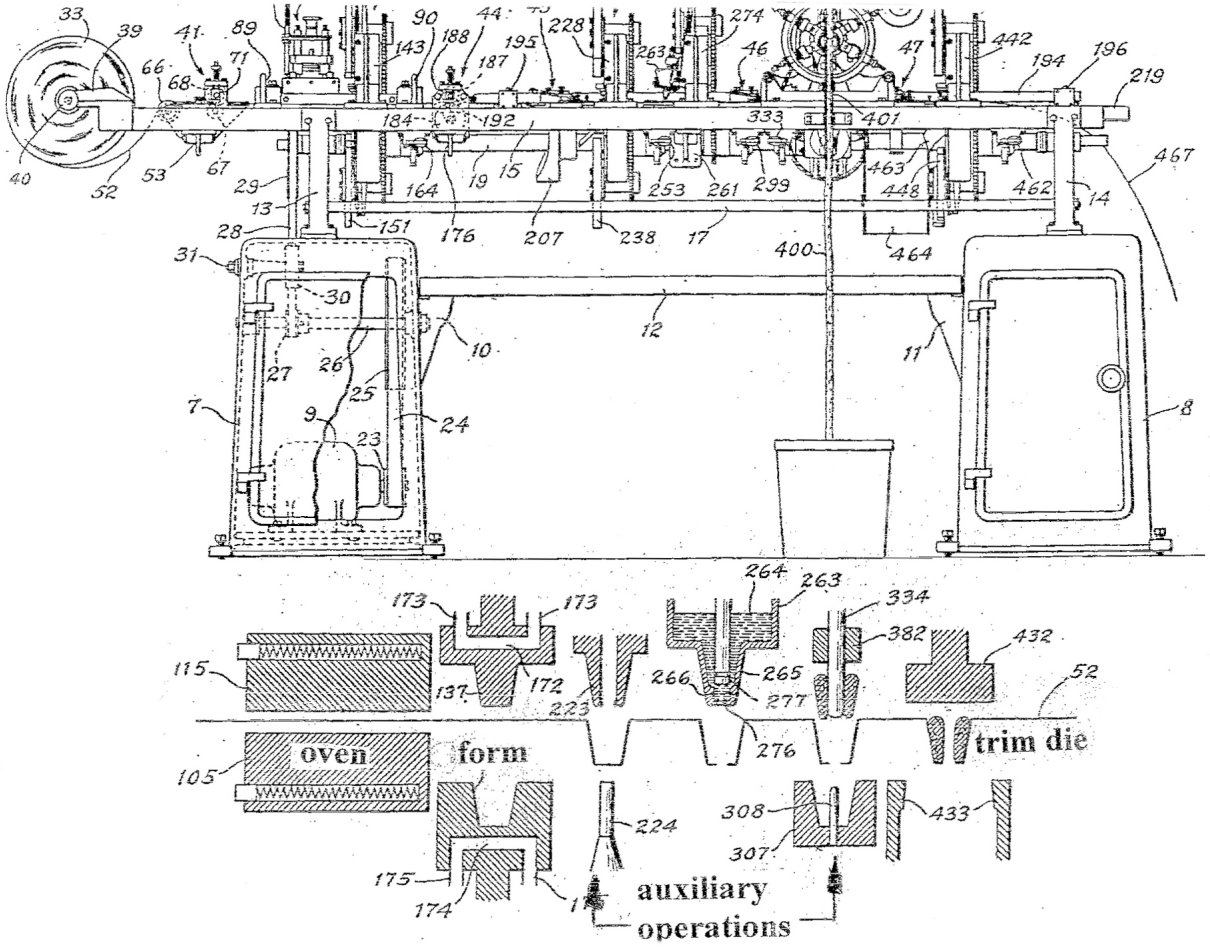


ILL. –G G. W. Borkland filed for a patent on 10-2-1941 to form decorative ribbing in a plastics part

A heated plastic sheet is held in a removable clamp frame above a box to which is fastened a soft thick sponge rubber membrane. The male cavity is mounted on an upper moving platen. The clamp frame containing the heated sheet is placed on the box and the male cavity extends forcing the sheet on to the male cavity where it cools and is formed. Sponge rubber played the part that vacuum or pressure forming does in present-day thermoforming.

