DATES IN AMERICAN TELEPHONE TECHNOLOGY

Compiled by

C. D. HANSCOM

BELL TELEPHONE LABORATORIES

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TABLE OF CONTENTS

INTRODUCTION ix
USE OF THIS BOOK xi
GLOSSARY AND REFERENCES xiii
KEY TO ABBREVIATIONS xv

THE BACKGROUND OF THE INVENTION OF THE TELEPHONE 1

Significant Early Techniques and Experiments 1
Transmission of Intelligence 1
Early Magnetism 2
Early Electricity 3
Early Acoustics 4
Early Electric Telegraph 5

Significant Previous Experiments in Electric Voice Transmission 6
Page 6
Bourseul 6
Reis 6
Gray 7

Alexander Graham Bell and the Concept of the Telephone 7
Bell's Ancestry 7
Alexander Bell 7
Alexander Melville Bell 8
Eliza Grace Symonds Bell 8
Alexander Graham Bell 8
Bell's Boyhood 8
Bell's Youth 8
Pre-Telephone Years 9
Telegraph Experiments 9

THE BIRTH OF THE ELECTRIC SPEAKING TELEPHONE 11

First Tone Transmitted 11
First Speech Sounds Transmitted 11
First Intelligible Sentence Transmitted 11
First Speaking Telephone, U. S. Patent 174465 11
Offer of Sale 11
The First "Telephones" 11
Photophone 12

APPARATUS 13

Amplifier 13
Call Answering 13
Capacitor 13
Coil 13
Computer 15
Contact 15
Crystal 16
Detector 17
Fuse 17
Inductor 17
Measuring 18
Modulator 18
Oscillator 18
Protector 19
Radio 19
Repeater 24
Resistor 26
Selector 26
Solid State Devices 26
Diode 26
General 27
Thermistor 28
Varistor 28

APPARATUS—*Continued*

Transistor 28
Point Contact 28
Phototransistor 29
Junction 29
Terminal Strip 30
Transformer 30
Vacuum Tube 30
Vacuum Tube Voltmeter 36
VODAS (Voice Operated Device-Anti-Singing) 36
VOGAD (Voice Operated Gain Adjusting Device) 36
Voltage Regulator 36
Volume Indicator 36
Miscellaneous 38

STATION PLANT 40

Transmitter 40
Receiver 42
Handset 42
Telephone Set 43
Signaling 46
Talking Battery 46
Ringing Power 47
Switchhook 47
Dial 47
Repeating Coil (Induction Coil) 48
Protection 48
Pay Station 48
Booth 49
Cord 49
Wire 49
Answering Set 49

CENTRAL OFFICE PLANT 50

Apparatus 50
AMA 50
Balancing Network 50
Cable 50
Call Indicator 50
Card Translator 51
Clock 51
CODAN 51
Compandor 51
Cord 51
Switchboard 51
Cord Pulley 51
Weight 51
Delay Line 51
Distributing Frame 52
Echo Suppressor 52
Electrolytic Capacitor 52
Filter 52
Jack 53
Key 53
Message Register 53
Multivibrator 53
Operator's Chair 53
Operator's Set 53
Plug 54
Protector 54
Relay 54
Switch 55
Trouble Recorder 55
Vocoder 55
PBX Switching 56
Power 56
Battery 56
General 56
Ringing 56
Talking 57
Shielding 57
Switching 57
Manual 57
Automatic 59
Village Systems 60
Step-by-Step 60
Rotary 62
Panel 62
Relay Chain Type 63
Crossbar 63
Electronic 64
Unattended Offices 64
Toll Switching 65
Automatic Message Accounting (AMA) 65
Automatic Ticketing 65
Centralized Automatic Message Accounting (CAMA) 65
Direct Distance Dialing (DDD) 65
Foreign Area Translation 65

General 66
Operator Toll Dialing 66
Tandem Operation 67

OUTSIDE PLANT 68

Apparatus 68
Automatic Transmission Regulator 68
Coil 68
Hardware 68
Insulator 68
Line Concentrator 68
Loading Coil Case 68
Repeater 68
Tool 69
Cable 69
Conductors 69
Gas Plug 69
General 69
Guard 70
Insulation of Wires 70
Sheath 71
Strand 72
Suspension Systems 72
Terminal 72
Conduit 72
Interference 73
Loading 73
General 73
Types 74
Pole Line 76
Pole 76
Crossarm 77
Drop Wire 77
Erection 77
Pole Preservation 77
Transposition 78
Wire Spacing 78
Protection 78
Testing 79
Wire 72
Line 79
Insulation 89
Joints 81
Wire Guards 82

TRANSMISSION 83

Band Width 83
Effectiveness 83
Range 84
Experimental Open Wire 84
Commercial Open Wire 84
Long Lines 84
Cable 85
Submarine Telephone 85
Submarine Telegraph 86
Loading 86
Voice Frequency 86
Wire 86
Transposition of Wires 86
Metallic Circuit 87
Phantom Circuit 87
4-Wire Circuit 88
Loading 88
Repeater 89
Balancing 91
Echo Suppressor 91
Equalizer 91
Filter 91
Carrier 92
Carrier on Open Wire 92
Carrier on Cable 95
Carrier on Coaxial Cable 96
Waveguides 97
Radio 97
General 97
Short-haul Links 99
Special Services 100
Ship-to-Shore 100
Coastal and Harbor 100
Aircraft 100
Mobile (Automobile) 100
Emergency 100
Emergency Announcement 101
Rural 101
Broadcasting 101
Railroad 101
Microwave 102
Special Wire Services 102

TRANSMISSION—*Continued*

Time of Day 102
Call Announcer 103
Weather Forecast 103
Delay Quote 103
Recorded Intercept 103
Emergency Announcement 103
Telemobile 103
Program Transmission 103
Broadcasting 103
Television 103
Municipal Emergency 105
Picture Transmission 105
Teletype 105
Answering Service 105
Pulse Transmission 106
Ordinary Simplex Telegraph ... 106
Time Division Multiplex 106
Variable Pulse 106
Pulse Position Modulation (PPM) 106
Pulse Amplitude Modulation (PAM) 106
Pulse Width Modulation (PWM) 106
Pulse Code Modulation (PCM) . 106
Measurement 107
General 107

TELEGRAPH 108

CIRCUITS 112

General 112
Station 113
General 113
Power 114
Central Office 114
Outside Plant 115
Modulation 116
Vacuum Tube Modulator 116
Copper Oxide Modulator 116
Non-linear Coil Type 116
Oscillator 116
Vacuum Tube Oscillator 116

MATERIALS 118

Contact 118
Crystal 118
Insulator 119
Magnetic 119
Miscellaneous 120
Rubber and Other Substances ... 120
Rubber 120
Paragutta 120
Solder 120

SCIENCE 121

Acoustics 121
Electricity 121
Chemistry and Metallurgy 122
General 122
Physics 123
Radiation 123
Transmission 124

BY-PRODUCTS 125

Audiogram 125
Audiometer 125
Hearing Test 125
Audiphone 125
Microphone 125
Loud Speaker 126
Public Address System 126
Phonograph 126
Stereophonic Music 127
Sound Pictures 127

Voder 128
Vocoder 128
Visible Speech 128
Artificial Larynx 128
Tape Recording 128
Electric Stethoscope 128
Mine and Explosive Atmosphere Telephone 128
Bank Vault Alarm 129
Radio 129
Broadcasting 129
Radio Altimeter 129
Aircraft Control Systems and Equipment 129
Loran 130
Commercial Radar Navigation ... 130
Crystal Frequency Standard 130
Electric Precision Clock 131
Watch Rate Comparator 131
High Speed Motion Pictures (Fastax) 131
Ribbon Frame Camera 131
Kirby Two-Eyed Camera 131
Television 131
Coronavisor 132
Solar Battery 132
Railroad Warning Signal 132
Train Dispatching 133
Electric Voltage Regulator 133
Start-Stop Oscillator 133
Computer 133
Mechanical Digital Type 133
Mechanical Analog Type 133
Mechanical–Electrical Type ... 134
Electrical Analog Type 134
Electrical Digital Type 134
Modern Types 134
Page Turner 134

MILITARY EQUIPMENT 135

Acoustic Equipment 135
Air Raid Systems and Equipment 135
Computers and Gun Directors ... 136
Flight Trainers 136
Missiles and Associated Facilities 136
Radar and Sonar 137
General 137
Army Radar 137
Navy Sonar 138
Navy Radar 138
Joint Army-Navy 140
Radio 141
Rockets 142
Telegraph 142
Telephone 143
Miscellaneous 145

BIBLIOGRAPHY 146

INTRODUCTION

The achievements of today become most significant when compared with what has preceded them. However, facts and dates are sometimes elusive. The facts and dates of technical advances in telephony have been hidden in literally thousands of publications.

This book lists important facts and dates for ready reference. It does not elaborate and references are given only as sources for the dates indicated; other and more detailed references may exist. With exceptions, 1956 is the closing date; later advances must in general be covered in later editions.

The references are (with only a few exceptions) to published articles and books. All such publications are in Bell Laboratories Library, Historical Collection, or files. References to original laboratory notebooks and files are not given. Different authors sometimes quote different dates for the same event; I have tried to establish facts or a weight of evidence from published sources, but in some cases there are unresolved differences. In a book of this scope, some errors are inevitable.

One point deserves note. Employees of various companies, such as the Western Electric Manufacturing Company, Gold and Stock, Williams, Gilliland, and some early operating companies, invented or developed important telephone devices or circuits. Since these companies joined Bell either as a result of the Western Union patent settlement or shortly thereafter, they have always been looked upon as part of the Bell System, which really got its start as a system at that time. These inventors are not listed as non-Bell System, although their companies might not have been part of the system at the time of an invention.

Finally, let me express appreciation for assistance and advice given by numerous members of Bell Telephone Laboratories and by the Publication Department which has supported this project.

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Historian, Bell Telephone Laboratories

USE OF THIS BOOK

A book must be divided in some manner. In this case, physical telephone items have been divided according to their place in the plant: the subscriber's premises (Station Plant); the central office (Central Office Plant); and elsewhere in the physical telephone lines (Outside Plant).

There remains a considerable residue of telephone items of four types: those that fall in more than one category (for example, capacitors and coils), those that might be argued (as radio), those used both in and out of the system (as vacuum tubes), and those that never were in the system (such as experimental apparatus). These are lumped under Apparatus.

In addition, systems and methods of transmitting messages, although including physical equipment such as cable, are lumped under Transmission. Band widths, range, carrier systems, filters, etc., fall in this category. But Telegraph is listed as a separate section.

Finally, there are the special sections: historical (Background of the Invention of the Telephone); beginnings (Birth of the Speaking Telephone); circuits (so designated); materials (also so designated); scientific achievements (Science); non-telephone products of telephone research (By-Products); and products to serve the Armed Forces (Military Equipment).

A glossary of certain terms, and a key to reference abbreviations, are necessary and are appended.

GLOSSARY* AND REFERENCES

Apparatus: Any unit: a transmitter, a coil, an amplifier (or repeater), or any other individual item.

Equipment: Assembled pieces of apparatus not normally forming a standard *apparatus* unit (e.g., a switchboard).

Plant: Apparatus or equipment in the telephone system.

STATION PLANT: Anything used on a subscriber's premises.

CENTRAL OFFICE PLANT: Anything used in an exchange or central office, local, toll, or otherwise.

OUTSIDE PLANT: Anything physical used in connecting the subscriber or central office to another subscriber or central office, but not wholly on his premises or in the central office.

Receiver: A telephone receiver, unless otherwise specified as "Radio receiver," "Telegraph receiver," or other.

Solid State: Includes solid diodes, triodes, thermistors, varistors, transistors, phototransistors, Bell Solar Battery, etc.

Transmission Effectiveness: Telephone connection compared to open-air voice communication.

Transmitter: A telephone transmitter, unless otherwise specified as "Radio transmitter," "Telegraph transmitter," or other.

Bell Solar Battery: See Solid State Devices

Call Answering: See APPARATUS

Condenser (used in old references): Capacitor

Diode, solid: See Solid State Devices

Operator's Set: See CENTRAL OFFICE PLANT

Power: See STATION PLANT, Talking Battery, Ringing Power; and CENTRAL OFFICE PLANT, Power

Radio: See APPARATUS and TRANSMISSION

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* Certain terms as used in this book; not necessarily approved or standardized. Only those are given which might not be recognized readily in these forms.

Special Wire Services: See TRANSMISSION
Includes time of day, weather forecast, program transmission, picture transmission, etc.

Submarine Cable: See TRANSMISSION, Cable
Subscriber Set: See STATION PLANT, Telephone set, Signalling, Talking Battery, Switchhook, Dial, Repeating Coil, Protection

Telephone Answering Set: See APPARATUS, Call Answering
Thermistor: See Solid State Devices
Transistor: See Solid State Devices
Varistor: See Solid State Devices
Waveguides: See TRANSMISSION
Wire Gun: See APPARATUS, Wire Wrapping Tool

KEY TO ABBREVIATIONS

NOTE: Many publications listed here are Bell System magazines, books, booklets, pamphlets, or leaflets. Most are out of print. Many can be found in libraries. Others are available only through or at Bell Telephone Laboratories, or in some cases the American Telephone and Telegraph Company or the Western Electric Company. For exact references see the Bibliography, pages 146-148.

AIEE	Proceedings, American Institute of Electrical Engineers
An. Report	Annual Report
Avalon–L. A.	"Avalon–Los Angeles Radio Toll Circuit"†
Bell Brief on Walker Report	Brief of The Bell System Companies on Commissioner Walker's Proposed Report on the Telephone Investigation
Bell Dep., Am. Bell Tel. Co. vs Peoples Tel. Co.; Bell Tel. Co. vs. Dowd	Bound volumes of legal cases in the Bell System Historical Collection Library, containing Bell's personal deposition
Bell Tel. Mag.	Bell Telephone Magazine (also formerly called Bell System Quarterly)
Black	Information obtained verbally from H. S. Black
Berger	Information obtained verbally from U. S. Berger
Bishop	Information obtained verbally from W. S. Bishop
BLR	Bell Laboratories Record
Bowles	Private memorandum of E. L. Bowles
Braund	Information obtained verbally from R. Braund
Brief Chron.	A Brief Chronology for Students of Telegraph, Telephones and Posts, H. G. Sellars (bound manuscript)
Brit. pat.	British patent
Brobst	Information obtained verbally from D. R. Brobst
BSTJ	Bell System Technical Journal
B–T Cat.	Catalog of early vacuum tubes prepared by Dr. Blanchard and Mr. Tyne
B–T Index	Index of collection of vacuum tubes identified and indexed by Blanchard and Tyne
B–T Notes	Notes on the index above
BTL Press Rel.	Press release from Bell Telephone Laboratories

†Entries within quotation marks are to pamphlets issued by various companies. Fuller references may be found in the bibliography.

ca.	circa (about)
Campbell	*Collected Papers of George A. Campbell**
Carrier Current Tel. and Tel.	"Carrier Current Telephony and Telegraphy"
Case	Bell Laboratories Case Authorization records
Casson	*History of the Telephone*, Casson
Chegwidden	Information obtained verbally from R. A. Chegwidden
Colliers Enc.	Colliers Encyclopedia
Comm. Thr. Ages	*Communication Through the Ages*, Still
Darrow	Manuscript notes of K. K. Darrow
Dietz	Information obtained verbally from A. E. Dietz
Early Corp. Dev. Tel.	"The Early Corporate Development of the Telephone".
Enc. Amer.	Encyclopedia Americana
Enc. Brit.	Encyclopedia Britannica, 1957 edition
Espenschied	Information obtained verbally from L. Espenschied
Espenschied MM	Technical memorandum written by Espenschied
Ev. Tel. Hist.	"Events in Telephone History"
Farmer	Information obtained verbally from W. J. Farmer
Gherardi	*Henry as Electrical Pioneer*, Gherardi
Guenther	Information obtained verbally from R. J. Guenther
Gumley	Information obtained verbally from R. H. Gumley
Hist. Firsts	"Historic Firsts"
Hist. Inf., WE	Historical Information from the Western Electric Company (bound manuscript)
HM...	Bell System Historical Collection exhibit item
HM Card	Card from Bell Laboratories Historical Collection Card File
Inf. Bull.	Bell Laboratories Information Bulletin
Inskip	Information obtained verbally from L. S. Inskip
Inst. EE	Institute of Electrical Engineers
IRE	Proceedings of the Institute of Radio Engineers
Lect. Dem.	Lecture Demonstration (Bell Laboratories)
Lowe	Information obtained verbally from J. T. Lowe
Lumsden	Information obtained verbally from G. Q. Lumsden
Machine Switching Tel. System	"Machine Switching Telephone System for Large Metropolitan Areas"
Magic of Comm.	"The Magic of Communication"
Man.	manual
MM...	Bell Laboratories Technical Memoranda
Mon....	Bell System Monograph No....
N&I Rel.	Bell Laboratories News and Information Release

* Entries in italic are references to published books.

