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THE M.C.GILL DOORWAY

New Vistas in Composites

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20 Years Aborning: THE CHAIR OF GILL

"The M.C. Gill Chair of

The M.C. Gill chair may be the first rocker in 600 years. It evidences the company history of innovation and in no way connotes a leisurely attitutde or that we've "got it made".

THE CHAIR... *a Tradition of Endowment for Academic Achievement*

The tradition of endowments to recognize the furthering of academic achievement dates back more than 600 years. During the 16th century, the English embellished the academic tradition with symbolism—the award of an actual chair, at the time a household possession affordable only by kings and bishops—to signify a professor's almost royal stature in the world of learning. The purposes of funding a chair are to attract distinguished educators and to support their research and teaching needs, including equipment and reference materials. In short, the chair becomes a vehicle to promote and perpetuate academic excellence in a given field.

As many Doorway readers know, M.C. Gill graduated from the University of Southern California's (USC) School of Engineering with a B.S. degree in Chemical Engineering. Since his graduation in 1937, he has maintained close ties with the University and has long promoted a formal program for composite materials as an integral part of the Engineering School's curriculum. In 1978, he put his money where his mouth was by pledging the initial payment on an endowment to be used for furthering the study of composite materials. In keeping with a Doorway editorial policy of periodically reviewing and updating the academic side of the M.C. Gill Corporation, what follows is a somewhat abbreviated chronology of the M.C. Gill Chair of Composite Materials.

1978

"Reinforced plastics should be given the same emphasis as steel, aluminum, wood, and other structural materials. College students should be acquainted fully with these important new materials."

This quote was taken from remarks made by M.C. Gill twenty-one years ago when he pledged $250,000 to USC's Engineering School to endow an academic chair for the study of reinforced thermoset polymeric materials, later to be known as composite materials.

Elaborating further on his reasons for the gift, M.C. stated that, "At the minimum students should be familiar with the basic electrical, physical and mechanical properties of reinforced plastics. We anticipate that as more students see and appreciate the technology and challenges of the reinforced plastics industry, more will enter it as a career. And, they will come better prepared. It is something they MUST know in order to keep up in the materials field."

1980

The Outstanding USC Engineering Alumnus Award was presented to M.C. for his contributions, both monetary and time, to furthering the study and understanding of composite materials.

1988

M.C. presented the School of Engineering the largest in a series of financial gifts culminating in the M.C. Gill Chair of Composite Materials. Although the original 1978 pledge described above was supposed to have represented a substantial portion of the total endowment, for reasons difficult to explain, the funds were not sufficient and insufficient action was taken to establish the chair or attain the goals M.C. had set forth.

However, with the appointment of Leonard Silverman as Dean of the School, the wheels of progress turned at

Composite Materials" at USC

M.C. presenting the endowment for the M.C. Gill Chair of Composite Materials to Dr. Leonard S. Silverman, Dean of USC's School of Engineering.

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Research and Initiat

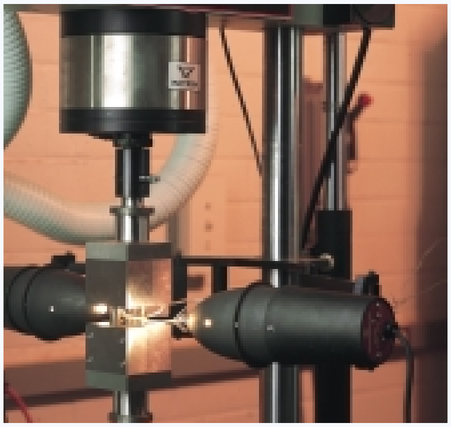
Dr. Steven A. Nutt, holder of the M.C.Gill Chair of Composites

Prior to his appointment, much of Dr.Nutt's work dealt with inorganic composites including ceramics and metals. He was asked to expand that scope to include organic composites. The M.C. Gill endowment allowed him to continue his own research and to expand on the opportunities offered in industrial composites.

An integral part of Dr. Nutt's initial efforts was to become acquainted with Southern California industry leaders..."to get them to better understand what they need and expect from composite materials. Ultimately, the objective would be to take that information and design materials from the atom up," he explained.