All of these pioneers struggled with methods of sheet heating, clamping the sheet, vacuum and pressure forming techniques and the evolution of various ways of dealing with these problems. Helwig heated plastic with **hot oil** and Leary tried **zoned radiant heat bulbs.** Braund found that **convection (heated air**) suited his project and Wiley experimented with **steam.** Borkland's early experiments forming with **sponge rubber** was soon abandoned in favor of **vacuum forming**.

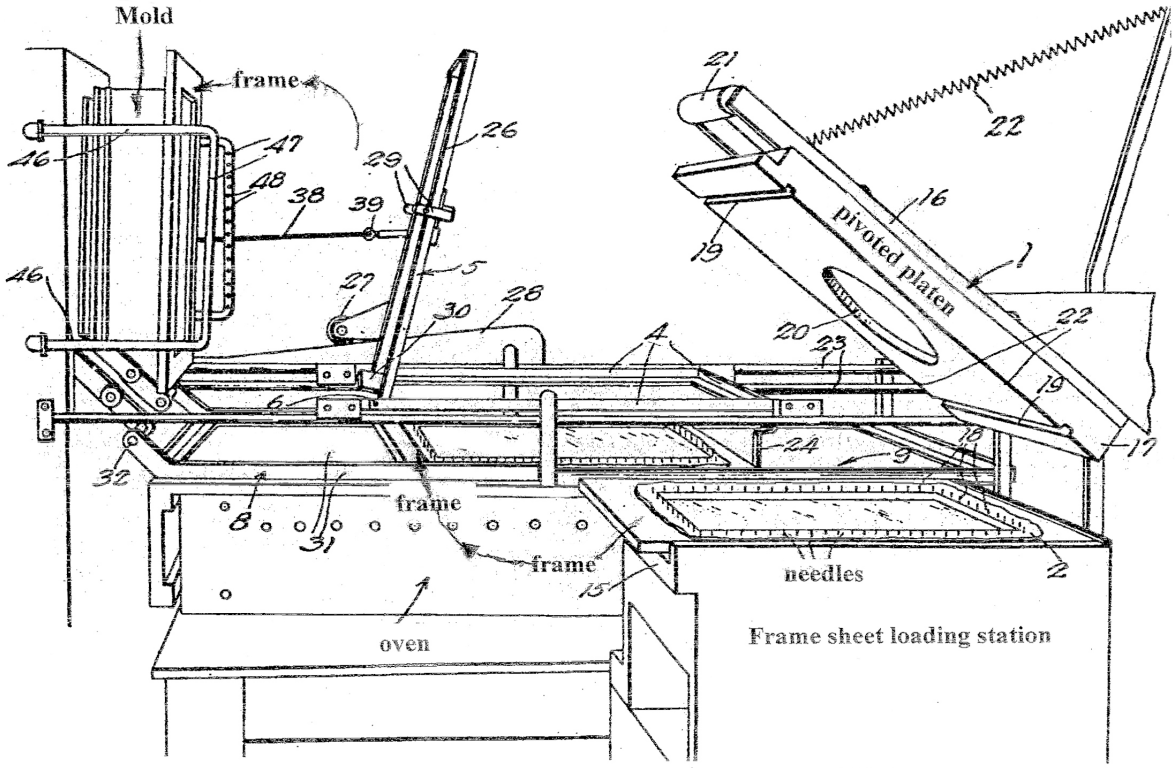
(ILL.-H). C. B. Strauch assigned to the Plax Corp., Hartford, Connecticut a patent filed 11-22-1938.



ILL. –H C.B. Strauch filed for patent 11-22-1936 for an inline thermoformer

This magnificent all-mechanical machine was the first roll fed inline thermoformer in which a plastic web entered the machine where it was formed and trimmed as finished parts. The plastic web was indexed from heating, forming and various auxiliary operations and blanked through die. Unfortunately its high productivity was its curse since in 1938 there was not sufficient high volume business to feed the machine's appetite. It successfully produced ice cube trays, Christmas ornaments and cigarette mouth tips.

