Bell Telephone Laboratories, Inc.
List of Significant Innovations & Discoveries (1925-1983)

YEAR	INNOVATION or DISCOVERY	INNOVATORS
1925	Electrical Sound Recording	Joseph Maxfield & Harry Harrison
1925	Quality Control Theory	W. A. Shewhart
1926	Thermal Noise	John B. Johnson
1926	Antenna Arrays	R. M. Foster
1926	*Permendur* Magnetic Alloy	G. W. Elmen
1927	Negative Feedback Amplification	Harrold Black
1927	Television Transmission	Herbert E. Ives
1927	Quartz Electronic Clock	Warren Marrison
1927	Transatlantic Telephone Service	
1927	Wave Nature of the Electron	Clinton J. Davisson & Lester. H. Germer
1927	Wearable Electronic Hearing Aid	Harvey Fletcher
1927	Telephone Trunking Traffic Analysis	Edward C. Molina
1928	Sampling Theorem	Harry Nyquist
1929	Artificial Larynx	Robert R. Riesz
1929	Broadband Coaxial Cable	Lloyd Espenschied & Herbert A. Apfel
1929	Ship-to-Shore Radio System	
1929	Frequency Interleaving of TV Signal	Frank Gray & John R. Hefele
1930	Moving-Coil Microphone	E. C. Wente & A. L. Thuras
1930	Negative Impedance Repeater	George Crisson
1931	Radio Astronomy	Karl Jansky
1931	Rhombic Antenna	Harald T. Friis & E. Bruce
1931	TWX Exchange Teletypewriter Service	
1931	Stereophonic Recording on Film	Harvey Fletcher
1931-32	Stereophonic Sound Recording (45°)	Harvey Fletcher, Arthur C. Keller
1932	Stability Criteria Diagrams	Harry Nyquist
1932	Waveguide Experiments and Theory	George C. Southworth, A. P. King, A. E. Bowen
1933	Equal-Loudness Contours	Harvey Fletcher & Wilden A. Munson
1933	Vitamin B1 Isolation Process	Robert R. Williams
1933	Stereophonic Sound Transmission	Harvey Fletcher
1934	Raster Scan TV System	Pierre Mertz & Frank Gray
1936	Stereophonc Phonograph Record	Arthur C. Keller & Irad S. Rafuse
1936	Vocoder Speech Synthesis	Homer Dudley
1936	Reed Switch	Walter B. Elwood
1936	High-Efficiency AM-Transmitter Amplifier	William H. Doherty
1937	Boolean Logic Relay Computer	George Robert Stibitz & S. B. Williams
1937	Velocity Modulation Diode	Frederick B. Llewellyn
1937	*Isograph* Analog Computer for Polynomial Zeros	R. L. Dietzold
1937-38	Voder Speech Synthesizer	Homer Dudley
1938	Crossbar Switching System	

1938	Insertion Parameter Filter Design	Sidney Darlington
1938	Phase-Gain Stability Criteria	Hendrik W. Bode
1939	Complex Number Calculator	George Robert Stibitz & S. B. Williams
1939	P-N Junction	Russell Shoemaker Ohl
1939	Smith Chart for Transmission Lines	Phillip H. Smith
1940	Pierce Electron Gun	John R. Pierce
1940s	Thermistor Materials	G. L. Pearson, J. A. Becker & C. B. Green
1940	Reflex Klystron	John R. Pierce & W. G. Shepherd
1940	Photovoltaic P-N Junction	Russell Shoemaker Ohl
1941	Sound Spectrograph	W. Koenig, H. K. Dunn & L. Y. Lacy
1941	Vocoder Speech Secrecy System	R. K. Potter & R. C. Mathes
1942	Acoustic Homing Torpedo	
1942	Horn-Reflector Antenna	Harald T. Friis & Alfred C. Beck
1943	Echo-Ranging Sonar	
1943	Microgel Synthetic Rubber Production Process	William O. Baker & C. S. Fuller
1943	Computer-Controlled Anti-Aircraft System (M5 Gun Director)	
1944	Close-Spaced Triode (Model 416)	Jack A. Morton
1944	Mathematical Treatment of Noise Theory	Stephen O. Rice
1940s	Microwave Radio Propagation Studies	A. B. Crawford & collaborators
1945	Pulse Code Modulation Paper	John R. Pierce, Claude Shannon & Bernard M. Oliver [Alec Reeves 1938 ITT Labs]
1945	Nike Anti-Aircraft Missile Project	
1945	“Drinking Brid” Amusement Device	Miles V. Sullivan
1945	Travelling-Wave-Tube (TWT) Analysis	John R. Pierce
1946	L1 Coaxial Cable System	
1946	Junction Solar Cell Patent	Russell Shoemaker Ohl
1947	The *Bit*	John W. Tukey
1947	Point-Contact Transistor	John Bardeen & Walter H. Brattain
1947	Cellular Wireless Concept	Donald H. Ring & W. Rae Young
1947	Helix Travelling Wave Tube	John R. Pierce & L. M. Field
1947	Chirp Radar	Sidney Darlington
1947	TDX Microwave Radio System	Harald T. Friis & G. N. Thayer
1948	Information Theory	Claude Shannon
1948	Error Correcting Codes	Richard W. Hamming
1948	Bipolar Junction Transistor	William Shockley
1949	Time Assignment Speech Interpolation	Carl B. H. Feldman
1949	Semiconductor Particle Detectors	Kenneth G. Mckay
1949	Gas Discharge Noise Tube	W. W. Mumford
1950	TD Transcontinental Microwave Radio System	
1950	Spatial Harmonic Trevelling Wave Tube Amplifier	Sidney Millman
1950	Differential PCM of TV Signals	C. C. Cutler, C. W. Harrison & B. M. Oliver
1950	Model of Basilar Membrane	L. C. Peterson & Bruce P. Bogert
1950	High-Quality Synthetic Quartz Crystal Growth	A. C. Walker, G. T. Kohman, E. Buehler & R. A. Laudise