New Haven Board, Coils	Coils used in the New Haven switchboard in 1878
Obs. Card Cat.	Catalog of obsolete Western Electric Card Catalog cards
Pan. of Tel. Prog.	"Panorama of Telephone Progress"
Photo Inf....	Photograph from Bell Laboratories Information Photograph File
Photo HM...	Photograph from Bell Laboratories Historical Photograph File
Phys. Rev.	The Physical Review
J. R. Pierce, World Enc.	Article by J. R. Pierce in World Encyclopedia
Post-War Achievements	"Post-War Achievements of Bell Laboratories"
Quarter Cent. Trans. Tel. Serv.	"A Quarter Century of Transcontinental Telephone Service"
Radar & Your Tel.	"Radar and Your Telephone"
Radio Extension	"Radio Extension of the Telephone System to Ships at Sea"
Recent Imp. in Hearing Aids	"Recent Improvements in Hearing Aids"
Rhodes	*Beginnings of Telephony*, Rhodes
Runyon	Information obtained verbally from B. F. Runyon
Sci.	Science
Sci. Am.	Scientific American
Sci. Rep.	Scientific Reports, Tohoku Imperial University, Japan
75 Years of Service	"75 Years of Service to the Nation"
Some War-Time Contrib. to Sci. Advnct.	"Some War-Time Contributions to Scientific Advancement"
Stereo. Recordings	"Program of Stereophonic Recordings of Enhanced Music"
Story of W.E.	"Story of Western Electric"
Strieby, Lect.–Dem. Rel.	Information release to Bell System lecturers and demonstrators from M. E. Strieby, AT&TCo.
Tech. Dev.	"Technical Developments Underlying the Toll Service of the Bell System"
Tel. Almanac	"Telephone Almanac"
Teleg. Dev.	Telegraph Developments (bound manuscript)
Teleg. Man.	*Telegraph Manual*, Schaffner
Tel. (Smithsonian Inst.)	"The Telephone", a pamphlet from the Smithsonian Institute
Tel. in Am.	"The Telephone in America"
Things Worth Knowing	"Things Worth Knowing About the Telephone"

Trans. Tel. Line	"Transcontinental Telephone Line"
Transoceanic Tel. Serv.	"Transoceanic Telephone Service"
Tyne	Information obtained verbally from G. F. J. Tyne
U.S. pat.	United States patent
Watson	*Exploring Life*, T. A. Watson
WE	"WE" magazine issued by the Western Electric Co.
W.E.	Western Electric
W. E. Card Cat.	Card catalog of all pieces of apparatus manufactured currently at any time by the Western Electric Co.
World Enc.	World Encyclopedia

† Non-Bell System

THE BACKGROUND OF THE INVENTION OF THE TELEPHONE[1]

SIGNIFICANT EARLY TECHNIQUES AND EXPERIMENTS

Transmission of Intelligence

	Date	*Reference*
Courier	Prehistoric	
Drum signals	Prehistoric	
Smoke signals—Mentioned by Homer	Prehistoric	Teleg. Man., p. 19
Fire signals—Mentioned by Homer	Prehistoric	Teleg. Man., p. 19
Supposedly used by Agamemnon	ca. 1084 B.C.	Teleg. Man., p. 21
Torch alphabet, Greece	before 264 B.C.	Teleg. Man., p. 20
Horn	Prehistoric	
Megaphone	Prehistoric	
Called a "telephone"	1796	BSTJ, 37, p. 289
Speaking tube	Prehistoric	
Called "telephone"	after 1796	BSTJ, 37, p. 289
Heliograph	ca. 490 B.C.	
Water clock signaling, Aeneas the Tactician	341 B.C.	Teleg. Man., p. 22
Cannon	before 1615	Teleg. Man., p. 19
Muskets	before 1615	Teleg. Man., p. 18
Optical telegraph, Marquis of Worcester	1663	Teleg. Man., p. 31
First practical telescope, Lippersky and Jansen, Holland	1608	Teleg. Man., p. 32
Galileo's telescope	1609	Teleg. Man., p. 32
String telegraph, Hooke	1667	BSTJ, 37, p. 289
Named string telephone	after 1796	
Optical telegraph, Hooke	1684	Comm. Thr. Ages, p. 30
Bells	before 1694	Teleg. Man., p. 18
Pith ball telegraph used, LeSage	1774	Enc. Brit., 21, p. 883
Barrel, flag, basket code signals on mast, telegraph	1775–83	Comm. Thr. Ages, p. 22
Semaphore, Chappé, France (Paris-Lille, 150 mi.)	1793	Sci. Mon., 12/44, p. 437

[1] Non-Bell System

	Date	*Reference*
Transmission of Intelligence (Cont'd)		
Electrolytic telegraph, Salva	1805	Enc. Brit., 21, p. 288
Carrier pigeons		
In use	ca. 1815	
Early Magnetism		
Lodestone known, Greece	ca. 575 B.C.	
Repulsion of poles known, Rome	100–0 B.C.	
Compass known, China,	ca. 1070 A.D.	
Used on ships by Moslems	1086–1099	
Known in England	ca. 1200	Mon. 1445, p. 2
Floating and pivot compasses known, France	1269	
Dip of compass, Gilbert	1600	
Earth known to be a magnet, Gilbert	1600	
Curie point discovered, Gilbert	1600	Mon. 1445, p. 3
Law of magnetic force, Coulomb	1785	
Nickel known to be magnetic	18th Century	Mon. 1445, p. 4
Deflection of magnet by current, Oersted	1820	Mon. C4, p. 3
Steel magnetized, Arago and Davy	before 1823	
Field effect of coil in deflecting magnet, Schweiger	before 1823	Mon. C4, p. 4
Early theory of electricity and magnetism, Ampere	1822–23	Mon. C4, p. 5; Comm. Thr. Ages, p. 72
Electromagnet, Sturgeon	1824*	Mon. C4, p. 5
Electromagnetic induction, Faraday	1831	Enc. Brit., 11, p. 445
Self-induction, Henry		
Noted	1829	Mon. 1445, p. 3
Theory	1832	Enc. Brit., 11, p. 445
"Conversion" of magnetism into electricity, Faraday and Henry	ca. 1832	Mon. 1445, p. 4
Magnetostriction observed by sound, Page, U.S.	1837	Mon. 225, p. 2
Cobalt shown to be magnetic, Faraday	1845	
Rotation of light in transparent bodies by magnetic field, Faraday	1845	Mon. 1445, p. 4
Diamagnetism (repulsion of non-magnet by magnet),		
Observed, Brugman	1778	
Recorded data, Faraday	1846	

* 1825, Mon. 1445, p. 3

	Date	*Reference*
Magnetic storms noted, Barlow, England	1847	BLR, 31, p. 380
Laws of electricity and magnetism, Maxwell	1873	Mon. 1445, p. 4
Magnetic rotation of plane of polarization, Kerr	1876	

Early Electricity

Static electricity on amber rods, Thales, Greece	ca. 600 B.C.	Enc. Brit., 8, p. 169
First static machine, von Guericke	1672	Comm. Thr. Ages, p. 42
Velocity of light, first attempt, Roemer, Denmark	1676	Comm. Thr. Ages, p. 25
First transmission of electricity over a line, Gray and Wheeler	1730	Comm. Thr. Ages, p. 43
Negative and positive electricity	1733	Enc. Brit., 8, p. 169
Leyden jar, van Musschenbroek	1745	Comm. Thr. Ages, p. 43
Earth circuit known, Watson	1747	Enc. Brit., 21, p. 882
Sent current through wire 2 miles		N.Y. Times, Aug. 11, 1858
Lightning and electricity, Franklin	1752	Enc. Brit., 9, p. 692
Pith ball telegraph proposed	1753	Enc. Brit., 21, p. 882
Used, Le Sage, Switzerland	1774	Enc. Brit., 21, p. 883
Battery, Galvani	1786	Enc. Brit., 21, p. 883
Electric pile, Volta	1799*	Mon. 310, p. 1
Wave interference principle		
Known	before 1800	Mon. 539, p. 2
Theory, Young	1802	Mon. 539, p. 2
Deflection of magnet by current, Oersted	1820	Mon. C4, p. 3
Steel magnetized, Arago and Davy	before 1823	
Field effect of coil in deflecting magnet, Schweiger	before 1823	
Early theory of electricity and magnetism, Ampere	1822–23	Comm. Thr. Ages, p. 72
Electromagnet, Sturgeon	1824	Mon. C4, p. 5
Resistance known	before 1827	Comm. Thr. Ages, p. 60
Ohm's law, Ohm	1827	Enc. Brit., 16, p. 737
Electric motor, Henry	1829	Enc. Brit., 11, p. 445
Existence of electron foreshadowed, Faraday	ca. 1830	Mon. 702, p. 1
Electromagnetic induction, Faraday	1831	Enc. Brit., 11, p. 445
Self-induction, Henry	1832	

* 1800, Enc. Brit., 21, p. 883

	Date	*Reference*
Early Electricity (Cont'd)		
Velocity of electric discharge, Wheatstone	ca. 1834	Enc. Brit., 23, p. 565
Relay, Henry	1835	Enc. Brit., 11, p. 445
Grounded earth return circuit, Henry	1835	
Oscillatory nature of electric discharge, Henry	1842	
Transmission and detection of radiated energy (radio), Henry	1845	Gherardi, p. 3
Electricity generated by vibration of bimetallic wire, Sullivan	1845	Mon. 585, p. 1
Secondary (or storage) battery, Plante	1859	Comm. Thr. Ages, p. 59
Electromagnetic theory		
Helmholtz	ca. 1864	BLR, 28, p. 129
Maxwell	1873	Mon. 1445, p. 4
Heaviside	ca. 1886	BLR, 28, p. 129
Nature of electron indicated, Stoney	ca. 1875	Mon. 702, p. 1
Incandescent lamp, Edison	1879	
Piezoelectricity discovered, Curie	1880	BLR, 22, p. 282
Hertz discovers radio transmission	1885–89	Enc. Brit., 11, p. 525
Word "electron" introduced	1891	Mon. 702, p. 1
Electron discovered, Thomson	1897	J. R. Pierce, World Book Enc., '5, p.167
Electron mass determined, Lorentz	1897	Mon. 702, p. 2
Atom model established, Rutherford and Bohr	1911	Collier's Enc., 2, p. 455
Early Acoustics		
Length vs. frequency of strings, Pythagoras	5th Century B.C.	Mon. 874, p. 1
Synthesis or imitation of speech, Orpheus head, Lesbos, Greece	B.C.	Mon. 1173, p. 2
Musical scale frequencies, Mersenne	1636	Mon. 874, p. 1
String telephone, Hooke	1667	BSTJ, 37, p. 589
Synthesis proper		
Vowel tubes, Prof. Kratzenstein, St. Petersburg	ca. 1779	Mon. 1173, p. 3
Consonants and vowels, Von Kempelen, Vienna	1780	Mon. 1169, p. 1
Speaking machine, Abbe Mical, France	ca. 1780	Mon. 1179, p. 3
Word "telephone" applied to megaphone	1796	BSTJ, 37, p. 289

	Date	*Reference*
Word "telephone" applied to speaking tube	after 1796	BSTJ, 37, p. 289
Mode of vibration of plates and diaphragms, Chladni	1802	Mon. 874, p. 1
Sound recording on drum proposed, Young	1807	Mon. 689, p. 2
Word "microphone" coined by Wheatstone	1827	Mon. 585, p. 10
Acoustic filter proposed, Herschel	1833	Mon. 256, p. 1
Sounds from magnet when magnetization was changed, Page, U. S.	1837	Mon. 585, p. 1
Sound recorded on drum, Wertheim	1842	Mon. 689, p. 2
Condenser "microphone", DuMoncel	1856	Mon. 585, p. 16
Loose contact experiments, DuMoncel	1856	Mon. 585, p. 7
Phonautograph, Scott	1857*	Mon. 377–II, p. 1
Diaphragm to receive sound waves, Scott	ca. 1857	Mon. 874, p. 1
Manometric capsule, Koenig	1862	Mon. 162, p. 1
Sound from a condenser, Varley	1870	Mon. 585, p. 2
Early Electric Telegraph		
Pith ball telegraph proposed	1753	Enc. Brit., 21, p. 882
Used, LeSage, Switerland	1774	Enc. Brit., 21, p. 883
Electrolytic telegraph, Salva	1805	
Electromechanical telegraph, von Sommering	1809	Comm. Thr. Ages, p. 3
First practical proposal, Henry	1830–31	Enc. Brit., 11, p. 444
Cooke and Wheatstone needle telegraph	1837	Enc. Brit., 23, p. 565
Dial telegraph, Wheatstone	1839	BLR, 31, p. 22
Morse telegraph		
Conceived	1832†	BLR, 1, p. 51
Built, Washington-Baltimore	1844	BLR, 1, p. 51
Time division multiplex		
Proposed, Farmer	1852	BLR, 1, p. 51
Patented	1853	MM54–122–3; Mon. 1220, p. 2
Duplex circuit	1854	BLR, 1, p. 51
Printing telegraph, Hughes and Phelps	1856	Circuits for Victory, p. 30
Automatic telegraph transmitter, Wheatstone	1858	Mon. 1, p. 6

* 1847, Mon. 689, p. 2
† 1824, Mon. C4, p. 6; 1836, Mon. 2026, p. 3

	Date	*Reference*
Early Electric Telegraph (Cont'd)		
Atlantic telegraph cable, Field		Mon. 1346, p. 2
First, 2 words/min.	1858	Pan. of Tel. Prog., p. 7
First successful cable	1866	
Mirror galvanometer cable receiver, 75 letters/min.	1866	BLR, 6, p. 237
Syphon recorder for submarine cable telegraph, Kelvin	1867	BLR, 6, p. 238
Carrier telegraph, Varley (England)	1870	
Tuning fork oscillator, 1 dc channel, 1 ac channel, inductance filter passes dc, capacitor passes ac, Geissler tube detector of ac		MM54–122–3
Liquid telegraph transmitter patented, Edison	1873	BSTJ, 37, p. 292
Local private line	1873	BLR, 23, p. 373
Electromagnetic receiver patented, Gray	1874	BSTJ, 37, p. 293
Quadruplex, Edison	ca. 1874	BLR, 1, p. 188
Multiplex, Baudot	1875	Mon. B1, p. 27
Harmonic telegraph experiments, Bell	1867–75	Rhodes, pp. 3–21

SIGNIFICANT PREVIOUS EXPERIMENTS IN ELECTRIC VOICE TRANSMISSION

Page, U. S.		
Sound transmitted by make and break circuit	1837	BSTJ, 37, p. 290
Magnetostrictive receiver	ca. 1837	
Bourseul, France		
Sound transmitted by make and break circuit	1854	
Reis, Germany		
Transmitter		
Cone mouthpiece, membrane diaphram, contact to make and break current	1860	Rhodes, pp. 54; 232 Mon. 581, p. 2 BSTJ, 37, p. 290
Receiver		
Coil around iron rod (a knitting needle) resting on a violin (magnetostriction).	1861	Rhodes, p. 233

	Date	*Reference*
Note: Will transmit tones. At very low levels, where vibration is not enough to break contact as Reis intended, transmitter *transmits* speech. *Reproduction* of speech officially declared impossible by court. Predecessor of the Berliner metal-to-metal variable pressure contact microphone. Reis came extremely close to inventing the telephone. However, unlike Bell, he did not appear to understand clearly what he was doing and stopped just short of success.		Rhodes, p. 55
Elisha Gray		
Variable resistance transmitter Gray filed a "caveat" in the Patent Office a few hours after Bell filed for a patent. A caveat is statement that the filer has an idea and plans to reduce it to practice. By implication, the idea has not been perfected, else a patent application would be filed. Bell's idea antedated Gray's, but because he delayed application to work further on the actual apparatus, he was first to file only by hours.	1876	Rhodes, p. 61

ALEXANDER GRAHAM BELL AND THE CONCEPT OF THE TELEPHONE

Bell's Ancestry		
Alexander Bell	1790–1865	Rhodes, p. 1
Grandfather of Graham Bell; actor, elocutionist, Shakespearean reader		Career of A. G. Bell, pp. 2, 3
Treated stammering, lisping, and other speech defects		Career of A. G. Bell, p. 3
Scientific studies of speech		Career of A. G. Bell, p. 3

	Date	*Reference*
Bell's Ancestry (Cont'd)		
Alexander Melville Bell	1819–1905	Career of A. G. Bell, p. 2
Father of Graham Bell, born, Edinburgh, Scotland	1819	Rhodes, p. 1
Teacher of speech		Rhodes, p. 1; Career of A. G. Bell, p. 1
Lecturer on elocution		Career of A. G. Bell, p. 1
Author of "Standard Elocutionist"		Career of A. G. Bell, p. 1
Inventor of "Visible Speech", a complete pronouncing alphabet for all languages and sounds	ca. 1862	Rhodes, p. 1; Career of A. G. Bell, p. 2
Scientific authority on speech		Career of A. G. Bell, p. 3
Moved to Canada	1870	Rhodes, p. 3
Elisa Grace Symonds Bell	1809–97	Career of A. G. Bell, p. 2
Mother of Graham Bell; musician; portrait painter		
Began going deaf	ca. 1859	
Alexander Graham Bell		
	1847–1922	Rhodes, pp. 1, 39
Bell's Boyhood		
Born, Edinburgh, Scotland	March 3, 1847	Rhodes, p. 1; Career of A. G. Bell, p. 2
Studied music extensively		Career of A. G. Bell, p. 3
Studied elocution under grandfather	1860	Career of A. G. Bell, p. 3
Studied speech defects under grandfather	1860	Career of A. G. Bell, p. 4
Invented wheat de-husker	1860–62	
Invented, with brothers, a speaking automaton	1860–62	
Taught pet dog to speak some phrases	1860–62	
Reis in Germany telegraphs tones	1861	Career of A. G. Bell, p. 11
Bell's Youth		
Made public demonstrations of Visible Speech	1862	Career of A. G. Bell, p. 4

	Date	*Reference*
Student teacher and student at Edinburgh University	1862–66	
Entered London University	1862–66	
Taught deaf children to speak	1862–66	
Proved vowel sounds are compound	1866	Career of A. G. Bell, p. 5
Mistranslated Helmholtz and thought he had telegraphed speech	ca. 1866	
Discovered his mistake	ca. 1866	Career of A. G. Bell, pp. 5, 6
Considered possibility of telegraphing speech	ca. 1866	Career of A. G. Bell, p. 5
Studied electricity	1867	
Pre-Telephone Years		
Ran father's classes and lectures in London	1868	
Partner with father	1869	Career of A. G. Bell, p. 6
Attended University College, London	1868–70	
Moved to Brantford, Canada	1870	
Translated Mohawk language into Visible Speech	1870–71	Rhodes, p. 3
Taught Visible Speech		
Boston School for the Deaf	1871	Career of A. G. Bell, p. 7
Clarke School, Northhampton	1871–72	
American Asylum, Hartford		
Opened School of Vocal Physiology and Mechanics of Speech, Boston	1872	Career of A. G. Bell, p. 9
Taught George Sanders, deaf son of Thomas Sanders	1872	Rhodes, p. 3
Professor of Vocal Physiology, School of Oratory, Boston Univ.	1873–77	Career of A. G. Bell, p. 9
Telegraph Experiments		
Harmonic multiple telegraph	1873–75	Career of A. G. Bell, p. 9; Rhodes, p. 4
Bell Patent Association		
Bell, Sanders, Hubbard	1874	
Thomas Sanders		
Leather merchant, Haverhill, Mass.		
Father of George Sanders, deaf		Rhodes, p. 16
Gardiner Greene Hubbard		
Lawyer		
With United Shoe Machinery Corp. (renting shoe machinery)		

	Date	*Reference*
Telegraph Experiments **(Cont'd)**		
Gardiner Greene Hubbard (Cont'd)		
Member, Massachusetts State Board of Education	1874	
Met Graham Bell	1871	
Daughter, Mabel Hubbard, deaf		Rhodes, p. 16
Bell-Sanders-Hubbard patent agreement	1874	
Tuning fork oscillators		
Reed oscillators		
Magnetized reed oscillators		
Decides current is too small	1873–74	Rhodes, pp. 11, 12, 13
Phonautograph experiments		
Gas flame graph experiments		
Human ear experiments		
Concept of the telephone Brantford, Ont.	July 26, 1874	Career of A. G. Bell, p. 13 Rhodes, p. 4 Pan. of Tel. Prog., p. 7
Harp transmitter concept	1874	Career of A. G. Bell, p. 13 Rhodes, pp. 10–13
Diaphragm transmitter concept	1874	Career of A. G. Bell, p. 13 Rhodes, p. 13
Membrane speaking telephone concept	1874	
Visit to Joseph Henry	1875	
Harmonic telegraph patent issued	1875	Rhodes, p. 14
Western Union points out further requirements	1875	

First Tone Transmitted

	Date	*Reference*
Bell, with Harmonic Telegraph Transmitter and 2 Harmonic Telegraph Receivers (one *Receiver* at Watson's end of line transmitted to the other *Receiver* at Bell's end of line (*Transmitter* transmitted to *Receiver*)	June 2, 1875	Bell dep., Am. Bell Tel. Co. vs. Peoples Tel. Co. p. 137; Bell Tel. Co. vs. Dowd, p. 471 Watson, p. 67

First Speech Sounds Transmitted

Bell, with Gallows Frame Telephone as transmitter and Harmonic Telegraph Receiver	June 3, 1875	Rhodes, p. 24

First Intelligible Sentence Transmitted

Bell, with Liquid Transmitter and Tuned Reed Receiver	March 10, 1876	Rhodes, p. 28 Note in back of "Career of A. G. Bell" in Museum

First Speaking Telephone, U. S. Patent 174465

Bell, application	Feb. 14, 1876	Mon. 1867
Issued	March 7, 1876	Rhodes, p. 26
Facsimile		BLR, 32, p. 7

Offer of Sale

Hubbard offered telephone to Western Union for $100,000. Western Union refused to buy	Fall, 1876	Rhodes, p. 51

The First "Telephones"

First Iron Box Receiver	by May, 1876	Rhodes, p. 29
First Box Telephone Experimental model, Bell	Oct. 1876	Rhodes, p. 37
First Commercial Type Box Telephone (Transmitter and Receiver combined)	1877	Rhodes, p. 176

	Date	*Reference*
The First "Telephones" (Cont'd)		
First Hand Telephone (Transmitter and Receiver combined), Bell	1877	Rhodes, p. 42, Fig. 7
First commercial wall telephone	1877	Rhodes, p. 176
Photophone		
Bell (Note: christened "Radiophone" by Mercadier)	1880	"On the Production and Reproduction of Sound by Light", Bell, p. 318 (HM 16209)

