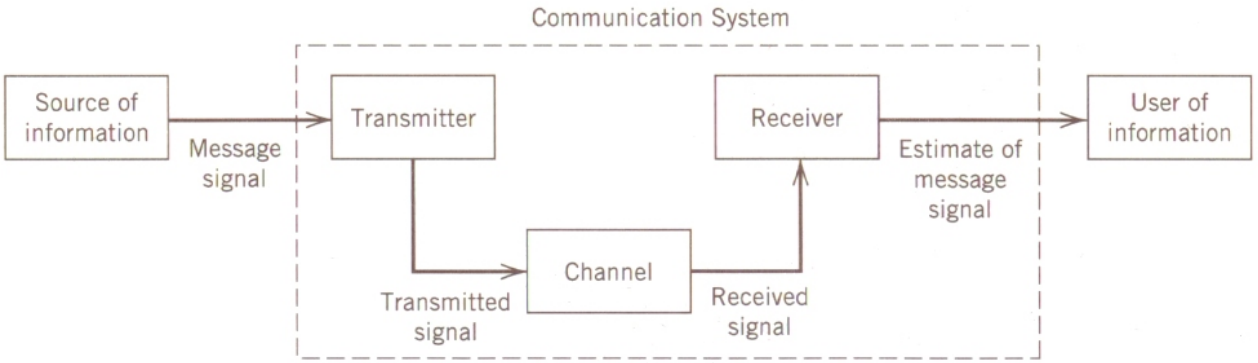
Chapter 1: Introduction

Wireless Information Transmission System Lab.
Institute of Communications Engineering
National Sun Yat-sen University

How is a communication system organized?

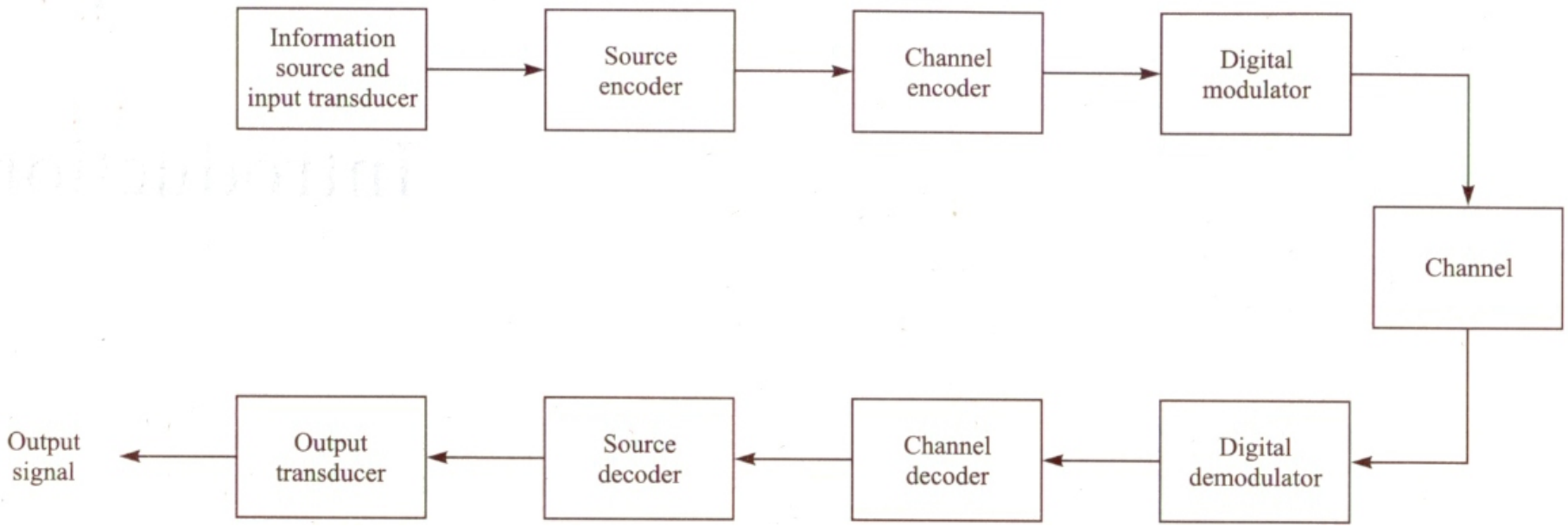


- *Source* of information: voice, music, picture, videos, data files, email.
- *Transmitter*: a generic term for the processing of information in the form provided by the source into a form that is *suitable for transmitting over the channel*.
- *Channel*: transmission medium, e.g. cable, optical fiber, free space.
- *Receiver*: a generic term for the process of converting the signal transmitted over the channel back to a form that may be understood at the intended destination. The receiver's function is typically greater than simply being the *inverse of the transmitter*; the receiver may also have to *compensate for distortions introduced by the channel* and perform other functions, such as the *synchronization* of the receiver to the transmitter.