Louis H. Phohl in 1938 in New York City used matched male and female wooden molds to form clear cellulose acetate domes for counter displays. He heated the plastic on a gas hot plate and transported the sheet to the molds mounted in a manual kick press where the parts were formed. His firm, Plaxall Corp., Long Island City, New York, continues today as a high-quality thermoformer and is a leader in its field. His son, Jim Phohl, describes a conference in which Louis Phohl met with Bill Simms, Editor of Modern Packaging Magazine. One topic they discussed was that **vacuum and pressure forming** is an inclusive term, and so they created the term **Thermoforming** to describe the overall process. Modern Packaging employed the word "thermoforming" in all of their articles and other periodicals picked up use of the term.

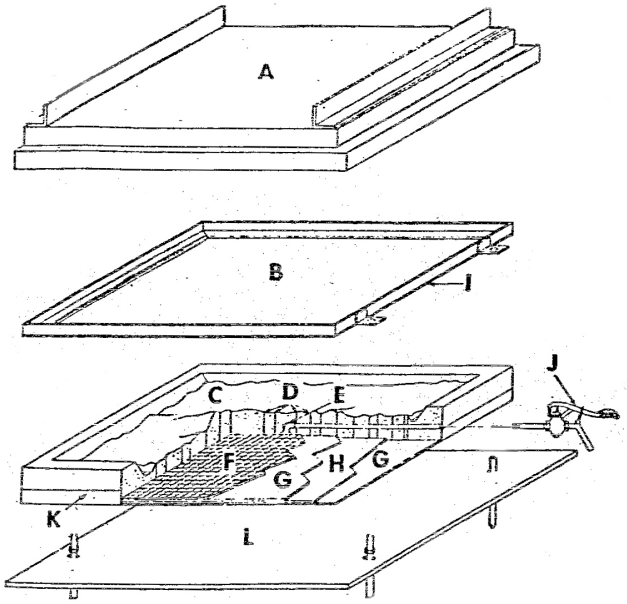


ILL. –J G.W.Borkland filed for patent 7-8-1947 for a vacuum forming machine

(ILL.-J). G. W. Borkland of Marion, Indiana filed a patent on 7-8-1947 for a vacuum forming machine. The equipment utilized individual loose single picture frames which had needles protruding upwards to impale the plastic's sheet. An operator places the plastic's sheet on the frame and manually closes a pivoted platen to force the sheet firmly on the needles. The sheet and frame are manually moved to the vacuum former where the plastic is heated in a lower oven and transferred to the mold which is mounted vertically and then vacuum formed.

Borkland had many patents issued in the 1940s pertaining to the thermoforming field and had advertised his processes in Modern Plastics Magazine to potential licensees. At the 1950 National Plastics Exhibition (NPE) in Chicago two booths showcased the first thermoformed parts at a public exhibition. Both Borkland Laboratories and Regal Plastics of Kansas City displayed their formed parts. Borkland offered thin walled vacuum formed packaging and Regal exhibited a heavy gauge motion picture machine case formed in matching wooden male and female mold cavities.

E. Bowman Stratton, Chief of the Relief Map Division, Army Map Service instituted the production of military relief maps fabricated in the equipment illustrated in (ILL.-K). His group built on the efforts of the Braund patent (ILL.-E). and produced a machine containing all of the elements of a modern vacuum former (ILL.-K).



This view shows the relationship of the essential components of vacuum-forming equipment as used by the Army Map Service in 1947 to produce three-dimensional maps: (A) superheater; (B) angle-iron frame; (C) mold; (D) vacuum holes; (E) vacuum pipe; (F) wire mesh, 2 layers; (G) aluminum sheet, 0.032"; (H) sponge rubber, ¼" to ⅜"; (I) sponge rubber gasket; (J) poppet valve; (K) heat-resistant tape; (L) aluminum plate, ½". (Courtesy, Relief Map Division, Army Map Service, Corps of Engineers, Washington, D.C.)

ILL. –K Bow Stratton's relief map vacuum former may have been the basis for the first commercial thermoformer.

Later this vacuum-forming machine was redesigned and manufactured by the Industrial Radiant Heat Corp., NJ, and were sold to commercial customers in 1950. (ILL.-L).