AMPLIFIER (SEE REPEATER)

CALL ANSWERING (SEE STATION PLANT, ANSWERING SET)

CAPACITOR

	Date	*Reference*
Metalized paper, Mansbridge¶, England		
Patented	1900	Mon. 1773, I, p. 2
Silvered mica, test standard		
In use	1906	Mon. 1411, p. 1
Electrolytic (telephone type)		
Siegmund		Hist. Firsts, p. 48
Patent application	1921	BLR, 26, p. 331
Extruded can	ca. 1939	BLR, 17, p. 277
Polystyrene	1941–45	BLR, 24, p. 111
Mica and foil	before 1946	Mon. 1411, p. 1
Silvered mica, general use	before 1946	
Lacquer film, experimental	ca. 1954	Mon. 2384, p. 1
Tantalum	1956	IRE, 44, p. 872

COIL (SEE ALSO INDUCTOR)

Repeating, "Probable first"		
Lockwood and Watson, Boston-Lowell (also called induction coil when in station apparatus)	1879	Lockwood, AIEE, III, p. 85
Loading		
Experimental, Campbell (air-core, solenoid coils)	1899	BLR, 30, p. 264 Mon. 1970, p. 3
Experimental, field trial, Campbell, Jamaica Plain-West Newton, Mass. (Air-core, solenoid coils)	1900	Rhodes, p. 140 Mon. 1970, p. 3
Field trial, Bedford, N.Y.—Brushton, Pa.	1900	Mon. 1970, p. 3

¶ Used for Non-Bell System throughout

COIL (Cont'd)

	Date	*References*
Commercial use, open wire, New York—Chicago, Warren	1901	Mon. 1970, p. 266 BLR, 30, p. 268
T300 (W.E. 501), first coil in commercial use 9 inch diameter, 4 inch thickness, 0.265 henry Core: 93,000 turns No. 38 B & S gauge mild steel wire. Nominal permeability, 65 Winding: 7 strand insulated copper, 22 gauge, 2.5 ohms dc resistance, 5 ohms + at 1000 cycles		BLR, 30, p. 268
Commercial use, cable, New York—Newark	1902	BLR, 30, p. 264 Rhodes, p. 140 An. Report, Eng'g. Dept., Am. Bell Tel. Co., 1902
T420 (W.E. 502), first coil in commercial use on cable 5 inch diameter, 2¼ inch thickness, 0.3 henry		
Iron wire core (loading)	1899–1927	Mon. 1970, p. 10
Toroidal	1916	BLR, 3, p. 35
Powdered iron		
Proposed, Dolezalek[1], Germany	1902	Mon. 153, p. 24
First (601, 602)	1916	Mon. 196, p. 23 Mon. 1970, p. 10
Hard (unannealed) iron dust core replaced soft iron dust	1918	Mon. 1970, p. 25
Non-magnetic core coils	1920	Mon. 1970, p. 10
Compressed powdered permalloy core (first coil small enough to be placed in loading splice sleeves), No. 612		
Experimental	1926	Mon. 1970, p. 67
Commercial	1927	Mon. 1970, p. 10 Mon. 976, p. 16
Standard	1928	Mon. 1970, p. 36
Molybdenum permalloy core (No. 622)		
In use	1936	Mon. 976, p. 16 Mon. 1970, pp. 10, 36, 50
Non-linear, for pulse generation and modulation	1941–45	BLR, 24, pp. 102, 450
In use		
"Wedding Ring", small coil, 1¼ inch diam.	1942	Mon. 1970, p. 76
War standard (SM and MF) low permalloy coil cores	1942	Mon. 1970, p. 43

	Date	*Reference*
Low permalloy cores standard	after 1945	Mon. 1970, p. 46
Sub-"Wedding Ring", 44 mh., 1.06 inch diam., molybdenum permalloy, for subscribers loops, No. 651	1948	Mon. 1970, pp. 81, 82
Cellulose acetate filled		
In use	1948	BLR, 29, p. 514
Pulse coils		
Available	1949	Mon. 1713, p. 1
Ferrite core		
In use	1952	Mon. 2116, p. 1
CAA type retardation		
Adjustable core to control inductance over wide limits		
Available	1953	BLR, 31, p. 302
L3 Carrier transformer coil, deposited copper on glass	ca. 1953	BLR, 31, p. 366
COMPUTER		
Basic logic, Aristotle¶	4th Century B.C.	BLR, 32, p. 321
Early form, first automatic digital computer for pure scientific computing, Stibitz and Williams	1938	Mon. 1972, p. 1 Mon. 2084, p. 3
Error correction developed, experimental, Hamming	1950	N&I Rel., 4/20/50
ECASS (Electronically Controlled Automatic Switching System), experimental	ca. 1953	Mon. 2084, p. 323
DIAD (Drum Information Assembler and Dispatcher), experimental	ca. 1954	
TRADIC (Transistor digital computer)		
Phase 1, first in operation	1954	Mon. 2395, p. 1 BLR, 36, p. 223
Flying model	1955	N&I Rel., 3/14/55 BLR, 33, p. 155
Leprechaun, experimental	1957	N&I Rel., 5/29/57
CONTACT		
Platinum	by 1859¶	BLR, 2, p. 8
First Bell System use	1876	Liquid transmitter, Bell

¶ Non-Bell System

CONTACT (Cont'd)

	Date	*Reference*
Brass	before 1875†	Telegraph Instruments
First Bell System use	1875	Rhodes, Fig. 3
Iron	1877	Rhodes, Fig. 8
Plumbago	1877	Rhodes, p. 78
Carbon	1878	Rhodes, p. 79
Gold	by 1885	Rhodes, p. 81
Rivet type platinum	until 1913	BLR, 18, p. 278
No. 1 Metal (gold, silver, platinum		
Field trials	1912–17	BLR, 2, p. 11
Adopted	1917	
Welded type	1913	BLR, 18, p. 278
No. 2 Metal (palladium)		
Tests concluded	1912	BLR, 2, p. 11
Adopted	1917	
No. 4 Metal (palladium alloy)	1920–1923	BLR, 2, p. 12
Embossed, coated	ca. 1930	Runyon, 6/30/59
Bar type		
Palladium for transmission, silver for signaling	1937	BLR, 18, pp. 278, 281 BLR, 27, p. 50
Silver	1937	BLR, 27, p. 50

CRYSTAL (SEE ALSO MATERIALS; APPARATUS, OSCILLATOR, SOLID STATE DEVICE, DIODE); CENTRAL OFFICE PLANT, APPARATUS, FILTER

Piezoelectric effect discovered, the Curies†	ca. 1880	Mon. 976, p. 9
Oscillator, Langevin† (submarine detection)	ca. 1917–18	Mon. 976, p. 9
Microphone, Nicolson	1917–18	BLR, 22, p. 282 Mon. 976, p. 9
Loud Speaker, Nicolson	1917–18	Mon. 976, p. 9
Oscillator, Nicolson		
Patent application	1918	BLR, 22, p. 601
Frequency control, Marrison		
Used to control broadcasting (Ryan and Marrison)	1924	Hist. Firsts, p. 51
Crystal clock, Marrison	1927	BLR, 22, p. 325
Zero temperature coefficient (less than one part per million per °C, zero at 1 temperature), doughnut shape, Marrison		
Patent application	1928	BLR, 23, p. 70 Hist. Firsts, p. 21

	Date	*References*
GT Cut, Mason		
Patent application (1 part per ten million for 30° range, 1 part per million for 0°-100°C)	1937	BLR, 23, p. 71
Portable frequency standard for clock (proved superior to Arlington time in bad weather, in U.S.S. Submarine Barracuda tests in West Indies)	1939	BLR, 18, p. vi
Wire mounted, Ziegler	1938	BLR, 30, p. 433
Patent application	1940	BLR, 23, p. 246
Silicon detector		
Experimental	ca. 1938	BLR, 26, p. 152
Limited use	by 1941	BLR, 26, p. 153
British design[¶] (present type) (limited by use of poor silicon)	1940–41	
Bell Laboratories improvement	ca. 1942	
Quartz plate, tuned to frequency by plating	before 1943	Mon. 1531, p. 4
Synthetic quartz	1948	BLR, 26, p. 384
Barium titanate, memory type		
Experimental	by 1953	BLR, 31, p. 316
Guanidine aluminum sulphate hexahydrate, memory type (storage crystal), experimental	1955	BLR, 33, p. 342

DETECTOR (SEE RADIO)

FUSE

Fuse link	ca. 1878	Dietz, 7/8/59
Grasshopper fuse, Craft		
Patented	1903	Dietz, 7/8/59
Cartridge (70 type)		
Design	ca. 1948	Dietz, 7/8/59; BLR, 29, p. 162
In manufacture	ca. 1951	BLR, 29, pp. 162, 226

INDUCTOR (SEE ALSO COIL)

Ferrite		
In use	1955	BLR, 33, p. 137

¶ Non-Bell System

MEASURING

	Date	*Reference*
Rapid record oscillograph	1930	Mon. 609, p. 1

MODULATOR

Vacuum tube, Van der Bijl	by 1915	BLR, 23, p. 6
Plate-grid modulation, full wave, Van der Bijl		
Patent application	1915	BLR, 26, p. 251
Rectifier modulator, Heising (half wave)		
Patent application	1916	Hist. Firsts, p. 46 BLR, 26, p. 251
Grid modulation, Heising (oscillating wave)		
Patent application	1916	BLR, 26, p. 251
Vacuum tube, Heising	1917	Hist. Firsts, p. 20
Copper oxide, C. R. Keith		
Patent application	1929	
Bridge type, Cowan		
Patent issued	1934	BLR, 23, p. 200
Ring type, Cowan		
Patent issued	1935	
Non-linear coil		
In use	1945	BLR, 24, pp. 102, 450
Magnettor (magnetic modulator)		
Experimental	1951	Mon. 1942, p. 1

OSCILLATOR

Harmonic generation		
Magnetic core coils, Epstein¶	1902	
Doublers and triplers, Joly¶ and Vallaucri¶	1911	Mon. 1036, p. 1
Multiple harmonic generation, electromagnetic, Peterson, Manley and Wrathall		
First use, New York—Philadelphia	1936	Hist. Firsts, p. 14
Crystal, Nicolson		
Patent application	1918	BLR, 22, p. 601
Crystal, quartz, zero temperature coefficient (less than 1 part per million per °C, zero at 1 temperature), Marrison		
Patent application	1928	BLR, 23, p. 70 Hist. Firsts, p. 21

	Date	*Reference*
Range available	1934	Mon. 839, p. 1
Triode—to 1200 megacycles		Mon. 839, p. 15
Barkhausen† tube (spiral grid type)—to 3000 mc		Mon. 839, p. 28
Magnetron—to 30,000 mc		Mon. 839, p. 29
Electromagnetic harmonic generator		
In use	1936	BLR, 22, p. 533
Crystal, quartz, GT cut (1 part per ten million for 30°C range, 1 part per million for 0°–100°C)		
Patent application	1937	BLR, 23, p. 71
Start-stop		
Patent application	1942	BLR, 26, p. 212

PROTECTOR (SEE FUSE, AND STATION PLANT, PROTECTOR)

Silk insulation between twisted wires	1877	BLR, 11, p. 80
Telegraph type plates In use	1878	
Brass plates separated by mica	1879	
Carbon blocks with mica separator (No. 1 Protector Carbon, later No. 1 Protector Block)	ca. 1890	BLR, 11, p. 80; Obs. Card Cat.
Porcelain block	ca. 1920–21	BLR, 11, p. 83; Dietz, 7/8/59
Gas-tight combined lightning arrester and aerial cable terminal		
Design	1948	BLR, 29, p. 163
In manufacture	1951	
Silicon pn junction diode, Pearson and Fuller	1954	IRE, 42, p. 760

RADIO (SEE ALSO TRANSMISSION)

First radio transmission, Henry†	1842	Sci. Am., 7/54, p. 76
Radio transmission, Hertz†, Germany	1887–91	BLR, 28, p. 129
Spark gap and wire loop (quoted by Kintner)	1887	AIEE, XXV, p. 781
Loop antenna (with spark gap), Hertz†	1887	

† Non-Bell System

RADIO (Cont'd)

	Date	*Reference*
Parabolic reflector antenna, Hertz¶	1887 or 1888	BLR, 7, p. 503
Dipole antenna, Hertz¶	ca. 1887–91	BLR, 7, p. 504
Parallel wire reflector, Hertz¶	1887 or 1888	Mon. 539, p. 2 AIEE, XXV, p. 781
Bell System experiments with 'radio telephony and carrier, Hayes and Stone	1892	Espenschied, MM-54-122-3
Negative particle noted, Perrin¶	1895	J. R. Pierce, World Book Enc., 5, p. 167
X-ray discovered, Roentgen¶, Germany	1895	
First radio-telegraph transmission, Marconi¶, Italy	ca. 1896	BLR, 28, p. 129
Electron discovered, Thomson¶, England	1897	J. R. Pierce, World Book Enc., 5, p. 167
Antenna array proposed, Brown¶, England	1899	Mon. 194, p. 1
One-way transmission antenna proposed, Blondel¶, Belgium	after 1899	
First transatlantic radio-telegraph transmission, Marconi¶	1901	Tel. Almanac, 1956
Use of diode vacuum tube as radio detector proposed, Fleming¶, England	1904	Brit. pat. 24,850 U.S. pat. 803,684
Three-element vacuum tube (Audion), DeForest¶		
Control element outside envelope	1906	U.S. pat. 841, 387
Control element on opposite side of cathode from plate	1906	
Control grid between cathode and plate	1907	U.S. pat. 879,532
Invention of single side-band transmission, Carson	1915	Mon. 1021, p. 21
"Master-Oscillator" transmitter (modulation at low-level, then amplified)		
Arnold and Van der Bijl		
In use	1915	BLR, 27, p. 24
Plate-grid modulation, full wave, Van der Bijl	1915	BLR, 24, p. 251
Analysis of modulated wave (carrier and side bands), Carson	1915	Mon. 1021, p. 21
First radio frequency vacuum tube voltmeter, Heising	1915	Ev. Tel. Hist., p. 20

	Date	*Reference*
First transatlantic radio telephone transmission, Arlington Va.,—Paris	1915	Tel. in Am., p. 41
Rectifier modulation, Heising Patent application	1916	BLR, 26, p. 251
Grid (half wave) modulation, Heising (oscillating wave) Patent application	1916	BLR, 24, p. 251
Coastal and Harbor		
First radio telephone transmission	1916	Ev. Tel. Hist., p. 21
Cannery tender	1930	BLR, 8, p. 500
New York fireboat	1930	BLR, 8, p. 609
Coast Guard	by 1931	BLR, 10, p. 205
Commercial (harbor craft and coastal)		
Field trial	1932	BLR, 11, pp. 62, 77
Commercial service	1934	Ev. Tel. Hist., p. 30
Ship-to-shore radio telephone		
First demonstration (U.S.S. New Hampshire)	1916	Mon. 503, p. 2
Experimental, Deal and Green Harbor to S.S. Ontario	1920	Mon. B40, p. 8
First commercial installation, S.S. Leviathan	1929	Tel. in Am., p. 44
Aircraft		
First radio telephone transmission (U.S. Army using Bell System equipment)	1917	Ev. Tel. Hist., p. 21
First commercial use of Bell] equipment (private installations)	1930	Mon. B478, p. 30
Radio reflection system, basis of radio altimeters and radar, Espenschied	1919	Ev. Tel. Hist., p. 22
Altimeter patented, Espenschied		
Patent application	1930	Mon. 1124, p. 3
Patent issued	1936	
Broadcasting		
Station 2XB, Bell Laboratories, experimental	1919	BLR, 26, p. 420
Volume indicator invented, Nelson	about 1920	BLR, 31, p. 341
First commercial radio telephone link, to Catalina Island, 1000 KC	1920	Avalon-L. A., p. 1 Tel. in Am., p. 33
Privacy system added	by 1923	BSTJ, 37, p. 322 Mon. 2434, p. 2
Waveguide research started	1920	BLR, 14, p. 285

† Non-Bell System

RADIO (Cont'd)

	Date	*Reference*
WEAF, changed call letters from 2XB	by 1922	BLR, 26, p. 420
Broadcasting started by Bell System, WEAF	1922	
Automatic gain control	1923	BLR, 28, p. 98
Automatic frequency control	after 1923	
Automobile		
Police		
First installation, WLAW, New York City	1924	Mon. 751, p. 1
Full service	1929	Mon. 751, p. 2
Private and commercial		
First use	1946	BLR, 24, p. 345
Crystal frequency control, Marrison	1924	Ev. Tel. Hist., p. 25
Crystal-controlled broadcasting, WEAF	1924	BLR, 26, p. 420
Two-loop antenna, Friis	1925	Mon. 168, p. 1
Ionosphere (Heaviside layer) measurements, Schafer and Goodall, step on way to radio altimeter and radar	1926	N&I Rel., 1/24/46
First commercial long-wave transatlantic radio telephone circuit, 60 KC	1927	Tel. in Am., p. 42
Beverage antenna, transatlantic, Houlton, Me.	1927	Mon. 1255, p. 31
Negative feedback perfected, H. S. Black	1927	Black
Zero temperature coefficient crystal (less than 1 part per million per °C, zero at 1 temperature)		
Patent application	1928	BLR, 23, p. 70
First commercial short-wave transatlantic radio telephone circuit	1929	Mon. 497, p. 21
Panel or curtain transmitting antenna, Sterba (Lawrenceville)	1929	BLR, 7, p. 506
Rhombic (diamond) antenna		
Patent application	1929*	BLR, 22, p. 440
Name rhombic in use	1935	Mon. 835, p. 1
Common frequency broadcasting, experimental	1929	Mon. 597, p. 3
Broadside antenna, receiving, Netcong, N. J.	1930	BLR, 7, p. 514

* 1930, Mon. 587, p. 26; 1931, Transoceanic Tel. Serv., p. 12

	Date	*Reference*
Spaced antenna	1930	Mon. 539, p. 2 BLR, 7, p. 503
First radio reflection noted	1932	BLR, 21, p. 363
Provincetown–Green Harbor link, 60 mc	1934	Mon. 873, p. 10
Pine tree antenna, Provincetown–Green Harbor link	1934	Mon. 1255, p. 29
Single sideband transmission on transatlantic short wave		
Tests	1934	BLR, 18, p. 84
In use	1939	
MUSA (Multiple Unit Steerable Antenna)		
Phase shift steering, Schelleng	ca. 1930	Mon. 1005, p. 4
Early experiments, Bruce	1931–35	Mon. 1005, p. 2
Antenna rotating, Jansky	ca. 1932	Mon. 1005, p. 4
Improved phase shift, Friis and Feldman	ca. 1934	
Antenna warping, Bruce and Beck	ca. 1935	
True MUSA, experimental	1935	Mon. 1005, p. 1
First commercial use, Manahawkin	1939	BLR, 18, p. 130
Doherty amplifier, using high power only as needed, to increase efficiency		
Published	1936	BLR, 22, p. 386
In use	1937	
Patent issued	1940	Hist. Firsts, p. 11
Shunt-excited antenna, base grounded, Morrison and Smith	1936	Mon. 938, p. 1
Envelope feedback (kills cross-modulation)	before 1938	BLR, 28, p. 102
Radio altimeter, BTL, W.E., United Air Lines	1938	BLR, 21, p. 363 Ev. Tel. Hist., p. 31
Range of ships (Narrows experiment)	1938	BLR, 21, p. 363
Horns as directive antennas, Southworth and King	ca. 1938	Mon. 1133, p. 1
Silicon crystal detector		
Experimental	ca. 1938	BLR, 26, p. 152
Limited use	by 1941	BLR, 26, p. 153
British† design (present type) (limited by use of poor silicon)	1940–1941	
Bell Laboratories improvement	1942	
Radio location work by BTL	before 1939	BLR, 21, p. 363