Analog vs. Digital

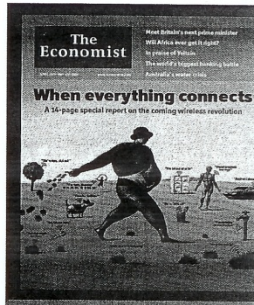
- All communications are by means of continuous signals and are thus analog in nature.
- It is the *information* which is to be transmitted that has an analog or digital nature.
- Since most modern communications are digital, the amount of emphasis placed on analog communications is steadily decreasing.
- Reasons to understand analog techniques:
  - Understanding of legacy systems;
  - Many digital communication techniques are motivated from their analog counterparts;
  - Many of the distortions observed in digital transmission systems can be characterized as analog in nature;
  - A thorough understanding of analog modulation systems leads to insight in identifying and compensating these distortions.

Basic Elements of A Digital Communications System



1956年
5MB IBM 硬碟正被裝上飛機
其重量超過1000公斤

The Economist(經濟學人), April 26th, 2007. When everything connects



為提供讀者更寬廣的國際視野，與世界經濟脈動同步，本刊與《經濟學人》簽約，取得台灣地區獨家授權報導。呈現給讀者最新、最快的世界政經脈動。

經濟學人

未來五十年 無線通訊將掀起生活革命

擺脫有形的電纜線束縛，無線通訊可應用在任何物品上，並能夠推升生產力。

無線電裝置曾經是放在客廳角落、微微發熱的木框機器，時至今日，已經是能夠輕巧放在口袋的時髦行動電話。未來幾年，隨著通訊晶片內建於許多日常生活用品，無線設備可能完全從眼前消失。這些通訊晶片以及連結晶片的網路，終將證實它們的最大影響力。

就像過去幾十年，每樣東西都找得到微處理器一樣，無線通訊晶片將來也會成為大小物品的一部分。此預言的可能性非常高。小玩意和小東西將和其他裝置對話，從遠端提供服務；農場的無線系統將測量溫度與濕度，控制灌溉設備；標籤將驗證食物的來源與通路，證實藥物的真偽；位於人們體表或體內的微晶片，將傳送生命跡象訊號到診所，協助監控身體健康。

擺脫電纜線束縛 資訊傳遞更快更便宜

電腦革命與資訊有關：將文件、照片等紀錄數位化，使資訊運用起來更簡便；無線通訊革命則是使數位資訊傳送至任何地方，而且幾乎毋須花費任何成本。不再受到有形的電纜線束縛以後，資訊將傳送到最有價值的目的地。

就現階段而言，大出風頭的是行動電話。從簡單的電話功能，逐步進化成電子錢包、鑰匙圈、健康監測器及導航裝置。

此成就得歸功於通訊公司馬可尼（Marconi）的無線電發報裝置及微處理器之間的整合與發展。無線電功能鑲嵌在矽晶片之後，尺寸與成本大幅減少，而運算性能大幅提升。今天的衛星導航晶片每片只需要一美元（約合新台幣三十三元），而無線射頻識別系統（Radio Frequency Identification，RFID）的標籤尺寸則可以小到放進指紋縫隙之間。當我們能以無線方式將電力傳送至這些裝置時（不久的將來就能實現），所有東西將能一切就緒。

無線通訊應加同資料科技一般，能夠推升生產力。想想無線通訊將如何改變汽車產業。汽車製造商開始監督車輛，根據震動或溫度的變化，在損壞之前知道何時該更換零件。

即時監控，故障前換掉零件 小晶片改變汽車產業

如果發生車禍，無線晶片可以告訴緊急服務人員地點在哪裡、發生的事件以及是否有人受傷。交通資訊可以立即反映，而且完全正確。依據精確的路線收取過路費。英國保險商以駕駛人精確的時間與地點為基礎，提供不同保費的保單。

當然，在無線通訊有能力實現承諾的願景之前，還有許多工作待完成。第一大障礙是新奇性。如一般新產業發展初期常見的，市場充滿各式各樣專利系統，其中許多是從零開始，不像一九七〇年代的早期電腦駭客，是以他們的Altair電腦（編按：第一台個人電腦，但功能極為簡單）招搖撞騙。

目前還不清楚能夠拔得頭籌設定準則的會是誰。行動電話產業兩大巨擘——索尼愛立信（Sony Ericsson）與諾基亞（Nokia）最近幾年已經實質退出通訊部門，此舉重大考量為隱私權問題。今天的法律通常假定隱私權受到消費者與公司，或民眾與政府之間的約定所保障。但在一個許多網路在空中相互連接、資訊廣泛共享的世界，無線網路使消費者知道，他們何時受到監督。