1950	Transmission Line Model of Vocal Tract	H. K. Dunn
1951	Zone Refining	William G. Pfann
1951	Direct Distance Dialing	
1951	Polymer Carbon	W. O. Baker & F. H. Winslow
1951	Epitaxial Deposition	Gordon Teal & Howard Christensen
1951	Stochastic Service Arrival Traffic	J. Riordan
1952	Ion Implantation	R. S. Ohl & William S. Shockley
1953	Photo-Transistor	J. N. Shive
1953	Reflected Binary Code	Frank Gray
1953	Avalanche Photodiode Physics	Kenneth G. McKay & K. B. McAfee
1954	Photovoltaic Solar Cell	Daryl Chapin, Calvin Souther Fuller & Gerald Pearson
1954	Formant Vocoder	Eric S. Weibel
1954	Coaxial Magnetron	Joseph Feinstein
1955	Linear Floating-Decimal Programming Languages	V. M. Wolontis & Richard W. Hamming
1955	Directive Antenna Arrays	E. N. Gilbert & S. P. Morgan
1955	Diffused Emitter & Base Silicon Transistor	Morris Tannenbaum and D. E. Thomas
1955	Oxide Masking of Silicon Wafers	Carl J. Frosh & Lincoln Derrick
1955	Pyrolytic Carbon (Missile Ablative Heat Shield)	F. H. Winslow & William O. Baker
1956	Polyethlene Cable Sheathing	W. Lincoln Hawkins & F. H. Winslow
1956	P-I-N Photodiode Theory	W. T. Read, Jr.
1956	Transatlantic Coaxial Cable System (TAT-1)	
1957	*Supermendur* Magnetic Alloy	H. L. B. Bould & D. H. Wenny
1957	Rare Earth Permanent Magnets	J. H. Wernick & E. A. Nesbitt
1957	Minimal Tree Algorithm	Robert C. Prim
1957	Computer Music	Max V. Mathews
1957	Information Rate of Human Channel	John R. Pierce & John E. Karlin
1958	Bell 101 Dataset Modem	
1958	Laser	Arthur L. Schawlow & Charles W. Townes [Gordon Gould 1957 independent inventor]
1958	Voice Excited Vocoder	Manfred R. Schroeder
~1958	Theory of Random Systems	Philip Warren Anderson
1958	Potassium Sodium Niobate Ceramic Delay Line	L. Egerton & S. S. Flaschen
1958	Synthetic Quartz Crystal Growth	Robert A. Laudise & Albert Ballman
1958	A/D Conversion System for Audio	Edward E. David, Jr., Max V. Mathews & Hank S. McDonald
1959	Macro-Instruction Programming	M. Douglas McIlroy & Douglas E. Eastwood
1959	Nike Zeus Anti-Ballistic Missile	
~1960	BLODI Block Diagram Compiler	John Kelly, Vic Vyssotsky & Carol Lochbaum
1960	*Echo* Communications Satellite	John R. Pierce & team
1960	Order-of-Arrival Service Model	Vaclav E. Benes
1960	MOS Transistor	John Atalla & Dawon Kahng
1960	High Magnetic Field Superconductivity	J. E. Kunzler, F. S. L. Hsu, E. Buehler & J. H. Wernick
1960	Silicon Epitaxy	Henry C. Theuerer