† Non-Bell System

RADIO (Cont'd)

	Date	*Reference*
Horn antenna for microwaves		
In use	1939	Mon. 1133, p. 1
First BTL work on radar for government	1939	BLR, 21, p. 363
Wire-mounted crystals, Ziegler		
Patent application	1940	BLR, 23, p. 246
Plate lens antenna for microwaves, Kock (had been proposed by King, Southworth and Mason)	1946	N&I Rel., 3/26/46
Cloverleaf antenna	1946	N&I Rel., 3/26/46
First commercial multi-channel UHF microwave radio telephone system, to Catalina Island	1946	Ev. Tel. Hist., p. 34
Railroad		
Experimental, Canada	1929	Mon. 1882, p. 1
First commercial use, New York–Washington (Penn. and B. & O. Railroads)	1947	Mon. 1882, p. 2
Delay lens antenna, Kock	1948*	N&I Rel., 2/13/48; Mon. 1689, p. 1
Broadband horn-reflector antenna for microwaves	1954	N&I Rel., 10/4/54
Flexible circular waveguide	1955	N&I Rel., 2/3/55
Over-the-horizon radio developed by BTL and M.I.T.	1955	N&I Rel., 3/23/55
First commercial Over-the-horizon radio link, U.S.–Cuba	1957	Ev. Tel. Hist., p. 45
Personal-signal service, trial installation, Allentown–Bethlehem, Pa.	1957	Ev. Tel. Hist., p. 45

REPEATER

First amplifier, Edison's[¶] carbon transmitter	1877	Rhodes, pp. 78, 79, 80
Granular carbon, Hunnings[¶] (pulverized engine coke)	1878	Rhodes, p. 79
Granular carbon, Edison[¶] (hard coal)	1886	Rhodes, p. 81
Carbon button type, experimental, Edison[¶]	before 1890	Private memo, Bowles
Mercury arc amplifier experiments, Cooper Hewitt[¶]	1902	Private memo, Bowles

* 1947, Mono. 1519, p. A1

	Date	*Reference*
Carbon button repeater, Shreeve		Quarter Cent. Trans.
Field test, Amesbury–Boston	1904	Tel. Serv., p. 11
Audion, De Forest¶	1907	U.S. pat. 879,532
21 Type Repeater	by 1911	Hist. Firsts, p. 29
Mercury arc repeater experiments (Bell System)	1912	
Negative voltage on tube grid, Lowenstein¶	1912	BLR, 11, p. 352
High-vacuum tube, Arnold and Langmuir¶	1913	
First field trial of vacuum tube repeaters, New York–Philadelphia	1913	Ev. Tel. Hist., p. 19
22 Type Repeater		
Invented, Richards	1895	Tel. Repeaters, p. 1296
Field trial, New York–Philadelphia	1914	Quarter Cent. Trans. Tel. Serv., p. 22 BLR, 20, p. 20
Successful experiments with Shreeve carbon button, Arnold mercury arc, and vacuum tube (cabinet type) repeaters on transcontinental line at Brushton, Pa.; Chicago, Ill.; Omaha, Neb.; Denver, Colo.; Salt Lake City, Utah, and Winnemucca, Nev.	1914	Trans. Tel. Line, p. 5 Private memo, Bowles BLR, 27, p. 6
Negative feedback proposed, Langmuir¶	1914	Private memo, Bowles
Repeaters in commercial service, on transcontinental line	1915	Trans. Tel. Line, p. 5 Quarter Cent. Trans. Tel. Serv., p. 23
Floor type repeater	1917	
Reading type, New York–Pittsburgh	1920	BLR, 27, p. 6
Type B Repeater	ca. 1921	
Voice operated repeater, experimental	1921	Darrow
22A1 Type	1923	BLR, 27, p. 6
44 Type (4-wire)		
In use	1926	Mon. 196, p. 32
Negative feedback perfected, H. S. Black	1927	Black
Cord circuit repeater	before 1932	Mon. 674, p. 3

¶ Non-Bell System

REPEATER (Cont'd)

	Date	*Reference*
Pad controlled cord circuit repeater		
In use	1932	Mon. 674, p. 4
V1 Repeater	1939	BLR, 27, p. 6
E1 Repeater (local)	ca. 1948	Mon. 2320, p. 1
V3 Repeater	1948	BLR, 27, p. 6
Diamond amplifier (experimental)	1948	BLR, 26, p. 127
Magnetic amplifier		
Available	1949	Mon. 1839, p. 1
Pole-mounted, for N1 Carrier		
In use	1953	BLR, 31, p. 397

RESISTOR

Wire wound	by 1878	Rhodes, p. 167
Deposited carbon	1941–45	BLR, 26, p. 402
Borocarbon	1950	N&I Rel., 9/28/50

SELECTOR

Vibrating reed, field trial	1949	BLR, 28, p. 2 Mon. 1662, p. 1 Mon. 1663, p. 1

SOLID STATE DEVICES (SEE ALSO THERMISTOR AND VARISTOR)

Diode

Polarizing effect of film on aluminum, Wheatstone¶, England	ca. 1855	Mon. 349, p. 1
Metallic rectifier, Braun¶, also Schuster¶	1874	Mon. 1850, p. 1 Mon. 2538, p. 1
Galena crystal rectifier, Braun¶, Germany	1874	Mon. 2538, p. 1 BLR, 33, p. 227
Selenium rectifier	1883	Mon. 1850, p. 1
First used in Bell System to provide line current and power for magnets in Teletype	1942	Mon. 1987, p. 2
Copper oxide rectifier, Grondahl¶ and Geiger¶, U.S.	1925	Mon. 1850, p. 1
Publication	1927	Mon. 2538, p. 2
First used in Bell System to trickle charge batteries	1927	Mon. 1987, p. 1

	Date	*Reference*
PN junction discovered, Ohl and Scaff	1935–40	Mon. 2538, p. 6 BLR, 33, p. 241
Silicon pn junction photovoltaic action, Ohl Patent	1941	Mon. 2096, p. 1
Silicon crystal detector (rectifier)		
Experimental	ca. 1938	BLR, 26, p. 152
Limited use	1941	
British† design (present type) (limited by use of poor silicon)	1940–41	
Bell Laboratories improvement	ca. 1942	
Germanium diode	ca. 1941–45	Mon. 1850, p. 1
Silicon photo-cell	1946	Mon. 1419, p. 1
Silicon junction diode	1952	Mon. 2064, p. 1
Solar battery (silicon diode), Chapin, Fuller, and Pearson	1954	N&I Rel., 4/25/54 BLR, 33, p. 241
First installation, Americus, Ga.	1955	N&I Rel., 6/23/55; 10/4/55
Silicon lightning protector, Pearson and Fuller	1954	IRE, 42, p. 760
Silicon power rectifier		
Junction rectifier, Pearson and Fuller	1954	N&I Rel., 7/7/55
Silicon power rectifier	1955	N&I Rel., 7/7/55 WE, VII, No. 5, p. 9

General

Negative temperature coefficient of resistance, silver sulphide, Faraday†, England	1833	Mon. 2538, p. 1
Photovoltage from electrode in electrolyte, Becquerel†, France	1839	
Photoconductivity of selenium, Smith†, England*	1873	
Contact rectification by metals and sulphides (including galena and pyrites), Braun†, Germany	1874	
By tarnished and untarnished copper, Schuster†	1874	
Selenium barrier layer photocell, Adams† and Day†, England	1876	

† Non-Bell System

SOLID STATE DEVICES (Cont'd)

	Date	*Reference*
General (Cont'd)		
Hall† effect	1879	Mon. 2538, p. 2
First large dry rectifier, Fritts†, U. S.	1883	Mon. 2538, p. 1
Conductivity by free electrons proposed, Drude†	1900	BLR, 32, p. 285
Point contact radio detectors ("cat's whiskers") with galena, silicon carbide, tellurium, silicon, etc.		
Bose†, U. S. Patented	1904	Mon. 2538, p. 1
Dimwoody†, U. S. Patented	1906	Mon. 2538, p. 1
Austin†, U. S.	1907	Mon. 2538, p. 1
Pierce, U. S.	1907	Mon. 2538, p. 1
Theory of solid semiconductor, Wilson†, England	1931	Mon. 2538, p. 3
Theory of rectification, Davydov†	1938	Mon. 2538, p. 6
Diamond amplifier (experimental)	1948	BLR, 26, p. 127
New hole theory, Shockley	1949	BLR, 32, p. 289
Thermistor		
Negative thermal coefficient discovered, Faraday†	1833	Mon. 2538, p. 1
Developed, BTL	ca. 1940*	BLR, 32, p. 286
Used in cable carrier	by 1949	Mon. 1712, p. 1
Varistor		
Name coined (from Variable Resistor)	1934	Mon. 1850, p. 2
Copper-oxide modulator for telephone use		
Tried	1927	BLR, 20, p. 105
In Type G Carrier	1936	BLR, 14, p. 393; BLR, 16, p. 210
Germanium, in use	1948	BLR, 26, p. 485
Transistor		
Point Contact Type		
First successful experiment	1947	Guenther
Announced Shockley, Bardeen, and Brattain	1948	N&I Rel., 7/1/48; 5/20/52

† Non-Bell System
* ca. 1939, Mon. 1443, p. 1

	Date	*Reference*
Type A, first in manufacture Available	1949†	Mon. 1640, p. 1 Mon. 1993, p. 1
First field trial as oscillators, frequency generators for multifrequency pulsing, Englewood, N. J.	1952	BLR, 30, p. 439
First transistor card translator, Pittsburgh, Pa.	1953	BLR, 31, p. 276
First transistorized carrier, Americus, Ga.	1954	BLR, 30, 3/11/54
First transistor repeater, Americus, Ga.	1954	Ev. Tel. Hist., p. 42
Phototransistor		
Silicon pn junction photovoltaic action described, Ohl	1941	Mon. 2096, p. 1
Phototransistor, Shive	1949	Phys. Rev., 76, p. 575 BLR, 28, p. 127
Junction Type		
Invented, Shockley		
Patent application	1948	Guenther BSTJ, 28, pp. 335–489 Mon. 1726, p. 101, 138
Produced, Sparks	after 1949	Mon. 1909-II, p. 1
Grown junction	1952	BLR, 36, p. 226
Junction tetrode, Wallace (2 junctions, 4 electrodes)	1952	Mon. 2089, p. 1 BLR, 31, p. 278
Silicon alloy, "new"	1953	BLR, 31, p. 361
pnip, Early (also npin)	1954	N&I Rel., 8/27/54
Diffused junction	1954	BLR, 36, p. 203
2-watt, experimental	1954	Mon. 2281, p. 14
npn junction tetrode 4 electrodes, high frequency (1000 mc)	1955	N&I Rel., 8/23/55
Alloy junction	1955	BLR, 36, p. 227
Field effect transistor		
First test, Shockley and Pearson	1948	BLR, 33, p. 168
Experimental	1955	
Diffused base, Lee and Dacey	1956	N&I Rel., 1/20/56; 2/5/58
Used in U. S. satellite "Explorer"	1958	N&I Rel., 2/5/58

† 1951, BLR, 36, p. 202

TERMINAL STRIP

	Date	*Reference*
Wood	1875	
Cast resin		
Field trials completed	1948	BLR, 32, p. 180
Production started (for solderless wrapped connections)	1952	BLR, 32, p. 181

TRANSFORMER

First input (ex-repeating coil)	1904	BLR, 3, p. 33
Vacuum tube input		
Experimental	1913	BLR, 3, p. 34
Transcontinental	1914	
High precision, glass core, plated windings, steatite housings, No. 2504A, for L3 microwave radio relay system	1951	Mon. 2390, p. 1
Ceramic core	ca. 1954	BLR, 32, p. 294

VACUUM TUBE

Geissler¶ tube, Germany	ca. 1850	Collier's Enc., 7, p. 209
Current, filament to plate, Hittorf¶, Germany	before 1878*	Enc. Amer., 14, p. 299
Shadow on tube wall caused by obstacle in Geissler tube, Crookes¶	ca. 1878	J. R. Pierce, World Book Enc., 5, p. 167
Charge from filament to plate, and rectification, Elster¶ and Geitel¶, Germany	1882	AIEE, XXV, pp. 741, 775
Vacuum tube diode, shown in vacuum tube voltmeter circuit, Edison†		
Patent application	1883	U. S. pat. 307,031
Patent issued	1884	
Cathode ray tube		
Proposed, Hess¶, France	1894	Mon. 639, p. 6
First tube, Braun¶, Germany	1897	
Vacuum tube suggested, John Stone Stone	1896	BLR, 25, p. 367
Mercury arc amplifier, early experiments, Cooper Hewitt¶	1902	Collier's Enc., 7, p. 209

¶ Non-Bell System
* ca. 1850, AIEE, XXV, p. 764
† Conceived by 1876, private memo, Bowles

	Date	*Reference*
Discovery of vacuum tube diode as detector of radio waves, Fleming[¶], England	1904†	Collier's Enc., 7, p. 209 Private memo, Bowles Brit. pat. 24,850 U. S. pat. 803,684
Coated filament		
Known	before 1904	Mon. 1117, p. 1
Experimenters smeared sealing wax on filament and burned it off to increase emission		
Tests to prove it	1904	Mon. 1117, p. 1
Application, Wehnelt[¶]	1905	Mon. 639, p. 9
Three-element vacuum tube (Audion), DeForest[¶]		
Control element outside envelope		
Patent application	1906	
Patent issued	1907	
Control element on opposite side of cathode from plate		
Patent application	1906	U. S. pat. 841,387
Patent issued	1907	
Mechanical movement of plate vs. filament		
Patent application	1906	
Patent issued	1907	
Control grid between cathode and plate		
Patent application	1907	U. S. pat. 879,532
Patent issued	1908	
Study of gas tube for possible telephone repeater, Campbell	1907	Espenschied, MM-54-122-3
Campbell urged study of vacuum tube as telephone repeater	1907	
Photoelectric cells		
Selenium, Willoughby[¶]	1873	Mon. 2538, p. 1
Potassium hydride, Elster[¶] and Geitel[¶]	ca. 1910	Mon. 681, p. 2
Caesium on tungsten, Langmuir[¶] and Kingdon[¶]	ca. 1923	
Caesium oxide-silver, Koller[¶]	ca. 1931	
Mercury vapor arc repeater tube studies, Arnold	1911	Espenschied, MM-54-122-3
Use of negative voltage on grid, Lowenstein[¶]	1912	U. S. pat. 1,231,764 Private memo, Bowles

† 1905, Mon. 2026, p. 3

VACUUM TUBE (Cont'd)

	Date	*References*
DeForest† (with Stone) brings audion to Bell System	1912	Private memo, Bowles
High vacuum tube, Arnold	1912	BLR, 21, p. 283
Partial high vacuum	1912	Espenschied, 3/10/59
Gaede pump and true high vacuum	1913	
Vacuum tube oscillator, Strauss† Patent application	1912	Mon. 1593, p. 17
Arnold (W. E.) and Langmuir† (G. E.) file for patent on use of high vacuum in vacuum tube	1913	Private memo, Bowles
First experimental Bell System audion	1913	B–T Index, I, p. 6
First reference to "getter", Audion No. 19	1913	B–T Index, I, p. 9
First vacuum tube installed on a telephone line, New York–Philadelphia, W. E. Type A, "Audion No. 64", at Philadelphia	1913	Ev. Tel. Hist., p. 19 B–T Index, I, p. 15 B–T Notes, p. 10
First use in radio telephony, Meissner†, Germany	1913	Mon. 1021, p. 5
First unipotential cathode, Audion No. 116	1913	B–T Index, I, p. 23
First reference to "Standard" Type (A tube)	1913	B–T Index, I, p. 29
Vacuum tube modulator, Alexanderson† (G. E.) and Colpitts	1913–14	Mon. 1021, p. 5
First proposal of negative feedback, Langmuir† (G. E.)	1914	Private memo, Bowles
First reference to tube "mounted in base, and socket"	1914	B–T Index, I, p. 82
Water-cooled tube	1914	B–T Index, I, pp. 118 ff
Heater cathode		
Nicolson	1914	B–T Index, I, p. 139
Patent issued	1923	BLR, 28, I, p. 221
Invention of chemical getter, Langmuir† (G. E.)	ca. 1914	U. S. pat. 1,244,217 Private memo, Bowles
Coated filament		
Manufacturing method, Nicolson		
Patent issued	1915	BLR, 28, p. 221

† Non-Bell System

	Date	*Reference*
Vacuum tube amplifier (cabinet type), carbon amplifier, and mercury arc amplifier, all tested on transcontinental line, at Brushton, Pa.; Chicago, Ill.; Omaha, Neb.; Denver, Colo.; Salt Lake City, Utah, and Winnemucca, Nev. All successful, but only vacuum tube type practical	1914–15	Trans. Tel. Line, p. 5 BLR, 27, p. 6
Screen grid tube, Schottky†, Germany	1916	U. S. pat. 1,537,708
Peanut tube (Type N, later 215A), Weinhart		
Experimental	1918	BLR, 23, p. 336
Patent applied for	1919	
Vacuum tube voltage regulator		
Patent application	1918	BLR, 25, p. 452
Copper-to-glass seal for high-powered water-cooled tubes (an improved seal), Housekeeper	1919	N&I Rel., 1/26/46 Radar & Your Tel., p. 9
Barkhausen† oscillator	ca. 1920	BLR, 28, p. 129
Magnetron†	ca. 1922	
Modern type, Randall† and Boot†, England	1939	J. R. Pierce, World Book Enc., 5, p. 167
Low voltage cathode ray tube, W.E. 224, J. B. Johnson	1922	Mon. 639, p. 6
Space charge grid, Langmuir†		
Patent issued	1925	BLR, 27, p. 6
Langmuir† patent on high vacuum in tubes issued	1925	Private memo, Bowles
Suppressor grid tube, Holst† and Telleger†, Holland	1927	Guenther
Experiments show original De Forest† tubes "hardened" in use until they had high vacuum in last part of their life	ca. 1928	Private memo, Bowles
High vacuum in tubes ruled not patentable by Supreme Court, Langmuir† patent voided	1931	Private memo, Bowles
Beam power tube, Bull† and Rodda†, England	1934	Pat. application (England) U. S. pat. 2,107,518

† Non-Bell System

VACUUM TUBE (Cont'd)

	Date	*Reference*
Air-cooled high power tubes	by 1935	BLR, 13, No. 1, iii
Klystron, Varian brothers[¶]	after 1935	Collier's Enc., 7, p. 216
"Doorknob" tubes, recent	1937	BLR, 15, p. 178
Traveling wave tube, Kompfner,[*] England	1943	Kompfner, 12/27/57
Moving screen cathode ray tube	ca. 1946	BLR, 26, p. 219
Fine-wire frame type grid (first used on 404A tube)	1947	BLR, 27, p. 59
416A "Close-spaced Triode", New York–Chicago radio relay	1949	N&I Rel., 2/3/49
Parallel stream traveling wave tube (double stream) "New"	1949	Mon. 1668, p. 1
Backward wave oscillator (traveling wave tube)		
Theory, Pierce	1950	Mon. 2295, p. 4
Available	1953	BLR, 32, p. 114
Cold cathode stepping tube	ca. 1950	Mon. 1772, p. 1
Data on certain early Bell System tubes		
First experiments	1912	BLR, 21, p. 283
First experimental "Audion"	1913	B–T Index, I, p. 6
Audion No. 64, first tube installed on a telephone line (Philadelphia) on the New York–Philadelphia line	1913	Ev. Tel. Hist., p. 19 B–T Index, I, p. 15
"Methuselah", had life of 6508 hours (Audion No. 152)	1913	B–T Index, I, p. 28
Referred to as "standard" (Type A) (Audion No. 162)	1913	B–T Index, I, p. 29 B–T Notes, p. 11
A (certain early experimental tubes by Arnold, not Type A)	1913	B–T Index, I, p9.
Type B		
Available	1913	B–T Index, I, p. 47
Used in transcontinental line	1914	B–T Index, I, pp. 58, 62
DD (certain early experimental tubes)	1913	B–T Notes, 102, p. 6
N (certain early experimental tubes by Nicolson)	1913	
OO (certain early experimental tubes)	1913	