政府應扮演關鍵角色 避免太多政策干預及管制

但就現階段而言，危險是來自於太多規範，而非太少管制，對於任何人（其中大多是政治人物）而言，描繪無線技術遠景的藍圖十分困難，就像電動馬達和微處理器的情況一樣。

未來五十年，無線技術無所不在的情形，不僅會像二十世紀前半期的電動馬達，出現在從打蛋機到電梯等每樣東西，也會像二十世紀後半期的電腦化操作模式，占據從汽車到咖啡機的各式各樣機器。儘管結果有可能令人恐懼，但大部分情況下，它們將帶來超乎想像的助益。

（譯●賴 美）

（本文譯自《經濟學人》When everything connects, Apr. 26th, 2007.）

Bell Labs Museum

Wireless Information Transmission System Lab.
Institute of Communications Engineering
National Sun Yat-sen University

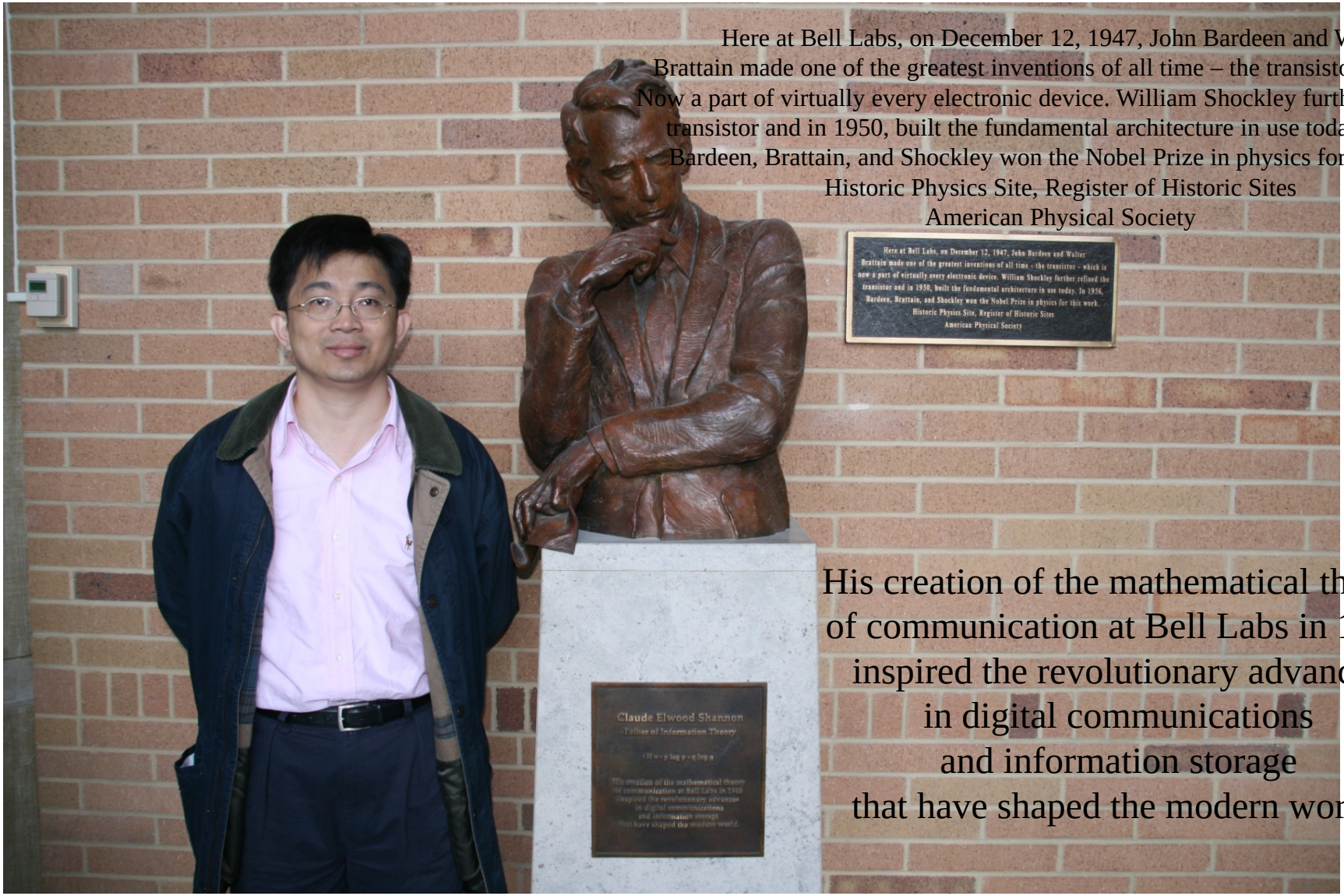
Alcatel-Lucent 大門 (Murray Hill, NJ)
5 December 2008

電話發明人
Alexander Graham Bell (1847~1947)

LEAVE THE BEATEN TRACK OCCASSIONALLY AND DIVE INTO THE WOODS. YOU WILL BE CERTAIN TO FIND SOMETHING THAT YOU HAVE NEVER SEEN BEFORE.