1960	Helium-Neon Gas Laser	A. Javan, W. R. Bennet & D. R. Herriott
1960	Space Saver Rotary Dial	Charles F. Matke
1960	Superconducting Niobium-Tin Magnet	John Eugene Kunzler
1961	T1 Digital Carrier Introduced	
1961	Theory of Optical Resonators	A. G. Fox & T. Li
1962	Short-Term Spectrum Analysis & Cepstrum Pitch Detection	Manfred R. Schroeder & A. Michael Noll
1962	*Telstar* Active Satellite Launch	John R. Pierce & Eugene O'Neil's team
1962	Electret Microphone	Gerhard Sessler & James E. West
~1962	Adaptive Echo Canceller	John Kelly, Ben Logan, M. Mohan Sondhi & A. J. Presti
1962	Electronic Artificial Larynx	H. L. Barney, F. E. Haworth & H. K. Dunn
1962	Computational Model for Basilar-Membrane Displacement	James L. Flanagan
1962	Vocal-Tract Speech Synthesis	John L. Kelly, Jr. & Carol Lochbaum
1962	Digital Computer Art	A. Michael Noll
1962	Grating-Type Delay Line	R. S. Duncan & Marsena R. Parker
1962	Red Helium-Neon Laser	Alan White & J. Dane Rigden
1962-68	Nonmetric Mutltidimensional Scaling	Roger N. Shepard, Joseph B. Kruskal, Newman Guttman
1963	Digital Filter Design	James F. Kaiser & Roger M. Golden
1963	Touchtone Dialing	Leo Schenker
1963	LightStick Chemiluminescence	Edwin A. Chandross
1963	Mosaic Computer Animation (BEFLIX)	Kenneth C. Knowlton
1963	Thin-Film Delay Line	Norman F. Foster
1963	Symbolic Algebra Programing (ALPAK)	W. Stanley, B. A. Tague & J. P. Hyde
1960s	Computer Animation (various scientific and artistic applications, incuding title sequences)	R. M. McCllure, Frank Sinden, Edward E. Zajac, Kenneth C. Knowlton, Joseph. B. Kruskal, Jr., A. Michael Noll
1964	Detect "Big-Bang" Radiation	Arno A. Penzias & Robert W. Wilson
1964	Adaptive Equalizer Modem	Robert W. Lucky
1964	Carbon-Dioxide High-Power Laser	C. Kumar N. Patel
1964	Yttrium Aluminum Garnet (YAG) Laser	J. E. Geusic, H. M. Marcos & L. G. Van Uitert
1964	Argon Laser Retina Repair (Photocoagulation)	Eugene I. Gordon & Edward F. Labuda
1964	Solid-State Electron Detector for Van Allen Belts	Walter L. Brown, Louis J. Lanzerotti & L. Medford
1964	MULTICS Time-Shared Computing	
1960s	Random-Dot & Self Stereograms	Bela Julesz
1965	Stereoscopic Computer Animation	A. Michael Noll
1965	No.1 Electronic Switching System	
1965	Fast Fourier Transform (FFT)	John Tukey & J. W. Cooley (IBM)
1965	Dedicated Laboratory Interactive Computing System	Peter B. Denes
1965	Remote Graphical Display Terminal	William H. Ninke
1966	List-Processing Computer Langauge (L^6)	Kenneth C. Knowlton
1966	Computer-Aided Library Distribution	W. Stanley Brown & Joseph F. Traub
1966	Silicon Gate	R. E. Kerwin, D. L. Klein & J. C. Sarace