Currently, Dr. Nutt directs the Center for Composite Materials. This includes the activities of the staff—six faculty members, four postdoctoral associates, 20 graduate students and 12 undergraduate students.

The dynamic mechanical analyzer determines the mechanical properties of material as a function of temperature. Dr. Terry Creasy, Assistant Director of the Composite Center, demonstrates the loading of the sample.



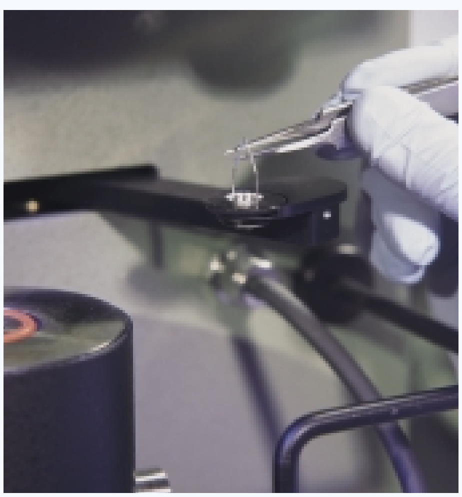
Quartz lamps enable this Instron machine to test in tension or compression (shown) at temperatures as high ae 2500°F while heating the samples within seconds. At USC, temperatures that range from 1400° to 2000°F challenge the performance of polymer matrix composites using the newest high-temperature formulations.

This CNC profiler is used to make tooling and patterns for contoured parts. The operator, Ms. Siari Sosa, is a Ph.D. candidate.

ives Driven By Industry

This high-power light microscope allows maximum magnification of polished polymer and composite samples through one of the five turrets. A real-time digital camera captures images for immediate analysis of parameters such as fiber volume fraction.

The primary purpose of this thermogravometric analyzer is to determine the onset of degradation. The operator is Hongbin Shen.



This differential scanning calorimeter measures the amount of energy needed to heat a polymer sample, determines properties such as glass transition temperature, crystallinity, and degree of cure.

Graduate student Chanman Park inserts a coupon to test for tension fatigue and stress rupture of ceramic matrix composites.

A Masters Program

To strenghten the Center's educational component one of the first tasks will be to design a Professional Master's Program in composite materials. This program will be aimed at engineers wishing to continue their education and acquire greater depth in the field of composites. The program will feature a design project proposed by an engineer and jointly advised by Center faculty and by senior personnel from the engineer's employer.

M.C. Gill has taken more than a passing interest in furthering a formal program for composite materials and a center to promote same. He is one of an all but vanished breed—a true pioneer in the reinforced plastics industry—and the company he founded in 1945 has outlived all the others and is now the world's oldest continuous operating company solely dedicated to composites.

Because of this, M.C. believes he has a vested interest in seeing the industry continue to grow and prosper. One way to achieve that goal is to ensure that future industry leaders have the opportunity to choose a college curriculum that will provide them the knowledge required to succeed.

Providing Technical Support

From the outset, the intent has been to make the Center "customer-oriented" and the first customers have come from the industrial sector. In fact, in1945 M.C. saw USC as more industry oriented than other universities.One of the distinguishing features of USC's Composites Center is that the research directions and initiatives are being driven in large part by industry, thus ensuring relevance and benefit to sponsoring companies. In the first two years, the Center has forged industrial partnerships that have led to eleven sponsored research projects (see Table 1). In these partnerships, the industrial sponsor typically identifies a need(s) for technical support and works with the Center to define an R&D project to address that need. Post doctoral or student personnel are assigned to the project which is supervised by Center faculty, The sponsors have found this to be cost-effective in meeting their research needs, identifying and previewing future hires, and keeping current on the latest developments in composite materials technology.