IN HONOR OF THE INVENTOR OF THE TELEPHONE ON THE CENTENNIAL OF HIS BIRTH

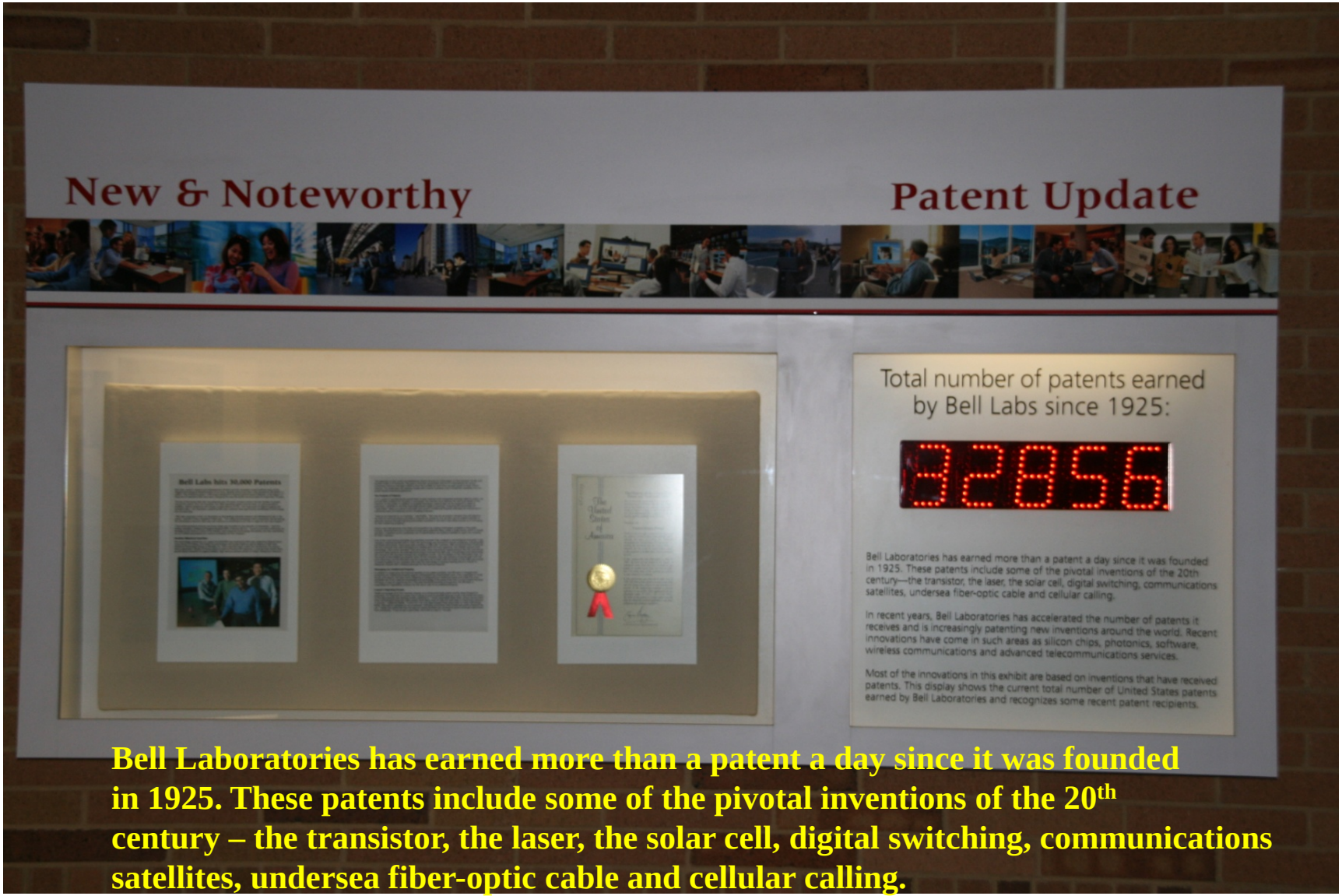
Claude Elwood Shannon
Father of Information Theory



Here at Bell Labs, on December 12, 1947, John Bardeen and Walter Brattain made one of the greatest inventions of all time – the transistor – which is Now a part of virtually every electronic device. William Shockley further refined the transistor and in 1950, built the fundamental architecture in use today. In 1956, Bardeen, Brattain, and Shockley won the Nobel Prize in physics for this work.
Historic Physics Site, Register of Historic Sites
American Physical Society

His creation of the mathematical theory of communication at Bell Labs in 1948 inspired the revolutionary advances in digital communications and information storage that have shaped the modern world.

