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CCEA Newsletter

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The Center for Controlled Environment Agriculture is a research organization dedicated to the improvement and vitality of the Controlled Environment Agri-culture Industry. CCEA is funded by industrial and grower partners who voluntarily contribute a yearly partnership fee. For more information contact:
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Vision Statement
CCEA, The Center for Controlled Environment Agriculture of NJAES at Rutgers University, a partnership among growers, industry, and researchers, will devote itself to research and transferring information required for an economically viable and environ-mentally aware controlled environment agriculture industry. We will particu-larly strive to identify future trends, critical issues, appropriate emerging technologies and provide leadership for opportunities which challenge world-wide controlled environment agriculture in the 21st century.

In this issue:

Happy Holidays!

The first air-inflated double-layer polyethylene greenhouse in the world (photo from the mid 1960s).

ASAE Historic Landmark

In the fall of this year, ASAE (Society for Engineering in Agricultural, Food, and Biological Systems) awarded Rutgers University an Historic Agricultural Engineering Landmark for the development of the first air-inflated double-layer polyethylene greenhouse (AIDLPG) developed by Professor Emeritus William J. Roberts. To date, only 42 such Historic Landmarks have been awarded. A list of these landmarks can be found on the ASAE web site: http://www.asae.org (click on awards).

We are in the process of organizing a dedication event commemorating the development of the AIDLPG. A date has not yet been determined, but we will keep you informed through future newsletter issues. A likely date will be some time during the second quarter of 2004.

During the dedication ceremony, a commemorative plaque will be unveiled showing a sketch of the first AIDLPG followed by a brief description of the Historic Landmark and its developer.

Starting on the next page is the text of the Landmark submission as it was presented to the ASAE Historic Commemoration Committee. The text describes some of the history behind the development of the AIDLPG, as well as its impact on greenhouse production worldwide.

HISTORIC AGRICULTURAL ENGINEERING LANDMARK

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
2950 Niles Road
St. Joseph MI 49085-9659

Name of Landmark: **Air-inflated double-layer polyethylene greenhouse (AIDLPG)**
Located at: Rutgers University, Cook College, New Brunswick, NJ 08901

In support of this nomination the following information is provided:

a. Location and date of construction or other significant date:
May, 1964, Rutgers University, Cook College, New Brunswick, NJ.

b. Name, title, and location of key person (s) associated with the project, such as inventor, designer, engineer, constructor, etc.
William J. Roberts, Professor Emeritus, Rutgers University, New Brunswick, NJ

In the early 1960's, as extension Agricultural Engineer, Bill Roberts was working with some growers who were using low-cost polyethylene film on simple wooden frames to construct greenhouses used primarily for spring transplant production and for bedding plant operations. One early concern was the tendency for a single layered roof to collect condensation that dripped on the small seedlings causing problems. To ameliorate this problem, a second layer of film was added by fastening it to the underside of the frame creating an airspace, and keeping the inner layer warmer. This was a cumbersome process so the next step was to install a single layer over the frame and fasten it to the rafters with 2x2 spacers then add on a second layer on top of the 2x2's and fasten it down with a 1x2. This was an improvement but still required two fastening steps for every rafter.

There had been some experimentation at Rutgers University on using a fan to create a bubble house from a single sheet of plastic with the edges buried in the ground. Recognizing the importance of the double layer covering on a greenhouse to reduce condensation, Bill tried fastening two sheets together around all four edges and used a small, low-pressure fan to inflate the space between. The proposed landmark is the first greenhouse on which this concept was successfully applied and is a wooden frame structure designed for the width of polyethylene sheeting available at the time. It was quickly noted that not only was there a significant reduction in the required construction materials and labor time, but the tension in the film due to the slight air pressure reduced the film flexing and flapping in the wind, reducing the likelihood of tearing the film, thereby increasing structural reliability and extending film life.

This concept was next applied to a portion of a large, gutter-connected commercial greenhouse in Allentown NJ, (Kube-Pak, Inc., then managed by Aart Van Wingerden). Several companies then developed frame structures for multi-span and single span structures. Probably first among these were Van Wingerden with steel frames and PolyGrower with aluminum. Bill also designed wooden greenhouse frames of several sizes to match available film widths, as well as a pipe frame structure and pipe bender to assist hand bending of the hoops. He developed the engineering plans and drawings for these easy-to-construct greenhouses. These plans were made available through the extension plan service. The early popularity of these designs and their rapid commercial acceptance was due primarily to their low-cost relative to conventional greenhouses glazed with glass or fiberglass. It was also noted that the insulation properties of the inflated air space reduced heat requirements by over a third, which became a more highly appreciated advantage in the years of the energy crisis from 1973 on. Finally, it should be noted that this development could not have taken place when it did nor have spread into commercial practices so

rapidly and broadly without the contributions of commercial growers who took the early risks. The leaders among these would be Aart Van Wingerden and Kenneth Bryfogle, who also started the first companies to provide gutter connected structures of steel and aluminum, respectively, and Frank Stuppy who developed the first extruded aluminum film fastener.