ILL.-L

Perhaps some of the former Army Map Service personnel founded this firm and employed Bow Stratton as sales manager in January 1952. It was the first vacuum former to be operated and displayed at the Fifth National Plastics Exhibition in Philadelphia, Pa. in March 1952.

Modern Plastics Magazine, May 1952, reviewed the exhibition and wrote the following glowing report…

> Rigid vinyl was also involved in the Industrial Radiant Heat Corp. exhibit which perhaps attracted more continuous attention than ***any other booth in the show***. The product on exhibit was the company's machine for vacuum forming thermoplastic sheet. Most of the sheets being vacuum formed were rigid vinyl, although the suitability of the machine for forming polystyrene, styrene copolymer, acetate, and even thin acrylic sheets was also demonstrated. The machine exhibited was designed for manual operation and employed an infra-red ***Super-heater** to soften the thermoplastic sheet prior to forming.
>
> ***Super-heater consists of an oven box with a fiberglass cloth fastened to the open face of the assembly. Nichrome (toaster) wire is stitched into a heating pattern and connected to an electrical source.***

The operation of the vacuum forming machine and the attention it attracted effectively dramatized the possibilities of this long-neglected process. The significance of the process as a possible alternative to injection molding for the production of large but essentially simple pieces was the subject of much comment. Some observers noted that the piece was almost as large as the inner door of a refrigerator. Others spoke of the possibility of extruding a thermoplastic sheet and vacuum forming it while still warm as

fast as it is extruded, thus creating a production setup with vast possibilities for high speed output of numerous end products.

Modern Plastics Magazine, February 1953 reported the following news item:

> **Auto-Vac Co.,** 2120 Post Rd., Fairfield, Conn., is a new company producing vacuum forming machines. The new machines include a wide range of sizes and new design features for rapid, economical production. A small-pilot-plant machine sells for about $1,500; a single-table operation machine is priced around $5,000; and a two-table machine at $10,000. The company is also setting up a product development and testing department to further the growth of the vacuum forming process. Several machines have already been installed with deliveries running from four to eight weeks after receipt of order.
>
> The company has been organized by **E**. **Bowman Stratton**, who helped develop the Army Map Service vacuum process for making contour maps from plastic sheet, and **R. L. Butzko**, formerly of Noma Electric Co.

Bow Stratton marketed this line of vacuum formers by means of magazine articles, seminars, shows and technical society papers. By the end of 1953, many entrepreneurs became very interested in this process. Bob Butzko was an experienced engineer who quickly redesigned the early models of equipment to stand up to industrial conditions. The oven and its controls were upgraded as well as the clamp frame, pneumatics and mechanical features. A half dozen thermoforming machinery building companies began competing within a year of AutoVac's founding giving thermoforming processors a variety of purchasing options early on.

The golden age of thermoforming, 1950-1960, finally had the tools to bloom.

REFERENCES

THERMOFORMING PIONEERS 1930-1950

Plastics History USA by J. Harry DuBois 1972 Cahners Publishing Co. Inc. Library of Congress No. 79-156480

Patent Nos. 2,142,445 filed 11-27-1936 and 2,365,637 filed 8-28-1942 by E. L. Helwig

Patent No. 2,377,946 filed 12-27-1940 by R. E. Leary

Patent Nos. 2,066,555 filed 2-17-1936 and 2,493,439 filed 9-24-1946 by J. J. Braund

Patent No. 2,468,697 filed 6-1-1944 by F. E. Wiley

Patent Nos. 2,347,806 filed 10-2-1941 and 2-559,705 filed 7-8-1947 by G. W. Borkland

Patent No. 2,229,613 filed 11-22-1938 by C. B. Strauch

Phone conversation with Jim Pfohl of Plaxall Corp., Long Island City, NY December 2004

SPI (NPE shows) archives from Hagley Museum and Library, Wilmington, DE for exhibitors 1950, 1952

Modern Plastics and Modern Packaging Magazine, issues 1950-53 Plastiscope columns, Feb 1952, Sept. 1952, Feb. 1953

Army Map Service, Relief Map Div., Corps. Of Engineers, Washington, DC