¶ Non-Bell System
* Invented before joining Bell Laboratories

	Date	*Reference*
SS (certain early experimental tubes)	1913	B-T Notes, 102, p. 6
Type C Lyre type, never commercial	1914	B–T Index, I, pp. 71, 159
Type M (named M for "Mounted") (later coded 101A)	1914	B–T Index, I, pp. 82–3
Type VM (type V, mounted, later coded 102A)	1914	B–T Index, I, p. 192 B–T Index, II, pp. 133, 149 B–T Notes, p. 11
Type J (military code, VT–1; Bell System code, 203A) Patented	1915	B–T Index, II, p. 130 B–T Cat., pp. 13, 16
Type L in J Type bulb (coded 101B unbased)	1915	B–T Index, II, pp. 130, 131
Type L (101B for telephone use, 208A for non-associate use)	1915	B–T Index, II, p. 198
Type S (coded 204A) "Government" tube. Used as amplifier in transatlantic tests (about 12 in. high; cf. W tube)	1915	B–T Index, p. 86 Tyne, 6/24/59
Type W (coded 204B) Power tube, unbased, used at Arlington in transatlantic tests (similar to S tube, but about 18 in. high)	1915	B–T Index, II, p. 120
Type P (military code, VT-3) Experimental dry battery tube Patented	1916	B–T Cat., p. 16 Tyne, 6/24/59
Type D (coded 201A with 3 base contacts and 1 to shell; coded 201B with 4 base contacts)	1917	B–T Cat., p. 23 Tyne, 6/24/59
Type E (coded 205A, B, D, and E; military code, VT-2) In use	1917	Tyne, 6/24/59 B–T Cat., pp. 5,6, 46, 111
Type N (peanut tube), Weinhart (coded 215A; military code, VT-5)	1918	N&I Rel., 1/24/46
Type EL (model L with Type E plate; coded 101B) never commercial	by 1920	B–T Cat. 101, p. 7
Type O (coded 104A, 104D)	by 1921	B–T Cat. 101, p. 8

VACUUM TUBE (Cont'd)

	Date	*Reference*
Type I (coded 212A as an amplifier, 219A as a rectifier) "Power amplifier used in first Broadcasting Transmitter in Station WEAF, 1922"	by 1922	B–T Cat., pp. 20, 87

VACUUM TUBE VOLTMETER (SEE ALSO VACUUM TUBE)

	Date	*Reference*
First proposal, Edison[¶]		
Patent application	1883	U. S. pat. 307,031
First practical form		
Patent application	1915	BLR, 24, p. 270

VODAS (VOICE OPERATED DEVICE, ANTI-SINGING)

Type A, available	ca. 1927	Mon. 1038, p. 2
Syllabic operation (Type 3)		
In use	1937	Mon. 1038, p. 9

VOGAD (VOICE OPERATED GAIN ADJUSTING DEVICE)

In use	1940	Mon. 1255, p. 11

VOLTAGE REGULATOR (SEE ALSO VACUUM TUBE)

Electronic		
Patent application	1918	BLR, 25, p. 452

VOLUME INDICATOR

Invented, Nelson	ca. 1920	BLR, 31, p. 341

TABLE OF CODE NUMBERS OF EARLY LETTER TUBES

Letter	W. E. No. Associate Use	W. E. No. Non-Associate	Military Army	Military Navy	Reference
A	(certain early experimental tubes by Arnold)				B-T Index, I, p. 9
A					B-T Index, I, p. 29
B					B-T Index, I, p. 47
C	("Lyre" type, experimental only)				B-T Index, I, p. 71
D		201A (3 contacts on base, 1 on shell) 201B (4 contacts on base)			B-T Cat., p. 23
DD	(Experimental only)				B-T Notes, p. 6
E		205A 205B 205D 205E	VT-2		B-T Cat., pp. 6, 46, 111 Tyne, 6/24/59
EL	101B (Model L with E type plates, experimental only, 101D				B-T Cat., p. 7
F	(Experimental only)				B-T Notes, p. 9
G		211A Amplifier	VT-4	CW-1818	B-T Cat., p. 18, 113
		214A Rectifier			B-T Cat., p. 113
H	103A (Experimental only, replaced by O)				B-T Cat., p. 29
I		212A Amplifier			B-T Cat., p. 20
		219A Rectifier			B-T Cat., p. 87
J		203A 203B	VT-1		B-T Cat., p. 13
K		202A (Used briefly by military)			B-T Cat., p. 25
L	101B	208A			B-T Cat., pp. 6, 20
M	101A				B-T Cat., p. 9
N	(certain early experimental tubes by Nicolson)				B-T Notes, p. 6
N		215A	VT-5		B-T Cat., pp. 156-7 B-T Index, p. 2 BLR, 23, p. 452
O	104A 104D D-86327				B-T Cat., p. 8 B-T Index, p. 111 B-T Index, p. 111
OO		223A			B-T Cat., p. 112
P	(Experimental dry-battery tube)		VT-3		B-T Cat., p. 16
Q	104C (never used)				B-T Cat., p. 11
R	(Experimental)				
S		204A			B-T Cat., p. 86
SS	(Experimental)				B-T Notes, p. 6
T	(Experimental)				
U	(Experimental)				
V	102A, 102D, 102F, 102G, D85792	209A			B-T Cat., pp. 9, 81 110, 118
VM	102A (V type, mounted)				B-T Index, I, p. 192; II, p. 133; II, p. 149
W		204B			B-T Cat., p. 132

MISCELLANEOUS

	Date	*Reference*
Blue Bell originated (Hibbard)	1888	BLR, 28, p. 393
Adopted	1889	
Simultaneous telephony and telegraphy		
First practical demonstration, Van Rysselberghe¶, Belgium		BLR, 28, p. 10
Hybrid coil, Edison¶	before 1890	Private memo, Bowles
Piezoelectric circuit (coupling of mechanical and electrical properties), Nicolson		
Publication	1919	BLR, 28, p. 221
Bell System frequency standard, 100 cycle tuning fork	1923	BLR, 6, p. 387
Automatic gain control	1923	BLR, 18, p. 98
Automatic frequency control	after 1923	
Transmission speeds*		BLR, 10, p. 138
Information theory developed	1924–52	BLR, 31, p. 331
Solderless connections		
Cords	before 1926	BLR, 32, p. 43
Step-by-step banks	ca. 1942	BLR, 32, p. 43
DC toll key pulsing, Detroit, first	1930	BLR, 23, p. 466
DC key pulsing	ca. 1930	BLR, 28, p. 53
221 Type Emergency Radio Telephone, 2–3 mc band	after 1938	BLR, 33, p. 365
Portable frequency standard for clock (proved superior to Arlington time in bad weather, in U.S.S. Submarine Barracuda tests in West Indies)	1939	BLR, 18, May, p. vi
2121 pair cable		
first, Jersey City		
In use	1939	BLR, 18, Sept., p. xvi
Weather report		
First commercial use	1939	BLR, 17, May, p. i
Multi-frequency key pulsing, first at Baltimore (2 out of 5 tones)		
In use	1945	BLR, 23, p. 466
16 PSV shielded video pair wire	ca. 1948	BLR, 29, p. 556
Error-correcting codes for binary circuits, experimental	ca. 1950	BLR, 28, p. 193

¶ Non-Bell System

* Radio 186,000 m/sec.
Open wire, non loaded 180,000 m/sec.
Cable, 16 ga., non loaded 130,000 m/sec.
Cable loaded, 44 mh at 6000 ft. 20,000 m/sec.
Cable, loaded, 88 mh at 3000 ft. 10,000 m/sec.

	Date	*References*
Solderless wrapped connections	1951	BLR, 29, May, inside back cover
New Bell System primary standard of frequency	1951	BLR, 29, p. 338
Mouse and Cheese, Shannon	1952*	N&I Rel., 3/10/52
Packaged plug-in units		
In use	1953	BLR, 31, p. 309
(Used by Germans in World War II)		
Audrey	1953	N&I Rel., 1/5/53
Barium titanate memory crystal	1953	N&I Rel., 7/15/53
Plastic battery jars		
In use	1954	N&I Rel., 3/31/54
Rubber base tape for recorded messages, new	1954	N&I Rel., 3/31/54
Solar Battery		
First public demonstration	1954	BLR, 32, p. 232
Mr. Meticulous (automation)		
Experimental use to make transistors	1955	BLR, 33, p. 108
Minaplas assemblies (mounting on plastic rails, in miniaturization)	ca. 1955	BLR, 33, p. 81
Sulphur hexafluoride gas for L3 Carrier cables		
First commercial installation, Philadelphia–Chicago, In use	1955	BLR, 33, p. 148
6A Announcement System (recorded announcements on the telephone)	ca. 1955	BLR, 33, p. 332
New system (emergency radio) 152–162 mc band, FM	1955	BLR, 33, p. 365
Blind switchboard operator's "eye," phototransistor, experimental, for PBX	1956	N&I Rel., 8/13/56
Data subset	1957	N&I Rel., 4/18/57

* 1953, BLR, 31, p. 231

STATION PLANT

TRANSMITTER

	Date	*Reference*
Harmonic telegraph receiver* One receiver, at Watson's end of line, transmitted a tone only to a second receiver at Bell's end of line	June 2, 1875	Bell dep. Am. Bell Tel. Co. vs. Peoples Tel. Co., p. 137: Bell Tel. Co. vs. Dowd, p. 471
Harmonic telegraph transmitter* Transmitter, at Watson's end of line, transmitted a tone only to receiver at Bell's end of line	June 2, 1875	Watson, p. 67
Gallows frame transmitter, Bell	1875	Rhodes, p. 24
Liquid transmitter, Bell	1876	Rhodes, p. 28
Permanent magnet type	1876	Rhodes, p. 37
Box telephone (commercial use, 1877)	1876	Rhodes, p. 37
Hand "Butterstamp" telephone	1877	Rhodes, p. 42
Wall telephone	1877	Rhodes, p. 176
Moving coil microphone proposed, Siemens & Halske‡	by 1877	Mon. 585, p. 16 Mon. 630, p. 1
Variable resistance ("loose") metal-to-metal contact, Berliner‡	1877	Rhodes, p. 77
Induction coil used, Berliner‡	1877	BSTJ, 37, p. 305
Carbon (graphite or plumbago) block, with coil, Edison‡	1877	Rhodes, p. 78
Compressed lamp black, Edison‡	1878	Rhodes, p. 79
Principle of loose microphone contact explained, Hughes‡, England	1878	Rhodes, p. 77
Improved carbon type, Blake† Carbon block, platinum button	1878	Rhodes, p. 79 Mon. 1867, p. 5
Granular carbon, Hunnings‡ (pulverized engine coke)	1878	Rhodes, p. 79

* This disagreement appears never to have been reconciled. Bell's story is the official one of the American Bell Telephone Company during the 1880's.

† Blake sold invention to Bell System

‡ Non-Bell System

	Date	*Reference*
Binaural effect discovered, Ader[¶] (2 transmitters, 2 receivers, 2 circuits)	1881	Mon. 585, p. 11
Granular carbon, horizontal button, platinum diaphragm (long distance type)	1885	Rhodes, p. 81
Granular carbon, (hard coal, roasted), Edison[¶]	1886	
Solid back, White	1890	Rhodes, p. 82
Condenser microphone		
Proposed, DuMoncel[¶]	1856	Mon. 585, p. 16
Developed, Wente	1917*	Mon. 585, p. 16 Mon. 538, p. 1
323 Type, centrally damped	1917	
Air-damped stretched diaphragm type	ca. 1917	Mon. 538, p. 11
Inertia microphone for submarine detection	1917–18	BLR, 4, p. 363
Crystal microphone, Nicolson	1919†	Mon. 976
Double-carbon-button microphone, push-pull	1921	Mon. 82, p. 7 Mon. 538, p. 11
Handset transmitter, Type 395	1926	Bell Brief on Walker Report, p. 71
Dynamic (moving coil) microphone (618A)	1931	Mon. 630, pp. 2–3
"Eight-ball" microphone (630A)	1935	Mon. 941
F1 handset transmitter	1937	Mon. 1867, p. 18
"Salt shaker" microphone (633A)	1937	BLR, 16, p. 80
High fidelity condenser microphone	1938	Photo 155515
Cardioid microphone (639)	1938	BLR, 17, January, p. i
Ribbon (first Bell System type)	1940	Photo 155515
52 Type operator's set transmitter	1940	W. E. Card Cat.
FM cardioid	1941	Photo 155515
Throat microphone	by 1944	BLR, 23, p. 196
Lip microphone	by 1944	BLR, 23, p. 197
T1 transmitter (500 Type set)		
Trial installation	1948	BLR, 29, p. 414
In service	1949‡	
Speakerphone available	1954	Ev. Tel. Hist., p. 42

* 1916, BLR, 33, p. 6
† 1918, Ev. Tel. Hist., p. 21
‡ 1951, 75 Years of Service, p. 36

RECEIVER

	Date	*Reference*
Harmonic telegraph receiver, Bell	1875	Rhodes, p. 25
Tuned reed receiver, Bell	1876	Note in back of "Career of A. G. Bell" in Museum
Iron box receiver	1876	Rhodes, p. 29
Permanent magnet, Bell (box telephone)	1876	Rhodes, p. 37
Hand ("Butterstamp") telephone, Bell	1877	Rhodes, p. 42
Terminals for connection, Bell	1877	
Adjustable magnet-diaphragm spacing, Bell	1877	
First quantity production	1877	N&I Rel., 3/31/54
Hard rubber case	1877	
Flat receiver, used on Brown Hand set	1878	BRLR, 12, p. 323
Head-band receiver, Shaw	1882	Rhodes, p. 158
Watch case receiver, Richards	1884	BLR, 7, p. 207
Head (watch case) receiver with head-band	1888	
Concealed terminals, 122 Type	1907	Museum Card File
Handset receiver, Type 557	1926	Bell Brief on Walker Report, p. 71
HA1	1937	Bell Brief on Walker Report, p. 71
Permendur diaphragm, heat treated		
Remalloy magnets		
45 Permalloy pole pieces		
First flat frequency characteristics		
U1		
Ring armature	by 1949	N&I Rel., 3/16/49
Piston diaphragm	1951	BSTJ, 37, p. 307
Loud speaking receiver (see Loud Speaker)		

HANDSET

Proposed and patented, McEvoy† England (Two hand telephones mounted on a handle; also one hand telephone with a speaking tube attached to side)	1877	BLR, 12, p. 322
Made and patented, using Edison† transmitter and Gray† receiver, Brown	1878	Rhodes, p. 153 BLR, 12, p. 323

† Non-Bell System

	Date	*Reference*
(Taken by Brown to France, where lower transmission requirements permitted its general adoption. Long referred to as a "French phone". This type was used in this country as an operator's phone on early switchboards (1878), and then for test and field use in this country continuously up to the present. R. G. Brown was Chief Operator of Gold & Stock board, N. Y. City, absorbed by Bell System.		
First subscriber use, France	ca. 1882	BLR, 12, p. 325
Transmitter and receiver developed satisfactorily	1926	Bell Brief on Walker Report, p. 71
First subscriber use in Bell System	1927	Mon. 1867, p. 6
(Scientific design advanced to point where hand-set could match other types)		
F1 Handset (300 Type set)	1937	Mon. 1867, p. 18
G1 Handset (500 Type set)		
Trial installation	1948	BLR, 29, p. 414
In service	1949	

TELEPHONE SET

First commercial type of box telephone, Bell		
Experimental model	1876	Rhodes, p. 37
In use	1877	Rhodes, p. 176
Induction (repeating) coil introduced, Berliner*	1877	BSTJ, 37, p. 305
First hand ("Butterstamp") telephone, Bell	1877	Rhodes, p. 42
Handset patented, McEvoy¶, England	1877	BLR, 12, p. 322
First commercial type of wall set	1877	Rhodes, p. 176
Switchhook, Roosevelt	1877	Rhodes, p. 178
Handset with Edison¶ transmitter, Brown (patented 1880)	1878	Mon. 665, p. 1 Mon. 1876, p. 6
Used in U. S. for switchboard (early) and plant purposes from 1878		

* Sold invention to Bell System

TELEPHONE SET (Cont'd)

	Date	*Reference*
Handset (Cont'd)		
Used in France from 1879. Transmission failed to meet American subscriber service standards until 1927		
Headset, England[¶]	ca. 1878	BLR, 12, p. 324
Hand telephone and push button, New Haven	1878	
Williams "Coffin" telephone	1878	
Blake box transmitter, Williams Subscriber's set with Williams bell and Roosevelt switch-hook, Western Electric, Le-Clanché battery on bracket	1879	Photo HM3818
Deskstand with Blake wood box transmitter, screwed down	1879	Things Worth Knowing, p. 15 Photo HM3452
Gilliland† Harness operator's set	1880	BLR, 7, pp. 203–4
Deskstand, movable	1881	Photo HM3452 HM Card 444, #2
Magneto backboard wall set, subscriber's set (magneto ringer and switchhook) at top, Blake box transmitter in middle, battery box below	1882	Photo HM3818
Head (watch case) receiver (Richards) with head-band (Shaw)	1884	Rhodes, p. 158
Deskstand with long distance transmitter, movable	1886	Photo HM3452
Wall set with long distance transmitter	1887	Photo HM3818 Photo Inf. 2523
First mine telephone	1888	BLR, 2, p. 238
Wall set with solid back transmitter	1891	Photo HM3818
"Tombstone" wall set	1891	
Deskstand with box transmitter, switchhook, and receiver	1892	Photo HM3452
"Wisconsin" desk set, concealed switchhook in column	1893	
Anti-sidetone circuit invented, Scribner	1893	BLR, 17, p. 347
In use	before 1938	Mon. 1082, p. 2
Common battery wall set	1895	Photo HM3818
No. 1 Common Battery Set		
In use	ca. 1898	BLR, 30, p. 87

† Manufacturer to Bell System, later absorbed

	Date	*Reference*
Hard of hearing set, mechanical amplifier	ca. 1905	BLR, 33, p. 361
Metal wall set	1912	Photo HM3819
Black finish deskstand, nickel transmitter, No. 20AL	1914	Photo Inf. 570, HM3452, HM3494
Dial deskstand	1919	Mon. 2045, p. 6
Dial wall set	1920	Photo HM3819
Black finish deskstand, including transmitter	1923	Photo HM3452
Handset for subscribers	1926	Bell Brief on Walker Report, p. 71
Hard of hearing set, vacuum tube amplifier	ca. 1928	BLR, 33, p. 361
Combined set (300 Type)		
Trial installation	1936	BLR, 14, p. 349
In service	1937	Post-war Achievements, p. 4 Mon. 2045, p. 6
1A Key Set for subscribers	1940	BLR, 18, p. 315
Dial set for explosive atmospheres	1940	BLR, 19, p. 42
Hard of hearing set, miniature mechanical amplifier	1941	BLR, 33, p. 361
Hard-of-hearing combined set	ca. 1942	BLR, 21, p. 45
500 Type set		
Adjustable ringing Resonator Numbers and letters outside dial Neoprene cord Base carries complete chassis; top only a cover Loop compensation tungsten ballast lamp, and thermistor close to ballast lamp filament on receiver circuit		Mon. 1856, p. 6
Varistor voltage protection for tungsten filament on ballast lamp		
T1 Transmitter		
Trial installation	1948	BLR, 29, p. 414
First use in service	1949	N&I Rel., 3/16/49 BLR, 29, p. 414 BLR, 32, p. 366
Telephone Answering Set		
Pre-field test	1954	Case 38736
Speakerphone available	1954	Ev. Tel. Hist., p. 42
First transistorized hard-of-hearing set		
In production	1954	BLR, 36, p. 217 Case 38736