David Mears worked with Bill Roberts on some aspects of the early research and contributed the engineering analysis of film stress as related to the geometry and size of the coverings and the structural loads. Later, Dr. Mears and a series of graduate students advised by him and Bill did further research on structural aspects, energy conservation and management, film properties and other issues associated with a series of advances in the technology. The key to all of these advances was the simplicity and functionality of the concept of using air to inflate the space between the layers, a concept that was developed by Bill.

c. Engineering historical significance of this landmark.

The development of the first AIDLPG in the world led to a variety of commercial greenhouse designs, which resulted in a significant reduction in greenhouse construction and heating costs.

d. What unique features or characteristics set this proposed landmark apart from others?

The first AIDLPG in the world was constructed at Rutgers University. The original prototype has been maintained and is still on the site.

Today, there are many companies manufacturing a wide variety of greenhouse designs around the world utilizing this principle. While much of the research at Rutgers University leading to subsequent advances in greenhouse engineering has been conducted in other facilities, the original structure has also been used continuously for a variety of research studies. It was also the first unit in which developments in floor heating and movable insulation/shade curtains were attempted. The method of fastening the film has been upgraded from the original wooden strip fastening method (Roberts and Mears, 1969) to aluminum extrusions. Otherwise, the greenhouse frame is the original to this date.

e. What contribution did this landmark made toward the development of:
   1. the agricultural engineering profession?
   2. the nation?

1. The development of the AIDLPG led to the introduction of a number of commercial designs that have been used around the world. Following the initial development of the basic structure there followed many research projects including studies of greenhouse film material characteristics, greenhouse heating system design and management, and optimization of environmental control strategies. These studies contributed significantly to the development of movable thermal curtains and root zone heating systems. These research efforts were highlighted in Resource Magazine (ASAE, March 2000 issue) as one of the outstanding achievements in agricultural engineering in the 20th century.
2. In 1999, approximately 9,250 ha (23,125 acres) of AIDLPGs were in production in the US (682,050 ha or 1,705,125 acres worldwide) (Takakura and Fang, 2002, Climate under Cover, 2nd edition, 190 pp.). Approximately 65% of all commercial greenhouses in the United States use the air-inflated system. While to total area for greenhouse production may seem small, production in these greenhouses occurs year-round, often producing multiple high-value crops. Therefore, the production on an area basis is much higher in greenhouses compared to field production. In addition, especially in lower-income countries, the AIDLPG is the only economic alternative for year-round production helping local farmers secure living wages and providing the local population with affordable produce even when adverse weather conditions prevent outdoor production. The to-

tal worldwide area in 2003 is estimated at 3,000 square miles (based on the 1999 data --Takakura and Fang, 2002-- plus 12%, representing a 4% annual increase which was the annual increase reported between 1991 and 1999) or roughly the size of the states of Delaware and Rhode Island combined.

f. In further support of this nomination, the following references are submitted:

Roberts, W.J. and D.R. Mears. 1969. Double covering a film greenhouse using air to separate film layers. Transactions of the ASAE 12(1):32-33, 38.

Roberts, W.J., M.K. Kim, and D.R. Mears. 1972. Air inflated and air supported greenhouses. ASAE Paper No. 72-404.

Mears, D.R., M.K. Kim, and W.J. Roberts. 1976. Structural analysis of an experimental cable supported air-inflated greenhouse. Transactions of the ASAE 19 (5):915-919, 924.

Simpkins, J.C., D.R. Mears, and W.J. Roberts. 1976. Reducing heat losses in polyethylene covered greenhouses. Transactions of the ASAE 19(4):714-719.

Simpkins, J.C., D.R. Mears, and W.J. Roberts. 1984. Evaluation of an experimental greenhouse film with improved energy performance. ASAE Paper No. 84-4033.

The first air-inflated-double-layer polyethylene greenhouse in the world 2003.

The next column shows AIDLPGs constructed in the USA, Taiwan, and the Netherlands.