TABLE 1

SPONSORED RESEARCH PROJECTS
Center for Composite Materials,
University of Southern California

Project	*Sponsor*
Orthotics (orthopedic bracing)*	M.C. Gill Corp.
Consolidation of 3-beam cured composites	HRL Labs
Improved formability of composites	Bell Helicopter
Composite performance in severe thermal transients	Raytheon
Toughening of friable phenolic foams for structural sandwich panel cores	M.C. Gill Corp.
Fiber pushout measurements of ceramic composites	TRW/Dep't of Energy
Seismic retrofit and repair with fiber composites	CC Meyers Technology
Acoustic damping of sandwich panels primarily for commercial aircraft interiors	M.C. Gill Corp.
Laser-machining composites	HRL Labs
Metallic foams synthesis	TRW
Composite-reinforced conductors Commission	California Energy

**This project is an effort to design and manufacture composite orthotics to alleviate foot drop and involves collaboration with Dr. Adrian Polliack of Rancho Los Amigos Rehabilitation Engineering Center. The project is the subject of a separate article which follows this one.*

to Industrial Partnerships

The Center has grown substantially in the past two years. One measure of this growth is the new equipment added during that period and include:

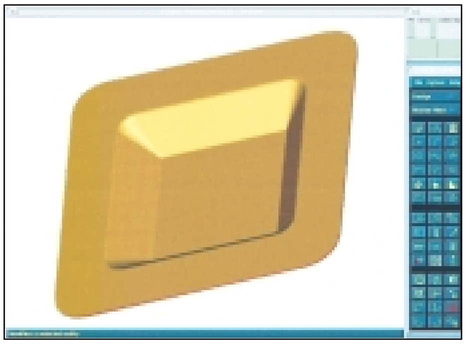
- Loom and creel for weaving fiber pre-forms;
- Ply cutter for cutting prepreg;
- Thermoforming press;
- RTM injection system and press;
- Two autoclaves;

- 3D CNC milling table for making custom tooling;
- Fiber pushout apparatus and SEM for measuring interface properties at high temperatures;

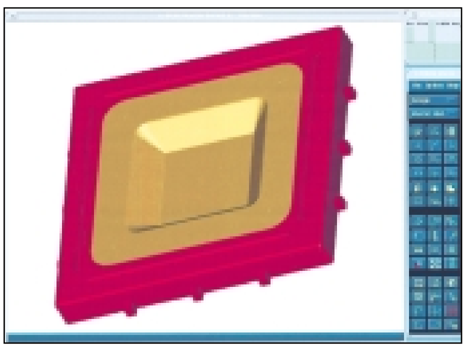
- Thermal analysis equipment;
- Rheometer; and,
- Two Instron testers equipped with special furnaces for controlled atmosphere testing.

Also, the Center will be moving to newly renovated and expanded lab space on the ground floor of the Vivian Hall of Engineering.

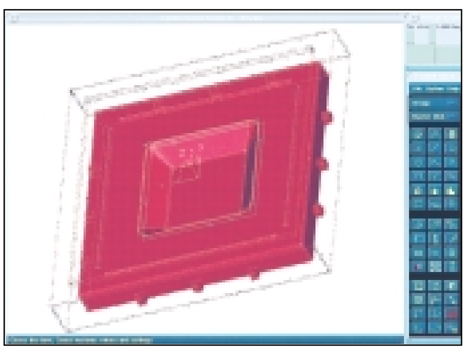
The move will provide upgraded space for the equipment listed above. These changes and additions will strengthen and support ongoing projects and help in initiating new ones.



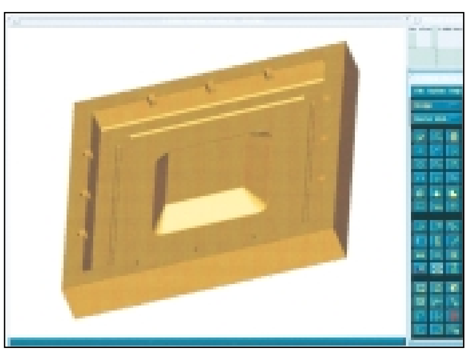
Step 1: Make the pattern.



Step 2: Form the tool from the pattern.



Step 3: Design the mold to press the part.



Step 4: Finish the part on the CNC machine.

The rapid growth of the past two years is expected to continue. A major task in the immediate future is to raise the Center's visibility beyond southern California through increased publications and presentations at technical conferences. This will be accomplished by leveraging federal support for projects that will compliment current industrially sponsored projects.

The goal is to earn a leadership role in composites technology and research, and to become involved internationally.

The industrial sponsorship of R&D projects has been critical to establishing the credibiltiy of the program and every effort is being made to expand this base while continuing to maintain the highest quality research attainable. Moreover, an Industrial Advisory Board will be appointed to assist in reviewing technical progress and identifying new research opportunities and directions.