1967	Linear Predictive Coding	Bishnu S. Atal & Manfred R. Schroeder
1967	Magnetic Bubble Memory Devices	A. H. Bobeck, H. E. D. Scovil & P. C. Michaelis
1967	Ion Implantation Implementation	Alfred U. Mac Rae & Walter L. Brown
1968	Interactive 3D Input & Display	A. Michael Noll
1968	Speech Synthesis by Rule	Cecil H. Coker
1968	Heterostructure Semiconductor Laser	I. Hayashi & M. Panish
1968	Molecular Beam Epitaxy	John R. Arthur & A. Y. Cho
1968	LED for Optical Fibers	C. A. Burrus
1969	UNIX™ Operating System	Kenneth Thompson, Dennis Ritchie, Brian Kernighan, Douglas McIlroy, Joseph Ossanna
1969	Charge Coupled Device (memory, delay line, imaging)	William Boyle & George E. Smith
1969	Virtual Circuit Switching (Spider)	Alexander G. Fraser
1969	Strip Hologram of Computer Imagery	Michael C. King
1969	Scanned-Display Raster Computer Graphics	A. Michael Noll
1970	Cellular Wireless Handoff System	Amos E. Joel, Jr., Richard H. Frenkiel, Philip T. Porter
1970	Adaptive Delta Modulation	N. S. Jayant
1970	Optical Levitation	A. Ashkin & J. M. Dziedzic
1970	Cylindrical Lead-Acid Central-Office Battery	D. E. Koontz, D. O. Feder, L. D. Babusci & H. J. Leur
1970	Tactile Force-Feedback Haptic System	A. Michael Noll
~1970	Individual Differences Multidimensional Scaling	J. Douglas Carroll & J. J. Chang
Early 1970s	Graded-Index Optical Fiber	D. Marcuse, E. A. J. Marcatili, D. Gloge, S. E. Miller, S. D. Personick, A. Hasegawa, F. Tappert
1972	Lightwave Repeater	J. E. Goell, P. K. Runge
1972	Data Ring	John R. Pierce, Cecil H. Coker
1972	Thin-Film Magneto-Optic Switch	P. K. Tien, R. J. Martin, R. Wolfe, R. C. LeCraw & S. L. Blank
1973	Cellular Switching Plan	Z. Fluhr & Eric Nussbaum
1973	Adaptiveley Quantized Differential PCM	James L. Flanagan, P. Cummiskey & N. S. Jayant
1973	C Programming Language	Dennis M. Ritchie
1974	Electronic Blackboard	O. Gabe Torok
1974	Transversal Digital Filter Design	Lawrence R. Rabiner
1974	Computerized Tomography Algorithm	L. A. Shepp & B. F. Logan
1974	Digital Wire Center & Small Digital Switch	Hank S. McDonald, Joseph H. Condon, H. G. Alles
1975	Single-Mode Laser	T. P. Lee, C. A. Burrus, B. I. Miller & R. A. Logan
1976	No.4 ESS Digital Switching System	
1976	Picturephone Meeting Service Video-Teleconferencing Service	Joseph J. Horzepa & team
1976	Common Channel Interoffice Signaling (CCIS)	

1977	Commercial Optical-Fiber Transmission System	
1977	*Belle* Dedicated Chess Computer	Joseph H. Condon & Kenneth L. Thompson
1977	Theory of Disordered States of Matter	Philip W. Anderson
1977	Hematofluorometer Detector for Lead Poisoning	William E. Blumberg, Josef Eisinger, Angelo A. Lamola & David M. Zukerman
1978	L5E Coaxial Cable System	
1978	Telephone Modular Plug & Jack	Charles L. Krumreich
1978	32-bit Microprocessor	Lee C. Thomas, Bernard T. Murphy & Alfred U. Mac Rae
1978	Experimental Digital Switch (XDS)	H. G. Alles, C. Christensen, R. W. Lucky
1978	Wide Area Telephone Service (800 service)	Roy P. Weber
1979	Psychoacoustic Masking Codec (MP3 precursor)	Manfred R. Schroeder, Bishu S. Atal, Joseph L. Hall
1979	Single-Chip Digital Signal Processor	
1980	Heterojuction Phototransistor	J.A. Copeland, J. C. Campbell
1980	Dynamic Non-Hierarchial Network Routing	Gerald R. Ash & Richard H. Cartwell
1981	AR6A SSB-SC Microwave System	
1982	5ESS® Digital Switching System	
1982	Fractional Quantum Hall Effect	Horst Störmer, Daniel Tsui & Robert Laughlin
1983	Hidden Markov Chain Speech Recognition	Biing-Hwang Juang, Stephen E. Levinson, Lawrence R. Rabiner, M. Mohan Sondhi
1983	Twin-Tub VLSI CMOS	Louis C. Parrillo & Richard S. Payne
1983	Code-Excited Linear Predictive Coding	Manfred R. Schroeder & Bishnu S. Atal

Notes:

• Compiled by A. Michael Noll (with personal knowledge and an admitted bias toward speech research and computer graphics) and with sagacious comments from several colleagues.

• Bell Telephone Laboratories, Inc. (BTL) was formed in 1925 and existed until the breakup of the Bell System on January 1, 1984. Only this period of nearly six decades is inluded here.

• Innovations and discoveries were chosen to be significant new directions and not just incremental advances. However, a few "fascinating" ones, such as the "dunking bird," have been included.