TELEPHONE SET (Cont'd)

	Date	*Reference*
Loud speaking, distant talking telephone booth set		
Preliminary trial, Boston	1954	Case 38736
Volume Control Telephone (532 type) with transistor amplifier, for the deaf	1955	BLR, 33, pp. 361–2
Picture-phone		
Preliminary experiments	1956	N&I Rel., 8/23/56
Call Director (actually a PBX)	1959	Inf. Bull., 1/5/59

SIGNALING

Tapping diaphragm	1876	Rhodes, p. 176
Thumper, Watson	1877	Rhodes, p. 176
Electric call bell	1878	BLR, 1, p. 208
Buzzer, Watson ("Coy's Chicken")	1878	Rhodes, p. 177
Polarized (ac) ringer, Watson	1878	
Magneto generator, Watson	1878	
Polarized ringing, Anders	1879	Rhodes, p. 184
First harmonic ringer	1882	BLR, 12, p. 160
Bridging ringer, Carty	1890	Rhodes, p. 180
Two-party selective ringing, Pickernell	1893	Rhodes, p. 187
Interrupted ac ringing, Hibbard		
Patent issued	1895	BLR, 28, p. 392
Four-party selective ringing, Hibbard	1895	BLR, 28, p. 392
Patented	1896	Rhodes, p. 187
Four-party selective common-battery ringing, Thompson	1899	BLR, 8, p. 115
Superimposed ringing (dc plus ac), Drake	1904	BLR, 8, p. 116
Vacuum tube selective ringing	1936	BLR, 15, p. 111
Adjustable volume (C type ringer) 1, 2, and 4-party selective, 4 and 8-party semi-selective		
Trial installation	1948	BLR, 29, p. 414
In service	1949	BLR, 29, p. 414 BLR, 32, pp. 366–7
C4A Universal Ringer		
In use	1954	BLR, 32, p. 366
Tone ringing		
Field trial, Americus, Ga.	1954	BLR, 35, pp. 21, 51
Field trial, Crystal Lake, Ill.	1956	BLR, 36, p. 217

TALKING BATTERY

First use, voltage unknown, wet battery, primary cell	June 2, 1875	BLR, 15, p. 138

	Date	*Reference*
Use discontinued for permanent magnet telephones	1878	BLR, 15, p. 140
Leclanché† cell, 1 volt, used	1878	BLR, 15, p. 141
Blake transmitter battery, 3 volts or more	1878	
6 to 160 volts, experiments	1885–1890	
Local battery dropped, common battery used, experimental, Hayes	1888	Rhodes, p. 163
4-volt storage batteries at subscribers stations, charged from central office	1891	BLR, 15, p. 141
Dry cells for subscribers stations Standardized soon after	1900	BLR, 15, p. 143

RINGING POWER (SEE ALSO CENTRAL OFFICE PLANT, EXCHANGE, POWER)

Wet battery	1878	Rhodes, p. 167
Magneto generator, Watson	1878	Rhodes, p. 177

SWITCHHOOK

Invented, Roosevelt	1877	Rhodes, p. 178
Concealed, "Wisconsin" desk set	1893	Photo HM3452

DIAL

Dial proposed, pointer type, Cooke† (fire alarm and district messenger use, also Wheatstone's† telegraph)	1836	BLR, 31, p. 22
Fan-type governor	1894	BLR, 32, p. 69
First finger-wheel dial (Strowger† and Automatic Elec. Co.†) Invented	1895	Note by Lowe
Installed, Milwaukee, Wis.	1896	
Atmospheric dash-pot governor	1897	BLR, 32, p. 70
Escapement governor	1898	
Centrifugal friction governor	1906	
Modern dial number and letter arrangement, Blauvelt	1917	BLR, 30, p. 13
First use, with 3-letter code, Omaha	1921	
Numbering moved outside dial	1949	BLR, 29, p. 414; Mon. 1856, p. 1
7 type	1951	BLR, 30, p. 211
Illuminated	ca. 1954	BLR, 32, p. 235

† Non-Bell System

REPEATING COIL ("INDUCTION COIL")

	Date	*Reference*
Metallic to grounded line through coil, Watson Patent application	1877–81	BLR, 26, p. 168

PROTECTION (SEE APPARATUS, FUSE, PROTECTOR; CENTRAL OFFICE PLANT, PROTECTOR; OUTSIDE PLANT, PROTECTION)

Metal plates, serrated edge, metal plug to close circuit	by 1878	Museum exhibits
Fuse ahead of protector		
Sneak current fuse with 350 mil heat coil	prob. by 1880	Inskip, 7/9/59
Carbon block protector under plastic cover	before 1951	BLR, 29, p. 226
Carbon block protector in metal cartridge (70 Type)		
Design	ca. 1948	Dietz, 7/8/59 BLR, 29, p. 162
In manufacture	ca. 1951	BLR, 29, pp. 162, 226
Fuse eliminated for stations with drop wire from grounded cable sheath		
Design	1950	Inskip, 7/9/59
In production	1952	
Fuse eliminated on all stations		
Fusible link (at pole) of D block wire, 20 gauge copper-steel bridle wire, for stations not grounded to cable sheath		
Available	1956	Inskip, 7/9/59
In service	1959	

PAY STATION

Bridgeport and Black Rock, Conn., Doolittle*	1878	Ev. Tel. Hist., p. 7
First attended pay telephones, New York	1880	Ev. Tel. Hist., p. 9
First Gray† public coin telephone, Hartford	1889	Ev. Tel. Hist., p. 12
Handset coin box	1940	BLR, 19, July, p. vi
Neoprene-coated coin collector coin chute sections		
Available	1947	BLR, 25, p. 341

* Bell licensee

BOOTH

	Date	*Reference*
Telephone-less (microphone and loud-speaker)		
Field test, Washington, D. C., "recent"	1954	BLR, 32, p. 197
Outdoor type		
In use	1954	Case 37977

CORD

Solderless cord tips	1926	BLR, 2, p. 198
Neoprene black retractile		
Available	1954	N&I Rel., 3/31/54
Plastic retractile		
Available	1956	N&I Rel., 2/10/56

WIRE

Twisted pair	before 1951	BLR, 29, p. 226
Thermoplastic insulated		
In use	1951	

ANSWERING SET

Phonograph, Edison¶	1877	BLR, 7, p. 81
Magnetic recording, Poulsen¶, Denmark	1907	BLR, 16, p. 2
Automatic, on customer's phone	1951	BLR, 29, p. 220
1A Telephone Answering Set		
In use	1953	BLR, 31, p. 443

¶ Non-Bell System

CENTRAL OFFICE PLANT

APPARATUS

AMA (Automatic Message Accounting)

	Date	*Reference*
Units:		
Call Identity Indexer		
Recorder		
Perforator Cabinet		
Master Timing Frame		
Transverter Connector		
Transverter		
Translator Frame		
In use	1952	BLR, 30, p. 173

Balancing Network (see TRANSMISSION, Balancing)

Cable

Cellulose acetate insulation,		
Available	ca. 1938	BLR, 20, p. 125
Recent	1941	BLR, 19, No. 7, p. v
Paper tape, lead alloy tape, paper tape, cotton wrapping, cotton braiding, gray paint, over conductors with cellulose acetate covered by cotton braid	before 1932	
Same, except aluminum tape instead of lead	1932	
Same, except Pliolite (rubber) coated paper instead of aluminum	1941	BLR, 28, p. 290
Same, except wax-impregnated paper tape instead of Pliolite-coated paper tape	1942	
Back to aluminum tape	1945	
Vistanex-coated crepe paper substituted for part of aluminum	1946	
Polyvinyl chloride covering introduced	1946	
Gas pressure	ca. 1951	BLR, 29, p. 226

Call Indicator

In use	1923	Mon. 36, p. 28

	Date	*Reference*
Card Translator		
First use, Pittsburgh, Pa.	1953*	N&I Rel., 6/30/53
Clock		
First quartz crystal clock, Marrison	1927	Hist. Firsts, p. 10
First use of crystal clock in telephone system	1927	Mon. 1593, p. 52
First use of GT cut crystal clock in telephone system	1937	Mon. 1593, p. 52
CODAN (Carrier Operated Device, Anti-Noise)		
In use	1937	Mon. 1038, p. 6
Compandor ([Volume] Compressor-Expander)		
Available	ca. 1934	Mon. 798, p. 1 Mon. 1512, p. 1, 8
In use	1937	Mon. 1038, p. 6
Cord		
Switchboard		
Cord pulley and weight Patent application	1880	BLR, 26, p. 168
Stranded copper wire conductors	by 1904	BLR, 13, p. 25
Tinsel protected by brass helix	ca. 1905	BLR, 13, p. 26
Steel conductor	1905	BLR, 13, p. 26
Rope-core tinsel, 18 threads	1909	BLR, 13, p. 26
Bronze tinsel, 2 ribbons per thread, 6 threads	1925	BLR, 13, p. 27
Standard	1926	HM17105
Solderless cord tips	1927	BLR, 13, p. 28 HM17105
Improved braid, etc.	1934†	BLR, 13, p. 28
Cord Pulley		
Patent application	1880	BLR, 26, p. 168
Weight		
Patent application	1880	BLR, 26, p. 168
Delay Line		
Solid type In use	1951	Mon. 1865, p. 2

* 1952, BLR, 36, p. 226
† 1933, HM17105

APPARATUS (Cont'd)

	Date	*Reference*
Distributing Frame		
First, Hibbard	1890	BLR, 28, p. 392
Echo Suppressor		
Invented, Mills		
Patent issued	1922	Mon. 165, p. 2
Introduced	1923	Mon. 1970, pp. 28, 30
Electrolytic Capacitor (see APPARATUS, Capacitor)		
Filter		
Ladder Type		
Invented, Campbell	1915	BSTJ, 37, p. 314
Patented, Campbell	1917	BLR, 21, p. 445
First use, transcontinental line	1915	Mon. 976, p. 7
Crystal		
Elementary concept, Nicolson	1917	
Specific concept, Espenschied	early 1920's	BLR, 22, p. 504
Lattice type, Campbell	1922	Campbell, p. 190 Mon. 1867, p. 10
Improved theory, Campbell	1922	Campbell, p. 190 Mon. 103, p. 1 Mon. 1867, p. 10
Use of wave guides for filters proposed, Carson	1924	Mon. 921, p. 2
Crystal		
Experimental, ladder type, Espenschied	1926	BLR, 22, p. 504
Lattice type, Mason	1929	Mon. 976, p. 11
In use	1930	BLR, 22, p. 504
General theory	1934	Mon. 843, p. 1
Coaxial and balanced transmission lines as filters and transformers at high frequencies, theory, Mason and Sykes	1937	Mon. 1003, p. 1
In use, Provincetown–Green Harbor, Mass.	by 1937	Mon. 1003, p. 1
Ferrites		
Material available	1945	Mon. 2224, p. 1
Microwave waveguide filter,	ca. 1948	BLR, 29, p. 164
Active (experimental)	1953	Mon. 2221, p. 1
Plug-in type		
In use	1955	BLR, 33, p. 137
Reversible (reversing interchanges bands)		
In use	1955	

	Date	*Reference*
Jack		
First jack knife switch, Scribner, used on ADT board, Chicago	1879	Rhodes, p. 152
First jack perpendicular to face of switchboard, Warner	1881	BLR, 1, p. 142
Busy test through "sleeve" contact, Carty	ca. 1885	Rhodes, p. 158
Separate answering jack per line, Seely		
Patent application	1885	Rhodes, p. 159
Strip jacks, Thayer	1887	Rhodes, p. 160
Key		
First generally used standard lever key, No. 52 Type	1888	BLR, 7, p. 56
First lever key with 2 sets of contacts, No. 51 type	ca. 1888	
No. 102 Type Key for 2-party selective ringing	ca. 1893	
No. 463 Type Key, with vertical springs	1907	Obs. Card Cat.; BLR, 7, p. 57
A1 Type Key, unit construction	by 1928	BLR, 7, p. 58
Message Register		
First, New York City	1898	BLR, 8, p. 273
Multivibrator		
In use	1941–45	BLR, 26, p. 114
Operator's Chair		
First standard	1900–10	BLR, 15, p. 171
Operator's Set		
Hand telephone	1878	BLR, 7, pp. 203–4
Handset, Edison¶ transmitter and flat receiver with handle magnet	1878	Mon. 665, p. 1
Headset, England¶	ca. 1878	BLR, 12, p. 324
Blake transmitter and hand telephone receiver	1879	BLR, 7, pp. 203–4
Gilliland* harness, with Blake transmitter and clamped hand receiver	1880	BLR, 7, pp. 204–6
Mounted Blake transmitter and hand receiver		

* Manufacturer to Bell System, later absorbed
¶ Non-Bell System

APPARATUS (Cont'd)

	Date	*Reference*
Operator's Set (Cont'd)		
Suspended Blake transmitter and head receiver	ca. 1884	BLR, 12, p. 325
Mounted carbon granule transmitter and hand receiver	1888	BLR, 7, pp. 204–6
White solid-back transmitter suspended, with head band watch case receiver	1891	BLR, 7, pp. 205–7
Bracket mounted transmitter	ca. 1891	BLR, 7, pp. 205–7
Anti-sidetone circuit used as required	1893	BLR, 17, p. 347
Breast plate transmitter, head band watch case receiver	ca. 1900	BLR, 7, pp. 205–7
Head band mounted (52 Type)	1940	W. E. Card Cat.
Plug		
Telegraph type, Holmes†	1877	Rhodes, p. 147
"Crossbar" manual plug, Doolittle,† Bridgeport, Conn.	1877	Rhodes, p. 149
Cord plug, "Edison" exchange, American District Telegraph,‡ Chicago	1878	
Busy test through sleeve contact, Carty	ca. 1885	Rhodes, p. 158
3-conductor, metallic circuit, No. 37	1891	BLR, 5, p. 105
No. 64 (wide insulator)	1897	
No. 104 (dead collar)		
Protector (see also STATION PLANT, Protection; APPARATUS, Fuse Protector; OUTSIDE PLANT, Protection)		
New type Under test	1951	BLR, 29, p. 226
Silicon pn junction diode lightning protector, Pearson and Fuller	1954	IRE, 42, p. 760
Relay		
Annunciator signal, New Haven switchboard*	1878	Rhodes, p. 167
Line Annunciator type	1878	
Clearing out, telegraph type	1879	Mon. C4, p. 8

† Bell licensee
‡ Absorbed by Bell System
* Non-Bell System. Bell licensee

	Date	*Reference*
Drop (used as line and clearing out relay)	1879	Mon. C4, p. 9
Clearing out, telephone type		
Sabin-Hampton type	ca. 1880	Rhodes, p. 162
Worcester common battery type	1896	Rhodes, p. 165 Mon. C4, p. 10
Supervisory		
Philadelphia	1895	Mon. C4, p. 12 Rhodes, p. 164
Cutoff		
Louisville	1897	Rhodes, p. 165
Flat type		
In use	1923	Mon. B28, p. 2
Multicontact	1938	Mon. 1119, p. 1
Glass-sealed (see also Switches)		
In pilot manufacture	1944	BLR, 25, p. 342
In full production	1945	BLR, 25, p. 344
Reed hinge type, Teflon separator limiting motion (Type U)	ca. 1951	BLR, 29, p. 466
Wire Spring		
Ready for production	1952	BLR, 30, p. 261 N&I Rel., 6/13/52
Pilot production	1954	Mon. 2282, p. 11

Switch

Wire spring		
"Piano wire", not very successful, included automatic release	1894	BLR, 31, p. 96
Sealed reed, Elwood (see also Relay)	1936	Mon. 2391, p. 1 BLR, 33, p. 355
First use, inside coaxial cable	1938	Mon. 2391, p. 3
In pilot manufacture	1944	BLR, 25, p. 342
In Stevens Point-Minneapolis cable	by 1947	Mon. 1516, p. 2
In full production	1954	BLR, 25, p. 344
223 Type Coaxial		
In use	1955	BLR, 33, p. 415

Trouble Recorder

No. 5 Crossbar	ca. 1948	BLR, 27, p. 214

Vocoder

Experimental	1936	BLR, 18, p. 122

PBX SWITCHING

	Date	*Reference*
Experimental panel installation, semi-mechanical, Bell Laboratories PBX	1910*	BLR, 31, p. 29
Experimental installation, fully mechanical, Bell Laboratories PBX	1913	Lowe
555		
Trial	1941	BLR, 27, p. 125
701A, step-by-step	ca. 1929	
740A, step-by-step	ca. 1929	
755A	ca. 1938	BLR, 29, p. 460
740E, step-by-step		
Recent	1951	
507	1951	BLR, 29, p. 470
756		
Trial installation, Cleveland	1956	BLR, 35, p. 485; Braund
(became first commercial installation, 1957)		
Call director	1959	Inf. Bull., 1/5/59

POWER

Battery		
Lead-antimony, Sellon†	1882	Mon. 883, p. 2
Objections stated, Jumau†	1898	Mon. 884, p. 1
Lead-calcium developed, Schumacher and Bouton	1930	Mon. 883, p. 2
In use	1950	BLR, 29, p. 97
General		
First fully automatic plant, Roanoke, Va.	1935	BLR, 30, p. 314
Ringing		
Wet battery, experimental telephone use	1877	Rhodes, p. 147
Commercial, ringing only	1878	Rhodes, p. 167
Ringing and operator's transmitter	1879	Rhodes, Fig. 33; p. 171
Central ringing battery	1880	Rhodes, p. 163

* 1912, N&I Rel., 10/51
† Non-Bell System

	Date	Reference
Talking		
Wet battery, experimental	1877	Rhodes, p. 147
Battery, commercial, ringing and operator's transmitter	1879	Rhodes, Fig. 33; p. 171
Common battery, experimental, Hayes	1888	Rhodes, p. 163
6 to 160 volts, toll service, experiments	1885–90	BLR, 15, p. 141
4-volt storage batteries at subscriber's station charged from central office	1891	
Common battery cord circuits for operators sets, Carty	by 1891	BLR, 15, p. 142
Central common battery, 10 volts, in each cord circuit, Winthrop, Mass.	ca. 1891	BLR, 15, p. 141
First common battery board, 16 volts, Lexington, Mass.	1893	Rhodes, p. 164 BLR, 16, p. 142
First 24-volt board, Worcester, Mass.	1896	BLR, 15, p. 142
48-volt battery for toll use	1902	BLR, 15, p. 143
SHIELDING		
First use, on entrance cables for open-wire carrier	1915	BLR, 18, p. 88
SWITCHING		
Manual		
First private telephone switchboard, plug type, made for Holmes,* Boston	1877	Rhodes, p. 147
Private switchboard, Smith,* Hartford	1877	Rhodes, p. 148
6-point "crossbar" private switchboard, Doolittle,* Bridgeport, Conn.	1877	Rhodes, p. 149
First commercial switchboard, 8 line, rotary switches, New Haven	1878	
First switchboard with complete signaling equipment, 20 lines, Williams,† Bridgeport, Conn.	1878	
First plug-tipped switchboard cords, "Edison" exchange, American District Telegraph,‡ Chicago	1878	

* Non-Bell System. Bell licensee
† Manufacturer for Bell System, later absorbed
‡ Absorbed by Bell System

SWITCHING (Cont'd)