The outstanding "Engineering Alumnus Award" M.C. received in 1980.

Left: This is an example of the Center's soup to nuts capabilitity– the design and testing process of a composite instrumentation housing.

Advanced Composites for

The Center for Composite Materials is not the only entity at USC working with and looking for new uses for thermoset reinforced plastics. Many of the programs at the USC affiliated Rancho Los Amigos Medical Center (Rancho) also utilize the properties of composites.

Background

Rancho is a public, nonprofit, rehabilitation hospital operated by the County of Los Angeles and is also a USC teaching hospital. Founded in 1888 as a "poor farm" to care for impoverished and homeless individuals, Rancho Los Amigos was a model of long-term care for its day, providing health care, housing, employment, personal assistance, and social services.

Adrian A. Polliack, Ph.D., Biomedical Engineer, Rancho Rehabilitation Engineering Program, and author of this article.

Beginning in the early 1950's, the Rancho Rehabilitation Engineering Program has been an important component of the rehabilitation program at Rancho. Since 1990, the Program has received two $2.5 million research grants from the National Institute on Disability and Rehabilitation Research (NIDRR) that includes exploring means of bringing advanced composites to the forefront of orthotics technology (orthopedic bracing) in much the same way these composites have brought benefits to the aerospace industry.

Advanced composites, developed in the aerospace industry, saw its start in this field in the 1950's and still holds considerable promise for challenging orthotic applications. While the industry standard material for lower extremity ankle-foot (AFO) braces is polypropylene, it is not without its drawbacks. For example, the fabrication process is labor intensive; the braces are often too heavy and too hot to wear in summer-type weather; the material is very thick in profile and thus limits the type of footwear that can be worn. At this writing, however, it is the best material available, and many of its drawbacks stem from the fact that the braces are worn by active children and young adults. Metal bracing is stiff but heavy and cumbersome, and requires considerable time for modification. Alternatively, composites appear promising. The state-of-the-art technique for using carbon fiber is a wet "layup" lamination procedure. However, this procedure can be time consuming and the resulting braces cannot be post-modified.

Fabrication Methods for AFO's

Prepreg material is laid up on a plaster cast positive mold of the patient's lower leg, in the desired shape and thickness. To reduce wrinkling, the layup is debulked by wrapping the prepreg with shrink tape.

Rancho Los Amigos orthotist Carin Caves laying up a carbon brace on a mold of the ultimate user's leg.

Orthopedic Bracing

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A short pictorial history of braces – far left is a steel brace attached to a shoe, heavy and rigid; the two middle braces are polypropolene; and, far right is Rancho's composite prototype carbon brace.

material for lower extremity ankle-foot (AFO) braces is polypropylene, it is not without its drawbacks. For example, the fabrication process is labor intensive; the braces are often too heavy and too hot to wear in summer-type weather; the material is very thick in profile and thus limits the type of footwear that can be worn. At this writing, however, it is the best material available, and many of its drawbacks stem from the fact that the braces are worn by active children and young adults. Metal bracing is stiff but heavy and cumbersome, and requires considerable time for modification. Alternatively, composites appear promising. The state-of-the-art technique for using carbon fiber is a wet "layup" lamination procedure. However, this procedure can be time consuming and the resulting braces cannot be post-modified.

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A custom-made reusable silicone vacuum bag is then assembled over the layup and mold and the part is cured under vacuum at 310°F. A resin that has a long shelf life and that can be stored at room temperature is desired because of the low volume of prototype braces currently being fabricated. A braided carbon prepreg is used for the structural framework with carbon and Kevlar®. fabrics used to reinforce the foot-plate and band area. The braided tubing is woven at a 30° angle which provides acceptable hoop strength. Flexural strength and stiffness is achieved by reinforcement using additional braided tubing.[1]

Results

Proof-of-concept AFO's were fabricated and proved feasible. Thereafter, various new AFO designs were based on existing designs; Recently, however, the anterior (floor reaction) brace design was selected as the primary design for testing based on the prevalence of its use with children with

The three braces on the left were early attempts using carbon. The two on the right are somewhat "standard" and are more workable designs. The shank on the brace in the middle also utilizes Kevlar in its construction.