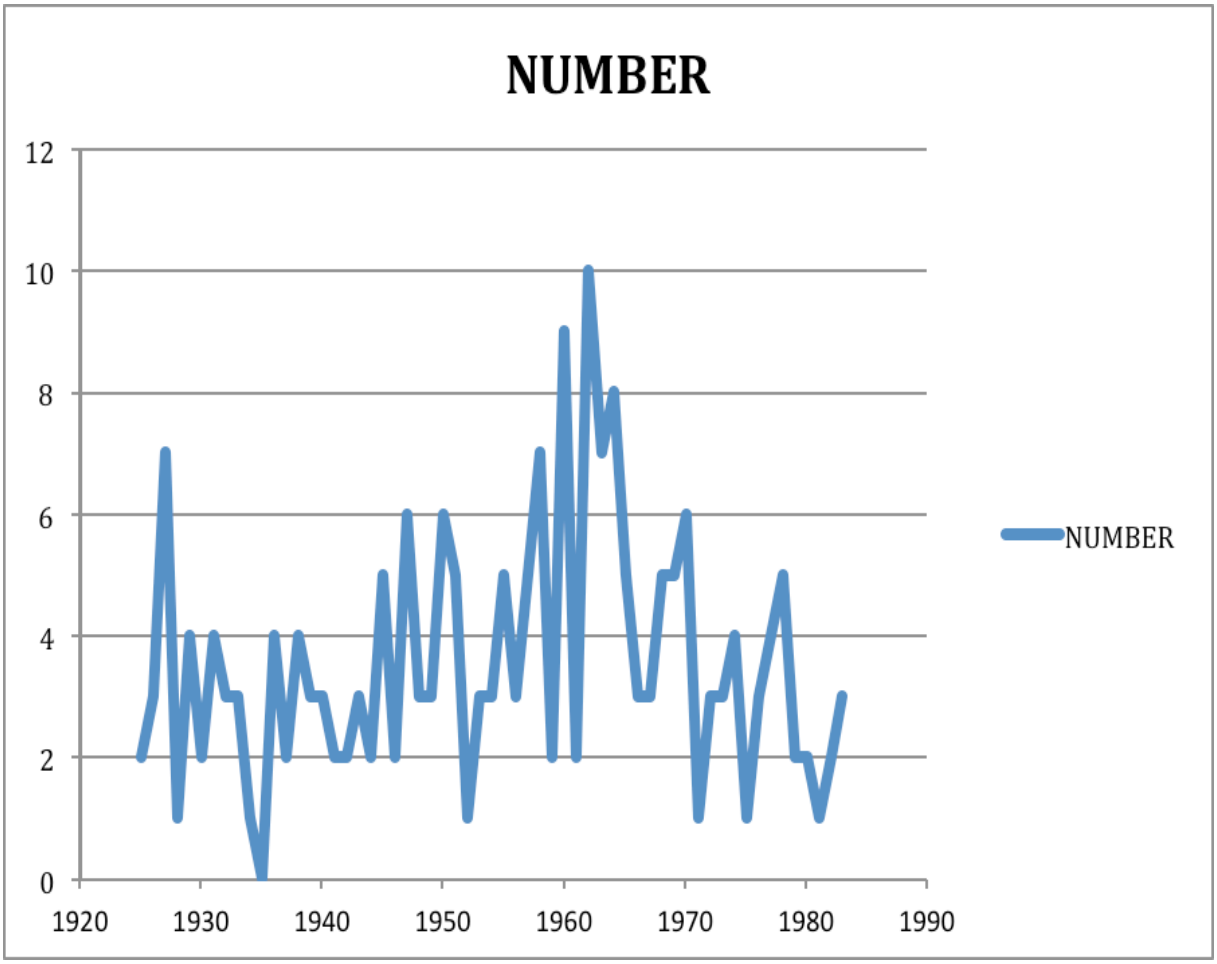
• Tens of thousands of engineers, scientists, technicians, and others worked at Bell Telephone Laboratories, and all contributed in their own way to the overall accomplishments of the organization. Only a small few are listed here though.

• On many of the larger development projects and systems, large engineering teams were involved, and accordingly individuals are not named.

• Sources: *Impact*, M. D. Fagen (Editor), 1971; *A History of Engineering & Science in the Bell System – Communications Sciences (1925-1980),* S. Millman (Editor), 1984; *A History of Engineering & Science in the Bell System – Physical Sciences (1925-1980)*, S. Millman (Editor), 1983.

5-16-2012

Yearly Number of Innovations and Discoveries
Bell Telephone Laboratories, Inc.
1925-1983



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