	Date	*Reference*
Manual (Cont'd)		
First cord circuit	1878§	Rhodes, p. 150
Multiple switchboard‡ invented, Firman	1878	Rhodes, p. 154
Target board busy signal,‡ Firman	1879	
First jack-knife switch, Scribner, used on ADT board,‡ Chicago	1879	Rhodes, p. 152
First W. E. "Universal Switch" board	1879	
First multiple board, ADT‡ office Chicago	1879	Rhodes, p. 154
First busy test (pneumatic), Scribner	1879	Rhodes, p. 154
Clearing out relay	1879	Mon. C4, p. 8, 9
Electrical line-busy test, Wilson & Haskins	1879†	Rhodes, p. 156
First W. E. "Standard" board	1880	Rhodes, p. 157
Law* board	1880	Things Worth Knowing, p. 32
First common battery signal system, associated with telephone	1880	Rhodes, p. 163
Gilliland** board	1880	Things Worth Knowing, p. 33
First jack perpendicular to board face, Warner	1881	BLR, 1, p. 142
First click test for busy, Scribner	1881	BLR, 1, p. 142
Pyramid board	1882	Things Worth Knowing, p. 34
Busy test through sleeve of plug, avoiding connection to busy line, Carty	ca. 1885	Rhodes, p. 158
Provision of keyshelf, cord weights, and ring and listen keys	ca. 1885	
Continuous multiple	1885	Rhodes, p. 159 Machine Switching Tel. System, p. 3
Separate answering jack per line, Seely Patent application	1885	Rhodes, p. 159
Strip jacks, Thayer	1887	Rhodes, p. 160
Common battery switchboard, Hayes, patent	1888	Ev. Tel. Hist., p. 12

§ 1880, BSTJ, 37, p. 325
* Non-Bell System, absorbed and used by Bell System
† 1881, BLR, 1, p. 142
** Manufacturer for Bell System, later absorbed
‡ Absorbed by Bell System

	Date	*Reference*
Intermediate distributing frame, Barton		
Patent application	1890	Rhodes, p. 160
First metallic circuit switchboard, Cortlandt exchange, New York	1890	Rhodes, p. 160
Main distributing frame, Hibbard	1891	BLR, 6, p. 333
First common battery switchboard, Lexington, Mass.	1893	Rhodes, p. 164
Incandescent lamp signals, O'Connell	1895	BSTJ, 37, p. 325
Line signals controlled by switchhook, Worcester, Mass.	1896	Rhodes, p. 165
No. 1 Relay Board, Louisville, incorporating multiple, common battery, lamp signals, cutoff relays, repeating coil cord circuits	1897	Rhodes, p. 165
No. 1 (common battery multiple) Switchboard	1901	BLR, 9, p. 268
506 Type PBX, last with magnetic drops	ca. 1929	BLR, 30, p. 205
Braille board for blind operators	before 1953	BLR, 31, p. 220
Automatic		
Dial invented, Cooke† Pointer type, used with fire alarm and district messenger systems, and Wheatstone's† telegraph	1836	BLR, 31, p. 22
First use of dial, Wheatstone† telegraph	1839	BLR, 31, p. 22
Sequence signalling to control remote apparatus, suggested, A. G. Bell	1875	BLR, 30, p. 463
Translation proposed, Molina	1905	BLR, 26, p. 445 Hist. First, p. 49 N&I Rel., 10/51
Patent application	1906	BSTJ, 37, p. 328 Hist. Firsts, p. 49 BLR, 26, p. 445
Counting relay circuits, McBerty Patent application	1909	BLR, 26, p. 292
Call Indicator, experimental	1910	BLR, 8, p. 171
Counting circuit, Molina Patent application	1911	Hist. Firsts, p. 49 BLR, 26, p. 291

† Non-Bell System

SWITCHING (Cont'd)

	Date	*Reference*
Village Systems		
Automatic telephone system, Connolly¶, Connelly¶, and McTighe¶		
Patented	1879	Rhodes, p. 166
Village system with rotary step switch (never used)		
Village automatic system, Gilliland (Bell System), patented, all lines to each customer	1884	BLR, 31, p. 23
Field trial, Leicester, Mass.	1885*	
Rotating brush, Ahearn¶, Canada		
Patent issued	1885	BLR, 31, p. 25
Dial telegraph switch with limited number of trunks between selectors, and automatic selection of idle trunk, Smith¶		
Patent application	1888	BLR, 31, p. 24
Application to telephone		
Patent issued	1895	BLR, 31, p. 25
Village System, Bell System		
Demonstrated, World's Fair (Columbian Exposition)	1893	Mon. 2040, p. 2
Line finder, automatic, Lorimer¶		Rhodes, p. 166
Patent application	1900	BLR, 31, p. 27
		Mon. 2040, p. 3
Faller¶ (never commercial)		
Patented	1901	Mon. 2040, p. 2
Bullard-Rorty single motion switch system		
Trial installation (Bell System), Queens, N. Y.	1902	N&I Rel., 10/51
Dropped as unsatisfactory		

Step-by-step

Progressive system: calls progress as number is dialed. Equipment does not know next step, cannot plan alternatives without feeding information into a different type of unit. Best suited to small and medium sized cities, without complex switching problems.

Adopted by Bell System and widely used. An example of willingness to adopt best device for the purpose, irrespective of origin.

Step-by-step switch invented, Strowger¶	1889†	BSTJ, 37, p. 326
Patent issued	1891	BSTJ, 31, p. 1086

* 1884, N&I Rel., 10/51
† 1886, Pan. of Tel. Prog., p. 20

	Date	*Reference*
Five-wire push button signaling Strowger¶	1891	N&I Rel., 10/51
First installation, LaPorte, Ind.¶	1892	BSTJ, 37, p. 326
First commercial automatic office in the world		
Finger wheel dial		
Invented, Keith¶, Erickson¶, and Erickson¶, Automatic Electric Co.¶	1895†	BSTJ, 37, p. 326
First installation, Milwaukee, Wis.¶	1896	N&I Rel., 10/51 Lowe
Modern form of step-by-step switch, Keith¶ and Erickson brothers¶		
In use	1895	BLR, 31, p. 96
Automatic trunk selection, Lundquist¶ (ex-Strowger)	ca. 1897	BLR, 31, p. 100
First practical commercial use, New Bedford, Mass.	1900	
Common battery (Strowger)¶ with automatic ringing	1905	
"Bank slip" to distribute selector search		BLR, 31, p. 102
Patent application	1905	
Four-party selective harmonic ringing	ca. 1905	
Plunger line switch patented Keith¶ (Automatic Electric Co.¶)	1905	BLR, 31, p. 103
In use	1907	BLR, 7, p. 236
Line selector	before 1907	BLR, 31, p. 103 BLR, 7, p. 236
Two-wire system, Pontiac, Ill. (Previously 5-wire then 3-wire, then "3-wire" with 2 physical wires and earth ground)	1908	BLR, 31, p. 103
Step-by-step system used by Bell System, Nebraska	1912	
Acquired patent rights	1916	
Modern dial numbering system, Blauvelt	1917	BSTJ, 31, p.1094 N&I Rel., 10/51
Adopted by Bell System	1919	
First Strowger¶ switchboard manufactured for Bell System, installed at Norfolk, Va.	1919	Ev. Tel. Hist., p. 22

¶ Non-Bell System
† 1896, N&I Rel., 10/51

SWITCHING (Cont'd)

	Date	*Reference*
Step-by-Step (Cont'd)		
First modern type (based on decimal system, 10 steps up, 10 steps around), W. E., Springfield, Mass.	1927	
First Bell System unattended community dial office, San Clemente, Calif.	1927	Ev. Tel. Hist., p. 27
No. 356A small packaged dial office	ca. 1952	BLR, 30, p. 106
Rotary		
Motor-driven rotary mechanism invented, Hayes and Sears (laboratory experiment only)	1889	BLR, 31, p. 24
Rotary switch plus sender, McBerty	ca. 1906	Ev. Tel. Hist., p. 16
First commercial use, Darlington, England¶	1914	BSTJ, 37, p. 328 Mon. 2040, p. 10
Director system with rotary system, first use, Havana¶	1924	Mon. 2040, p. 10
Panel		
"Common control" system, based on nondecimal system. Stores dialed digits, then releases as needed. Uses translator to change from decimal dial pulses to 500-unit panel numbering groups.		
Reverse impulse control for telegraph, later used in panel system, Smith¶		
Patent application	1889	BLR, 31, p. 24
Application to the telephone, Smith¶		
Patent issued	1889	BLR, 31, p. 25
Studied	1907	N&I Rel., 10/51
Experimental installation, semi-mechanical, Bell Laboratories PBX	1910*	BLR, 31, p. 29
Experimental installation, fully mechanical, Bell Laboratories PBX	1913	Lowe
Field trial, semi-mechanical, Mulberry office, Newark, N. J.	1915†	BLR, 31, p. 29 Mon. 2040, p. 9

* 1912, N&I Rel., 10/51
† 1914, BLR, 10, p. 104

	Date	*Reference*
First completely automatic office, Atlantic Office, Omaha, Neb.	1921‡	BLR, 10, p. 104

Relay Chain Type

Purchased from non-Bell System sources. Used for very small offices only		
First use	ca. 1930	
Standardized	1936	

Crossbar

Relay chain principle, but uses large multiple-contact relay type switches as well as relays. Common control system, stores dialed digits, selects path from alternates under control of marker.

First use of crossbar (manual non-automatic) switchboard, Bridgeport, Conn.	1877	Rhodes, p. 149
Principle of crossbar switch conceived, Roberts¶, Automatic Elect. Co¶.	1901	BSTJ, 37, p. 329
Marker invented, Palmgren¶ and Betulander¶, Sweden	1912	BSTJ, 37, p. 329
First commercial use, England¶	1915	BSTJ, 37, p. 329
Crossbar switch invented, Reynolds	1913	BSTJ, 31, p. 1096
Patent issued	1915	Mon. 2040, p. 11
First commercial use, Sweden¶, in step-by-step	1926	BSTJ, 37, p. 331
First installation, No. 1 Crossbar, Troy Avenue, Brooklyn, N. Y.	1938	Magic Behind Your Dial, p. 20 Mon. 2040, p. 11 BLR, 18, p. 113 WE, VII, No. 5, p. 15
Decoder available	by 1938	Strieby, Lect. Dem. Rel., 1/6/54
Call-back invented, Erwin	1938	BSTJ, 37, p. 331
Crossbar tandem office	1942	BLR, 20, p. 286
First toll crossbar, No. 4 (regional operator dialing), Philadelphia	1943	BLR, 22, p. 101 Mon. 2045, p. 10 Strieby, Lect. Dem. Rel., 1/6/54 N&I Rel., 10/51 BSTJ, 37, p. 332 WE, VII, No. 5, p. 15
4-wire switching	ca. 1943	BLR, 23, p. 151

‡ 1919, WE, VII, No. 5, p. 15

¶ Non-Bell System

SWITCHING (Cont'd)

	Date	*Reference*
Crossbar (Cont'd)		
No. 5 Crossbar, Busch		
Patent application	1948	U. S. pat. 2,585,904
First installation, No. 5 Crossbar, Media, Pa.	1948*	Post-War Achievements, p. 20; N&I Rel., 10/51
Card translator		
First use of transistors in the telephone system	1952	BLR, 36, p. 226
Pittsburgh	1953	N&I Rel., 6/30/53
Electronic (experimental)		
Includes use of transistors, solid diodes, cold cathode tubes ("talking diodes"), electron beam tubes, photographic memory plates, etc. High speed and low power requirements permit large reduction in equipment		
Concept of electronic switching system, Brooks	1951	Fortune, 12/58, pp. 142, 144
Barium titanate memory crystals, Remeika (BTL)	before 1952	Mon. 2014, p. 1
ECASS (Electronically Controlled Automatic Switching System), experimental	ca. 1953	BLR, 32, p. 323
DIAD (Drum Information Assembler and Dispatcher), experimental	ca. 1953	Mon. 2151, p. 1
Part electronic system, I. T. & T.†, Ski, Norway	1954	BSTJ, 37, p. 334
One-at-a-time operation	before 1955	Mon. 2393, p. 1
Used with DIAD	by 1955	Mon. 2393, p. 5
First trial installation, Morris, Ill., scheduled	1960	Guenther
Unattended Offices		
Satellite dial exchanges, Westinghouse†		
Patent issued	1879	BLR, 31, p. 23
First Bell System unattended community dial office, San Clemente, Calif.	1927	Ev. Tel. Hist., p. 27
First No. 5 Crossbar with tributary offices, Wheaton, Ill.	1950	Ev. Tel. Hist., p. 38

* 1947, WE, VII, No. 5, p. 15

† Non-Bell System

TOLL SWITCHING

	Date	*Reference*
Automatic Message Accounting (AMA)		
First installation, Media, Pa.	1948	N&I Rel., 12/10/48
Call Identity Indexer		
In use	1952	
Master Timing Frame		
In use	1952	
Perforator Cabinet		
In use	1952	
Recorder		BLR, 30, p. 173
In use	1952	
Translator Frame		
In use	1952	
Transverter		
In use	1952	
Transverter Connector	1952	
Centralized Automatic Message Accounting (CAMA)		
First installation, Washington, D. C.	1953	Ev. Tel. Hist., p. 41
Assembler-computer, using sealed switches	ca. 1955	BLR, 33, p. 356
Automatic Ticketing		
First American installation, Culver City, Calif.	1943*	N&I Rel., 10/57
Identifier (used with automatic ticketing)	ca. 1943	Mon. 1908, p. 31
Centralized Automatic Message Accounting (CAMA) (see Toll Switching, AMA)		
Direct Distance Dialing (DDD)		
Also known as Continent-wide Subscriber Dialing; also known formerly as FACD (Foreign Area Customer Dialing)		
First trial installation, Englewood, N. J.—single-frequency type	1951	BSTJ, 37, p. 332 N&I Rel., 10/51 N&I Rel., 5/3/51
Foreign Area Translation		
(short cut to neighboring exchange from edge of one National Area to another) In use	1955	BLR, 33, p. 57

* 1944, Mon. 2045, p. 10

TOLL SWITCHING (Cont'd)

	Date	*Reference*
General		
Tandem trunks		
In use	1919	Mon. 322, p. 4
Straightforward tandem	1924	
No. 1 Toll Board	before 1926	Mon, 235, p. 1
Dial tandem, first service	1926	Mon. 322, p. 9
Dial tandem, Los Angeles metropolitan district and adjacent areas	1927	Mon. 322, p. 10
A-B Toll, Chicago		
In use	1927	Mon. 323, p. 2
Call circuit operation		
Recent	1929	Mon. 453, p. 21
No. 4 Toll Board, Philadelphia	1943	BLR, 29, p. 197
No. A4A Toll Board (Advanced 4A)		
In use	1951	BLR, 29, p. 197
No. 4A Toll Board		
First installation, Scranton, Pa.	1953	BLR, 31, p. 366
Operator Toll Dialing		
Automatic circuit changer, (operator toll dialing in embryo) Worcester-Leicester, Mass., Gilliland*	1885	BLR, 31, p. 24
Experimental, Worcester-Gloucester, Mass.	1896	Ev. Tel. Hist., p. 14
First installation, regional operator dialing, Philadelphia	1938	Strieby, Lect. Dem. Rel., 1/6/54
No. 4 Toll Board	1943	N&I Rel., 10/51
Multiple testing of trunks, No. 1 Crossbar	by 1940	Mon. 2273, p. 2
Multi-frequency key pulsing	before 1941	BLR, 26, p. 218
Remote control zone registration	1941	Mon. 2347, p. 2
Alternate trunking	1941	Mon. 2273, p. 2
First transcontinental operator dialing, New York-San Francisco	1947†	N&I Rel., 10/51
First commercial transcontinental	1949	N&I Rel., 10/51
Intertoll trunk concentrating equipment available	1954	Mon. 2274, p. 3
In-band single-frequency signalling available	1954	Mon. 2346, p. 1

* Manufacturer to Bell System, later absorbed
† 1945, Mon. 2273, p. 1

	Date	*Reference*
Tandem Operation		
Call indicator (announcer)	ca. 1930	Mon. 2213, p. 1
Manual straightforward		
In use	1936	Mon. 936, p. 13
Toll office		
In use	1936	Mon. 936, p. 27
Straightforward toll line	1936	Mon. 936, p. 3
Toll switching trunk	1936	Mon. 936, p. 2
Panel sender	1936	Mon. 936, p. 6
(most with operator positions)	1936	Mon. 936, p. 5
Panel office selector	1936	Mon. 936, p. 34
Step-by-step	1936	Mon. 936, p. 61
(a few with "B" Board operators)	1936	Mon. 936, p. 5
(a few with intermediate dialing or key pulsing)	1936	Mon. 936, p. 4
Trunk concentrating (all these at toll centers)	1936	Mon. 936, p. 9

WIRE

General		
Printed		
In use	1955	BLR, 33, p. 137
Insulation		
Silk	1878	New Haven Board, coils
First gutta percha or rubber	ca. 1880	Mon. 313, p. 1
Cotton	after 1880	Mon. 313, p. 1
Paper		
Barrett and Sargent experimental, spiral wrapped	1889	Mon. 714, p. 2; BLR, 3, p. 148
Adopted	1891	BLR, 3, p. 148
Standardized	1892	BLR, 27, p. 259
Manila, hemp, or manila-cotton or hemp-cotton paper	up to 1920	Mon. 714, p. 2
Kraft (wood pulp-hemp or wood pulp-manila)	1920	Mon. 714, p. 2
Pulp insulation		
Experiments	1924	Mon. 714, p. 5
Field test	1925	Mon. 714, p. 5
Commercial use	1928	Mon. 714, p. 6
Cellulose acetate	ca. 1938	BLR, 20, p. 125

APPARATUS

	Date	*Reference*
Automatic Transmission Regulator		
Spacing		
Open wire, 2 repeaters (100 miles)	1932	Mon. 700, p. 5
Underground (cable) (180 miles)	1932	Mon. 700, p. 6
Coil (see APPARATUS, Coil, and TRANSMISSION, Voice Frequency Loading)		
Hardware		
Corrosion resistant		
In use	1951	BLR, 29, p. 226
Insulator (see also Transpositions)		
Wood	ca. 1876	
Tin on wood ("niggerhead")	ca. 1876	Tel. (Smithsonian Inst.), p. 16
Glass	ca. 1876	Rhodes, p. 97
Ceramic	ca. 1878	
Double transposition, Hibbard	1889	BLR, 28, p. 392
Drop bracket		
In use	1930	Mon. 529, p. 3
Suspended	ca. 1954	BLR, 32, p. 122
Suspension type, recent	1955	Mon. 2457, p. 2
Double skirted		
In use	1955	BLR, 33, p. 46
Line Concentrator		
Field trial	1954	Case 33974
Loading Coil Case		
Cast iron	1905	BLR, 9, p. 518
Welded steel	1931	BLR, 9, p. 519
Lead, small cases	1930–35	Mon. 1970, p. 86
Lead, steel tube lined	1930–35	
Cylindrical steel tube	1940	
Repeater		
Pole-mounted, for N1 carrier		
In use	1953	BLR, 31, p. 397

	Date	*Reference*
Tool		
Pole hole borer		
In use	1929	Mon. 476, p. 14
CABLE		
Conductors		
Copper		
In use	1878	Tech. Dev., p. 6
Aluminum,		
Experimental	ca. 1951	BLR, 31, p. 467
Field trial, Baltimore	1952	BLR, 31, p. 469
Gas Plug		
Cold resin type		
Field trial	ca. 1954	BLR, 32, p. 260
General		
Proposed, Bell	1878	Mon. 313, p. 1
Experimental (per Barton, W. E. President)	ca. 1878	Rhodes, p. 100
Twisted pairs		
Conceived, Bell	1878	Rhodes, p. 93
Used	1887	Mon. 1275, p. 1
Maximum diameter established (2 in.)	1887	Mon. 1275, p. 1
50-pair lead-tin sheath, cotton insulation, 18 gauge	1888	BSTJ, 37, p. 309; BLR, 3, p. 146
First metallic circuits in cable	1888	BLR, 3, p. 148
Cable standardized	1888	Circuits for Victory, p. 13
19 gauge in use (100 pairs)	1892	BLR, 3, p. 149
22 gauge in use (404 pairs)	1901	BLR, 27, p. 258
Quadded		
First practical form, Boston-Neponset	1910	Rhodes, p. 194
Vacuum drying	after 1911	Mon. 313, p. 9
24 gauge in use (1212 pairs)	1914*	Mon. 1275, p. 1; BLR, 27, p. 258
Gas pressure		
Proposed	by 1925	75 Years of Service, p. 19
First installation	1927	Mon. 1473, p. 1