[1] There is some concern regarding the use of carbon fiber in combination with Kevlar in that the differences in modulus may cause internal stress gradients leading to delamination after long term usage. Tests are being conducted to resolve the extent of this issue.

Quick Reference to
Qualified to Major Airframe

The following quick reference guide lists commercial aircraft, by manufacturer, model, application, manufacturer's specification, and qualified M.C. Gill product(s). We have included only those products that are most current and are qualified to the manufacturers' most recent specifications in our files.

Airframe Mfg & Aircraft Model	Application and Location	Specification	M.C. Gill Part Number
AIRBUS INDUSTRIE			
A300/A300-600/	Passenger flooring	TL53/5000/79, Ty 1	4105 Ty 1
A310/A330/A340	Passenger flooring	TL53/5000/79, Ty 2	4105 Ty 2
A300/A310/A300-600	Passenger flooring	TL53/5000/79, Issue 8, Annex A, PC 3, Ty 1 and Ty 2	4405 Ty 1 4405 Ty 2
A319/A320/A321/ A330/A340	Passenger flooring, aisles/galleys	5360 M1M 000600, Issue 3 Ty PC 3	4505
A320 and A321	Passenger flooring	5360 M1B 000100	4205
	Cargo flooring, containerized	5360 M1B 000100	4322
A300/A310/A300-600/ A319/A320/A321/ A330/A340	Cargo flooring, containerized	536O M1M 000500, Issue 5 Type CCC1	4522
	Cargo flooring, bulk	5360 M1M 000500. Issue 3 Type BCC2	4223
A319/A320/A321/ A330/A340	Passenger flooring, under seat	5360 M1M 000600, Issue 3 Type PC1	4605
A300/A300-600/ A310/A320/ A321/A330/A340	Cargo flooring, bulk	5360 M1B 000100	4323
All applicable models	Cargo flooring, main deck freighter aircraft combi/convertible	5360 M1M 000500, Issue 5 Type MDC2	4123
BOEING			
All 700 Series	Cargo liner	BMS 8-2 Cl 2	1366/1366T
	Cargo liner	BMS 8-223 Cl 2	1367/1367A
777	Cargo liner	BMS 8-223 Cl 4	1367B
737	Cargo liner (lower sidewall)	BMS 8-2 Cl 3	1076B
747	Cargo liner (ceiling only)	BMS 8-2 Cl 1	1076A
All 700 Series	Nomex® honeycomb core	BMS 8-124 Cl 4	Gillcore® HD
	Passenger and cargo flooring	BMS 4-17	4417, Ty I thru Ty VI and Drawing 69B15779(Ty V)

Airframe Mfg & Aircraft Model	Application and Location	Specification	M.C. Gill Part Number
BOEING (Con't)			
747-400, 767-200/-300, and 777	Passenger flooring	BMS 4-20	4409, Ty II and Ty III
737 and 757	Passenger flooring	BMS 4-23	5424, Ty I and Ty II
	Cargo flooring entry	BMS 7-326	5433C
777	Aft cargo flooring	BMS 7-326	5433C:
BRITISH AEROSPACE			
148-200/300, ATP, and 1000	Passengar flooring, under seat	BAeR 3231	41O9 Gr L 4609 Gr L
	Passenger flooring, aisle	BAeR 3231	4109 Gr M 46O9 Gr M
146-200/300, ATP, and 1000	Passenger flooring	BAeR 3247	41O9C
	Passenger flooring	BAeR 3247	4109D
	Cargo flooring	BAaR 3232	4004A
(Note: Customer should specify core density when ordering to BAeR 3232,)			
Jetstream 31/41	Passenger flooring, under seat	MAT OO6, Ty 1, Ty 2, Ty 3	4004B, Ty 1, Ty 2, and Ty 3
	Passenger flooring, aisle	MAT OO3, Ty 1, Ty 2	4017A, Ty 1, and Ty 2
	Passenger flooring	MAT 003	4017T
deHAVILLAND			
Dash 8	Cargo liner	DHMS P1.42 Cl A	1566
	Cargo liner	DHMS P1.42 Cl B	1366
	Nomex honeycomb core	DHMS P1.26 Issue F	Gillcore HD
EMBRAER			
EMB-110, 120, and 123	Galley/bulkhead	MEP-02-011	5040
	Galley/bulkhead	MEP-15-017	4117
	Galley/bulkhead	MEP-15-029	4122
	Passenger flooring, aisle	MEP-15-030	4009
	Passenger flooring	MEP-15-031	4017 Ty 1 and Ty

M.C. Gill Composites
Manufacturer's Specifications

We have not included superseded specifications nor, unless necessary, such details as product type and grade, honeycomb core cell sizes or densities. Our Customer Service Department will be pleased to provide this Information.