Bell Labs Patents



Bell Laboratories has earned more than a patent a day since it was founded in 1925. These patents include some of the pivotal inventions of the 20th century – the transistor, the laser, the solar cell, digital switching, communications satellites, undersea fiber-optic cable and cellular calling.

Awards

6 Nobel Prizes in Physics shared by 11 scientists
9 U.S. Medals of Science
7 U.S. Medals of Technology
1 Draper Prize
6 Marconi International Fellowship Awards
7 C&C Prizes shared by 12 scientists and engineers
27 IEEE Medal of Honor winners

Nobel Prizes

Nobel Prizes

- 1937 Clinton Joseph Davisson, New York, "for their experimental discovery of the diffraction of electrons by crystals"
- 1956 John Bardeen, Walter Houser Brattain, William Bradford Shockley, Murray Hill, "for their researches on semiconductors and their discovery of the transistor effect"
- 1977 Phillip Warren Anderson, Murray Hill, "for their fundamental theoretical investigations of the electronic structure of magnetic and disordered systems"
- 1978 Arno Allan Penzias and Robert Woodrow Wilson, Holmdel, "for their discovery of cosmic microwave background radiation“
- 1997 Steven Chu, "for development of methods to cool and trap atoms with laser light"
- 1998 Robert B. Laughlin, Horst L. Stormer, Daniel C. Tsui, "for their discovery of a new form of quantum fluid with fractionally charged excitations"

Innovation Timeline 1869~1930s

•In 1864, James Clerk Maxwell has formulated the electromagnetic theory of light and predicted the existence of radio waves.
•The existence of radio waves was established experimentally in 1887 by Heinrich Hertz.
•The first successful use of mobile radio dates from the 27 March 1899, when M. G. Marconi established a radio link between a land based station and a boat sailing the English channel.

1869 Gray & Barton
(becomes Western Electric in 1872)

1876 First Telephone

"Mr. Watson, come here, I want you!" The Telecommunications revolution begins when Alexander Graham Bell speaks these words into his prototype telephone on March 10, 1876.

1914 Vacuum Tubes

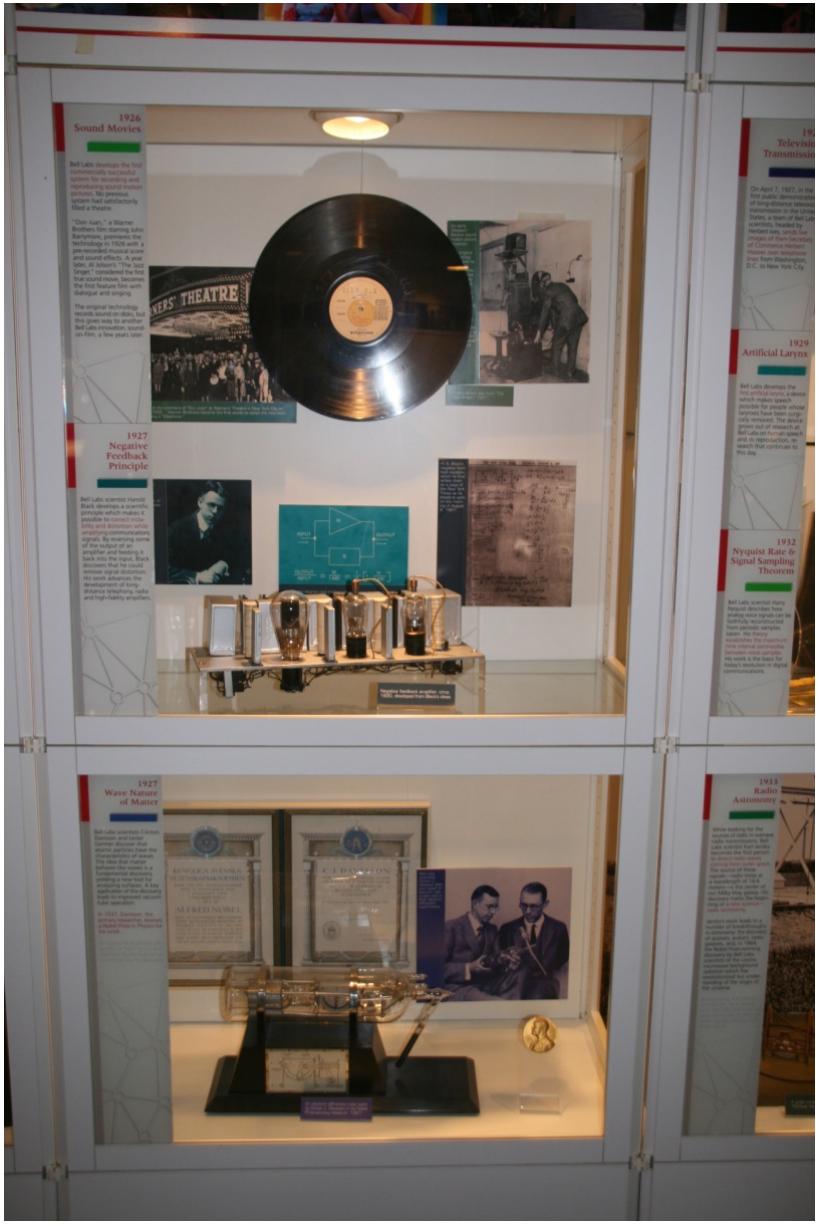
1916 Condenser Microphone

1916 Two-Way Radio Telephony

1917 Electric Wave Filter

1924 Statistical Process Control Charts

1924 Facsimile Services



1926 Sound Movies

1927 Negative Feedback Principle

1927 Wave Nature of Matter

1927 Television Transmission

1929 Artificial Larynx (喉嚨)

1932 Nyquist Rate & Signal Sampling Theorem

1933 Radio Astronomy

1933 Stereo Recording

1936 Speech Coding & Synthesis

1939 Electrical Digital Computer

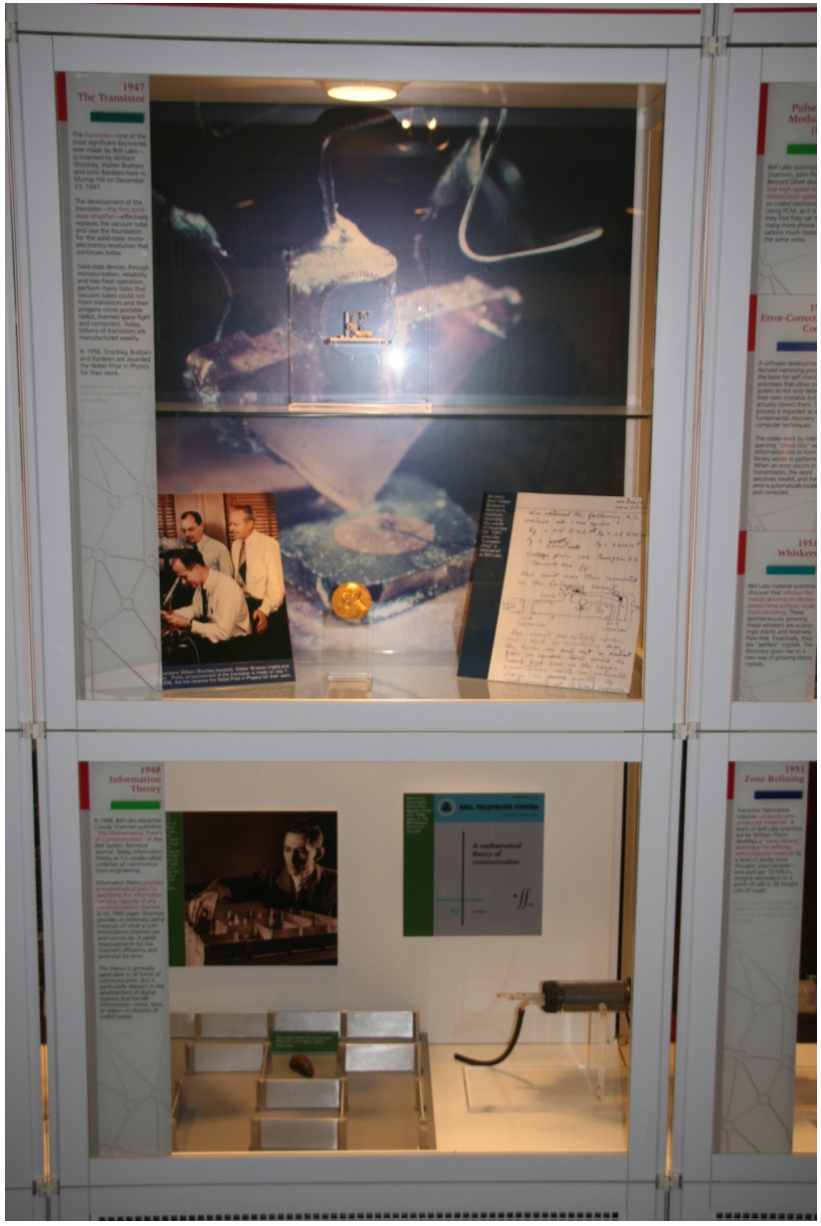
Innovation Timeline 1930s~1950s

1939 Radar Research

1936 Closed-Spaced Triode

1939 Traveling Wave Tube Amplification

1947 Cellular Concept



1947 The Transistor

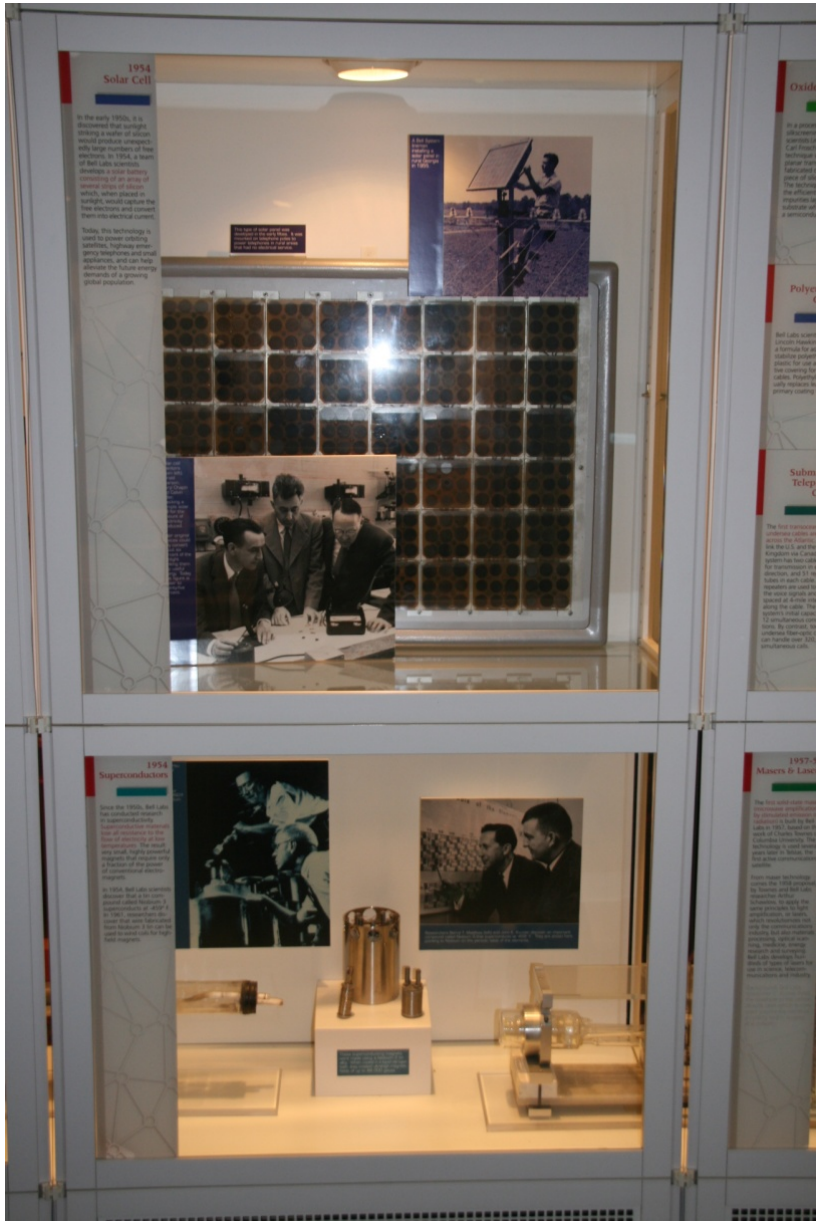
1948 Information Theory

1948 Pulse Code Modulation (PCM)

1948 Error-Correcting Codes

1951 Whiskers

1951 Zone Refining