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AIRBUS INDUSTRIE			
A300/A300-600/	Passenger flooring	TL53/5000/79, Ty 1	4105 Ty 1
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A319/A320/A321/ A330/A340	Passenger flooring, aisles/galleys	5360 M1M 000600, Issue 3 Ty PC 3	4505
A320 and A321	Passenger flooring	5360 M1B 000100	4205
	Cargo flooring, containerized	5360 M1B 000100	4322
A300/A310/A300-600/ A319/A320/A321/ A330/A340	Cargo flooring, containerized	536O M1M 000500, Issue 5 Type CCC1	4522
	Cargo flooring, bulk	5360 M1M 000500. Issue 3 Type BCC2	4223
A319/A320/A321/ A330/A340	Passenger flooring, under seat	5360 M1M 000600, Issue 3 Type PC1	4605
A300/A300-600/ A310/A320/ A321/A330/A340	Cargo flooring, bulk	5360 M1B 000100	4323
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BOEING			
All 700 Series	Cargo liner	BMS 8-2 Cl 2	1366/1366T
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747	Cargo liner (ceiling only)	BMS 8-2 Cl 1	1076A
All 700 Series	Nomex® honeycomb core	BMS 8-124 Cl 4	Gillcore® HD
	Passenger and cargo flooring	BMS 4-17	4417, Ty I thru Ty VI and Drawing

69B15779(Ty V)

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	Passenger flooring	BAeR 3247	4109D
	Cargo flooring	BAaR 3232	4004A
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	Passenger flooring, aisle	MEP-15-030	4009
	Passenger flooring	MEP-15-031	4017 Ty 1 and Ty

THE FUNNY SIDE

A Cowboy's Guide to Life:

...Don't squat with your spurs on.

...Never smack a man who's chewin' tobacco.

...Never kick a fresh cow chip on a hot day.

...There's two theories to arguin' with a woman. Neither works.

...Don't worry about bitin' off more'n you can chew. Your mouth is probably a whole lot bigger than you think.

...If you get to thinkin' you're a person of some influence, try orderin' around someone else's dog.

...When you find yourself in a hole, the first thing to do is stop diggin'.

...Good judgement comes from experience, and a lot of that comes from bad judgement.

...Always drink upstream from the herd.

...When you give a lesson in meanness to a critter or a person, don't be surprised if they learn their lesson.

...Never miss a good chance to shut up.

...When throwin' your weight around, be ready to have it thrown around by someone else.

★★★★

Question: "What is the name given to the practice of delaying sex until marriage?" Answer: "Obstinance."

★★★★

Be nice to your kids. They'll choose your nursing home.

Trivia

Next time you feel discouraged, just remember: After Fred Astaire's first screen test, the testing director wrote the following memo: "Can't act; slightly bald; can dance a little."

★★★★

It was once said of Vince Lombardi that he possessed minimal football knowledge and lacked motivation.

★★★★

Louisa May Alcott was advised by her family to find work as a servant or seamstress.

★★★★

Beethoven's violin teacher called him hopeless as a composer.

★★★★

Walt Disney was fired by a newspaper for not being innovative.

★★★★

Enrico Caruso's first voice teacher said he had no voice and couldn't sing.

★★★★

225 gallons of makeup remover have been used by the Broadway cast of "Cats" since the show opened in 1982.

★★★★

Yo-yos were first used by the Greeks in 450 B.C.

★★★★

The comic strip "Blondie" appears in 2,300 newspapers in 55 countries, is translated into 35 languages, and is read by 280 million people every day.

★★★★

Mark Twain took out a patent for suspenders.

★★★★

The four most popular names for pet female cats are Misty, Muffin, Fluffy, and Samantha.

★★★★

Bugs Bunny's was originally named was Happy Bunny.

★★★★

The decibel level of a snore can be almost as loud as a pneumatic drill.