1954 Solar Cell

1954 Superconductors

1954 Oxide Masking

1956 Polyethylene Coating

1956 Submarine Telephone Cable

1957~58 Masers & Lasers

Innovation Timeline 1950s~1970s

1958 Physics of Imperfect Crystals

1959 MOSFETs

1959 Artificial Neuron (神經元)

1959 Time Assignment Speech Interpolation

1959 Macros

1960 Epitaxial Film Transistors

1960 Random Dot Stereogram
(立體照相)
1960 Computer Generated Music

1962 Foil-Electret Microphone

1962 Telstar (AT&T發射的通訊衛星)

1963 Touchtone Telephone

1964 Support for the Big Bang Theory

1964 Picturephone

1965 Echo Canceller

1965 IESS Switch

1966 Magnetic Bubbles

1967 Linear Predictive Coding (LPC)

1968 Molecular Beam Epitaxy (MBE)

1969 Charged Coupled Device (CCD)

1969 UNIX System

1970~71 Heterostructure &
Distributed Feedback Lasers

Innovation Timeline 1970s~1990s

1973 C Language

1974 Computerized Axial Tomography (CAT) Algorithm

1974 Lithium Niobate for Lightwave Modulation

1974 Modified Chemical Vapor Deposition (MCVD)

1975 Speaker-Independent Voice Recognition

1977 Commercial Lightwave System

1978 Cellular Trials

1980 Solitons

1979 Text-to-Speech Voice System

1981 S Language

1980 Master-Rated Chess Machine

1982 Fractional Quantum Hall Effect

1983 Hidden Markov Models

1983 C++ Language

1984 Karmarkar Algorithm

1985 Atom Trapping

1986 SEEDs

1986 High-Temperature Superconductors

1986 Erbium-Doped Fiber Amplifiers

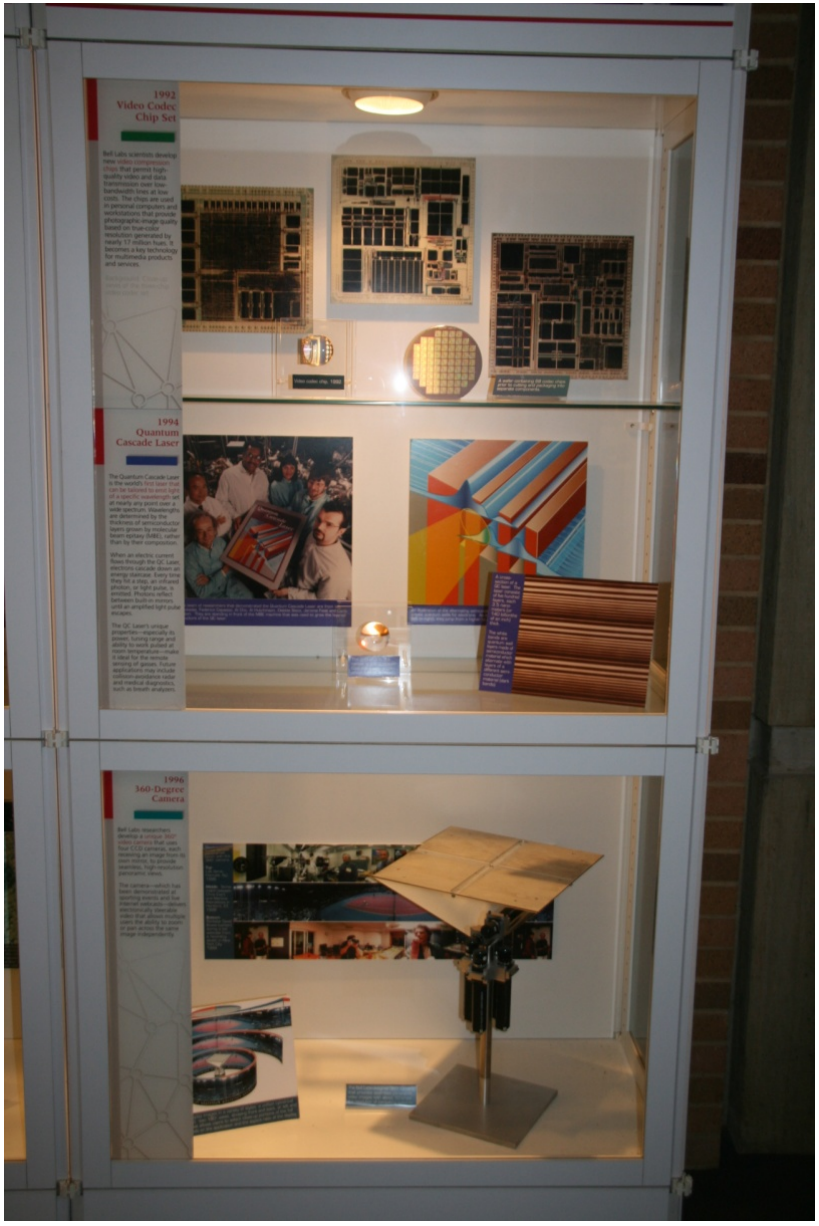
1988 Digital Cellular

1988 Undersea Fiber Optic Cable

1989 High Definition Television (HDTV)

1991 Microdisk Laser

1992 Magneto-Optic Data Storage



1992 Video Codec Chip Set

1994 Quantum Cascade Laser

1996 360-Degree Camera

1927 Experimental Television Receiver

1926 Sound Motion Picture Projector