* 1915, BLR, 3, p. 150

CABLE (Cont'd)

	Date	*Reference*
General (Cont'd)		
Testing		
First method: compressed air	before 1929	Mon. 420, p. 3
Second method: carbon dioxide	before 1929	Mon. 420, p. 3
Third method: nitrogen		
South Bend to Toledo	1925	75 Years of Service, p. 19
Constant pressure	by 1929	Mon. 420, p. 11
26 gauge in use (1818 pairs)	1928	BLR, 27, p. 258
Coaxial		
Espenschied and Affel		
Patent application	1929	BLR, 8, p. 467
First service, New York-Phila., ¼ inch diameter	1936	BLR, 8, p. 30
Minneapolis-Stevens Points, Wis., ⅜ inch diameter	1941	Ev. Tel. Hist., p. 32
Solid dielectric, in production	1954	Case 38466
Buried		
First demonstration of plowing in, Ezra Cornell[1] (founder of Cornell University)	1840–45	Bell Tel .Mag., p. 87
First plow for telephone cable	1930	Bell Tel. Mag., 21, p. 88
In use	1942	Bell Tel. Mag., 21, p. 87
28 gauge in use	1942	BLR, 21, Jan., p. vii
Video pair cable	1948	BLR, 26, p. 202
Guard		
Polyethylene	ca. 1954	BLR, 32, p. 475
Insulation of Wires		
Gutta percha[1]	by 1855	Rhodes, p. 93
Rubber[1]	ca. 1855	Rhodes, p. 100
Cotton, impregnated with paraffin oil	by 1878	Rhodes, p. 101
Kerite (rubber compound)	by 1879	Rhodes, pp. 100, 104
Cotton impregnated with resin and paraffin	1880	Rhodes, p. 102
Also resin and beeswax	1880	Rhodes, p. 103
Sisal and cotton	after 1880	Mon. 313, p. 1
Glass	1881	Rhodes, p. 103
Double cotton and rubber	by 1882	Rhodes, p. 106
Jute impregnated with paraffin	1883	Rhodes, p. 106
Paper (manila rope paper)		
Barrett and Sargent	1891	Mon. 1275, p. 1
Standardized	1892	BLR, 27, p. 259

	Date	*Reference*
No impregnation, dry core		
Experiments	after 1886	Rhodes, p. 127
Standardized	1891	Mon. 1275, p. 1
"Conference Standard" dry-core cable	1892	Rhodes, p. 129
Manila, hemp, or manila-cotton or hemp-cotton paper	until 1920	Mon. 714, p. 2
Kraft (wood pulp-hemp or wood pulp-manila, 45%, 40% wood, 15% cotton)	1920	Mon. 714, p. 2
Pulp insulation		
Experiments	1924	Mon. 714, p. 5
Field test	1925	
Commercial use	1928	Mon. 714, p. 6
Polyethylene		
Coaxial cable, New York-Washington	1939	Mon. 1933, p. 1
Sheath		
Lead water-pipe, experimental	1878	Tech. Dev., p. 6
Pure lead sheet, wrapped*	1880	BLR, 4, p. 420
Extruded lead		
Experimental, small	early 1880s	Rhodes, p. 126
Barrett and Robertson	1886	Rhodes, p. 127
In use	1892	Circuits for Victory, p. 13
Lead-tin	1894	BLR, 23, p. 248
Core pulled into pipe	ca. 1878	Mon. 313, p. 1 Rhodes, pp. 101, 102
Use continued until	1894	Mon. 313, p. 4
Lead-antimony sheath	1912†	BLR, 23, p. 248 Things Worth Knowing, p. 35
Tape armored	1929	Ev. Tel. Hist., p. 28
In use, Fort Worth-Cisco, Tex.	1930	BLR, 8, p. 467
Lead-calcium studies, Schumacher and Bouton	1930	Mon. 467, p. 1
Lead-antimony-arsenic studies	1930	Mon. 468, p. 4
Gopher protection	1940	BLR, 19, p. 165
Stalpeth (steel-aluminum-polyethylene)		
First use	1947	BLR, 29, p. 353
Alpeth (aluminum-polyethylene)		
First trial, solid polyethylene, Cooperstown, N. Y.	1948	BLR, 26, pp. 35, 441

* By 1879, BLR, 23, p. 248
† 1911, Mon. 313, p. 9

CABLE (Cont'd)

	Date	*Reference*
Sheath (Cont'd)		
Alpeth (Aluminum-polyethylene) (Cont'd)		
First trial, expanded polyethylene, Grandville-Zeeland, Mich.	by 1953	Mon. 2194, p. 7
Lepeth (lead-polyethylene), recent	1950	BLR, 28, p. 241
Polyethylene		
In use	1951	Mon. 1933, p. 1
Strand (see CABLE, Suspension Systems)		
Suspension Systems		
Experimental	1881–82	Rhodes, pp. 104–5
Canvas slings	1880–90	
Marlin (light rope) loops or windings	1880–90	
Wire loops or windings	1880–90	
Cable lashing machine, experimental	1880–90	BLR, 19, p. 270
Metal hangers	ca. 1890	
Sheet metal rings	ca. 1890	
Spring steel wire rings	ca. 1915	
Cable clamped to strand at points	before 1941	
Cable supports gripping cable but loose on strand	before 1941	BLR, 19, p. 271
Modern cable lashing machine, recent	1941	
Corrosion resistant strand		
In use	1951	
Corrosion resistant hardware		BLR, 29, p. 226
In use	1951	
Pre-lashed cable and strand		
Under test	1951	
In use	by 1955	BLR, 33, p. 165
Terminal		
Gas-tight combined lightning arrester and aerial cable terminal		
Design	1948	BLR, 29, p. 163
In manufacture	1951	
Distribution cable terminal, protectors integral	ca. 1951	BLR, 29, p. 226

CONDUIT

First cable conduit, wood	1881	Ev. Tel. Hist., p. 9

	Date	*Reference*
First "drawing-in" underground conduit (boiler tubes in concrete), Davis	1882	BLR, 26, p. 457
Iron pipe	1884*	BLR, 10, p. 164
Tile (clay)	1890†	BLR, 10, p. 164
Creosoted wood ducts	ca. 1890	BLR, 26, p. 458
Unglazed long unit	ca. 1951	BLR, 29, p. 226

INTERFERENCE

Common neutral power connections, first extensive use, Minneapolis	ca. 1922	Mon. 981, p. 3
Common neutral introduces added noise on telephone lines	ca. 1922	
Study of noise, Minneapolis	1924–26	
Study of noise, Elmira	1926–29	Mon. 981, p. 4
Recommendations	1937	Mon. 981, p. 16

LOADING

General

Theory of frequency distortion and correction, Heaviside¶, England	1887	Mon. 145, p. 4
Loading proposed, Heaviside¶, England	1887	Rhodes, p. 146
Loading coils proposed, Vaschy¶, France	1889	
Discussion of impedance matching, Heaviside¶, England	1893	Mon. 145, p. 5
Continuous loading theory, John Stone Stone	1897	Mon. 1970, p. 3
Loading coil spacing rules, Pupin¶ and Campbell, independently,	1899	Mon. 1970, p. 3 Rhodes, p. 140
Patented, Pupin¶	1900	BLR, 30, p. 264
First line, with air-core coils, Jamaica Plain–West Newton, Mass.	1900	Rhodes, p. 140
Toroidal coils	1901	
Iron core coils in use, New York–Chicago	1901	BLR, 30, p. 268
First iron-core coils on a cable circuit, New York–Newark	1902	Rhodes, p. 140 An. Report, Eng'g. Dept., Am. Bell Tel. Co., 1902

* Ca. 1890, BLR, 26, p. 458
† After 1890, BLR, 26, p. 458
¶ Non-Bell System

LOADING (Cont'd)

	Date	*Reference*
General (Cont'd)		
First standard loading system (Heavy, medium, light)	1904	Mon. 196, p. 8
Heavy loading only for open wire	1904	
Open wire phantom loading	ca. 1910	Mon. 196, p. 16
First successful loaded phantom, Boston–Neponset cable	1910	Rhodes, p. 194 Mon. 196, p. 13
Medium heavy loading	1910–11	Mon. 196, p. 14
Philadelphia–Washington	1911	Mon. 1970, p. 14
First loaded repeatered line in service, New York–San Francisco	1915	Mon. 1970, p. 16
Loading stopped on repeatered circuits	1924	Mon. 1970, p. 18
Loading finally removed	1934	
Frequency modulation broad band lines, to 15,000 cycles	1948	Mon. 1970, p. 51 Mon. 606, p. 9
Types		
Heavy loading 7400 ft. spacing, 200 mh. sides, 135 mh. phantom, 10 and 13 A.W.G.	1914	Mon. 700, p. 2
Medium heavy loading 6000 ft. spacing, 175 mh. sides, 2800 cycle cut off, (H-175)	ca. 1914	
H-245-155 245 mh. sides, 155 mh. phantom	before 1917	Mon. 1970, p. 30
H-174-106 174 mh. sides, 106 mh. phantom Trial	1917	Mon. 1970, pp. 29, 30
6000 ft. spacing, 44 mh. coils on side, 25 mh. coils on phantoms (H-44-25) New York–Philadelphia–Reading	1919	Mon. 606, p. 9 Mon. 1970, pp. 29, 30
H-174-63 174 mh. sides, 63 mh. phantom	1923	Mon. 1970, pp. 29, 30
9000 ft. spacing, 88 mh. coils In use	1923	Mon. 1970, p. 63
6000 ft. spacing, 135 mh. coils In use	1923	

	Date	*Reference*
6000 ft. spacing, 175 mh. coils		
In use	1923	Mon. 1970, p. 63
4500 ft. spacing, 175 mh. coils		
In use	1923	
6000 ft. spacing, 28 mh. coils on sides, 16 mh. coils on phantom, for entrance cable		
In use	1927	Mon. 1970, p. 106
H22, for 50–8000 cycles (program circuits) (6000 ft. spacing, 22 mh. coils)	1927	Mon. 1970, p. 49
6000 ft. spacing, 31 mh. coils on side, 18 mh. coils on phantom, voice frequency entrance cable	1928*	Mon. 1970, p. 108
B22, for 50–8000 cycles (3000 ft. spacing, 22 mh. coils) (program circuits)		
Trial	1929	Mon. 1970, p. 49
Commercial	1930	Mon. 1970, p. 50
12000 ft. spacing, 44 mh. coils on side, 25 mh. coils on phantom (2H-44-25), used for submarine local cables (i.e., San Francisco Bay)		
In use	1931	Mon. 606, p. 13
H-172-63		
6000 ft. spacing, 172 mh. sides, 63 mh. phantom, abandoned in new circuits	1932	Mon. 700, p. 5
Two-wire standard		
6000 ft. spacing, 88 mh. sides, 50 mh. phantom (H-88-50)	1932	
3000 ft. spacing, 88 mh. sides, 50 mh. phantom (B-88-50)	1932	Mon. 1970, p. 39
Four-wire standard, 6000 ft. spacing, 44 mh. sides, 25 mh. phantom (H-44-25)	1932	Mon. 700, p. 5
6000 ft. spacing, 88 mh. coils, standard	1932	Mon. 1970, p. 72
3000 ft. spacing, 88 mh. coils, standard	1932	
3000 ft. spacing, 135 mh. coils, standard	1932	Mon. 1970, p. 72

* 1942, Mon. 1970, p. 48

LOADING (Cont'd)

	Date	*Reference*
General (Cont'd)		
Types (Cont'd)		
9000 ft. spacing, 44 mh. coils for subscribers loops		
In use	1933	Mon. 1970, p. 70
6000 ft. spacing, 44 mh. coils for subscribers loops		
In use	1933	Mon. 1970, p. 70
7400-ft. spacing		
In use	1914	Mon. 700, p. 2
6000-ft. spacing (H spacing)	ca. 1914	Mon. 700, p. 2
9000-ft. spacing (M spacing)		
In use	1923	Mon. 1970, p. 63
4500-ft. spacing (D spacing)		
In use	1923	Mon. 1970, p. 63
3000-ft. spacing (B spacing)		
In use	1929	Mon. 1970, p. 49
12000-ft. spacing		
In use	1931	Mon. 606, p. 13

POLE LINE

Pole		
Chestnut		
In use	ca. 1900	Mon. 1352, p. 2
Still being set (but blight wiping out chestnut trees)	ca. 1930	Mon. 2118, p. 4
Northern white cedar		
In use	ca. 1900	Mon. 1352, p. 2
Western red cedar		
In use	ca. 1900	Mon. 1352, p. 2
Creosoted southern pine		
In use	ca. 1900	Mon. 1352, p. 2
Standard	after 1918	Mon. 2118, p. 4
Lodge pole pine		
In use	1911	Mon. 208, p. 2
Red pine		
In use	1942	Mon. 1352, p. 2
Douglas fir		
In use	1942	Mon. 1352, p. 2
Jack pine (Lake states)		
In use	1953	Mon. 2118, p. 5
Ponderosa pine (California)		
In use	1953	Mon. 2118, p. 5

	Date	*Reference*
Crossarm		
Laminated, experimental	1946	Mon. 2443, p. 2
Field test	1952	Mon. 2443, p. 3
Drop Wire (see Wire)		
Erection		
Ground-erected rural		
Field trial, Virginia, Colorado,	ca. 1954	BLR, 32, p. 125
Pole Preservation		
Creosote pressure "full cell" treatment introduced and patented, Bethall¶, England (Creosote was then known as "dead oil of coal tar")	1883	
Thermal (non-pressure) treatment		
Patented, Seeley¶	1867	
Introduced in practice, von Schrenk¶	1904	
Used for butt treatment, Bell System	1918	
Used for full-length treatment, Bell System	ca. 1938	
Pressure treatment used by Bell System (previously, use of chestnut and cedar had made treatment unnecessary)	1897	Lumsden, 6/25/59
Empty cell process (air pressure, then superimposed creosote pressure, then release; causing much creosote to come out, saving creosote and leaving a cleaner pole)		
Rueping¶	1902	
Used by Bell System	ca. 1930	
Greensalt treatment (potassium dichromate, copper sulphate and arsenic acid)		
Laboratory study started	1933	BLR, 21, p. 117
Initial tests started	1934	BLR, 21, p. 62
Field trial	1940	BLR, 21, p. 118
Limited commercial use	1941	
Pentachlorphenol (war substitute)		
In use	1941	Lumsden, 6/25/59
Chromated zinc chloride Wolman salts		
In use	1942	Mon. 1342, p. 1

¶ Non-Bell System

POLE LINE (Cont'd)

	Date	*Reference*
Pole Preservation (Cont'd)		
Zinc meta arsenite		
In use	1942	Mon. 1342, p. 1
Mold treatment to increase preservative absorption		
Experiment	1951	BLR, 33, p. 17
Field test	1952	BLR, 33, p. 19
Transposition		
Drop bracket		
In use	1930	Mon. 529, p. 3
Point type		
In use	1930	Mon. 529, p. 3
R1 Tandem	before 1955	Mon. 2457, p. 2
Phantom (double drop bracket)		
In use	1955	BLR, 33, p. 46
Double-skirted insulator		
In use	1955	BLR, 33, p. 46
Wire Spacing		
8 inch		
In use	1930	Mon. 529, p. 18
12 inch		
In use	1930	
18-¼ inch		
In use	1930	

PROTECTION

Fuse and protector adequate for maximum expected power exposure (standardized at 5000 volts between wires of power system, 2900 volts to ground, with estimated 2300–2400 effective volts to ground on actual lines)	ca. 1878	Inskip, 7/9/59
24 gauge wire (6 ft. or more) in cable replaced fuse at office or aerial-underground cable junctions on cables with grounded sheath. Protector grounded to sheath. Isolated cable (non-grounded sheath) protected and fused at office	1927–28	Inskip, 7/9/59
Voltage limitation eliminated		
Inserted extra-high-current-		

	Date	*Reference*
capacity gap with 3000 volt breakdown. This not only shunted power, but de-energized the power circuit. On these high current protected lines, our ground was tied to the power ground.	1936	Inskip, 7/9/59
All pairs protected, not just exposed pairs, at terminals		
Studied	1934	Inskip, 7/9/59
In production	1940	
Power and telephone grounds tied in other cases as convenient	ca. 1946	Inskip, 7/9/59
Gas-tight combined lightning arrester and aerial cable terminal		
Design	1948	BLR, 29, p. 162
In manufacture	1951	
104A Protector for power line induction	until 1952	BLR, 30, p. 165
108A Protector for power line induction	ca. 1952	
Silicon pn junction diode lightning protector, Pearson and Fuller	1954	IRE, 42, p. 760
All protection, except for long severe exposure, eliminated on polyethylene insulated conductor cables	ca. 1954–55	Dietz, 8/6/59
TESTING		
Line insulation, preventive		
In use	1951	BLR, 29, p. 226
WIRE		
Line		
Bell wire (really station wire)	1876	Museum Exhibit, HM18
Telegraph type	1876	Rhodes, p. 35
Iron, stove pipe wire	1876	Bell Dep., p. 123
Hard-drawn copper		
Doolittle*		
Experimental	1877	Rhodes, p. 91 BSTJ, 37, p. 309
Production	1878	Rhodes, p. 91 Tech. Dev., p. 5

* Non-Bell System. Bell licensee

WIRE (Cont'd)

	Date	*Reference*
Line (Cont'd)		
Hard-drawn copper (Cont'd)		
First commercial line, New York–Philadelphia	1885	Rhodes, p. 92
Iron		
109 mil (12 BWG)	ca. 1880	Rhodes, pp. 89, 94 Mon. 529, p. 28
83 mil (14 BWG)	ca. 1880	Mon. 529, p. 28 Rhodes, pp. 89, 94
Copper-clad steel, trial	ca. 1910	Mon. 1781, p. 1 BLR, 18, p. 333
DB steel	1929	Farmer, 7/8/59
Copper		
104 mil, 128 mil, 165 mil In use	1930	Mon. 529, p. 2
Long-span rural		
250 ft., high tensile steel, 109 size, heavy zinc coated	1934	Mon. 2457, p. 1
350–450 ft., 109H high tensile steel		
Field trial	1937	Mon. 2457, p. 1
Available	1939	Farmer, 7/8/59
600 ft., 083H, 109E, extra high tensile and 134H	1946	Mon. 2457, p. 1 Farmer, 7/8/59
Copper-clad steel	1947	Mon. 2457, p. 1
109F, low resistance, extra high tensile, replaced 109E	1958	Farmer, 7/8/59
Copper-steel	1942	Farmer, 7/8/59
Buried		
Local		
In use	1936	BLR, 15, p. 70
Rubber-covered rural, recent	1941	BLR, 19, No. 3, p. 5
UG distribution		
In use	1947	BLR, 26, p. 5
B Service Wire	1956	Bishop, 7/7/59
Neoprene covered, first installation, Atlantic City, N. J.	1941	Mon. 1781, p. 3
Tree wire, copper-clad steel with GRS rubber and neoprene	1949	BLR, 27, p. 382
Station wire, JKT, copper-steel	1949	Bishop, 7/7/59
Aluminum, trial only	1951	BLR, 31, p. 467
B Rural Distribution Wire, six pair 18 gauge plus 109E steel wire	1953	BLR, 32, p. 115 Mon. 2457, p. 2
Urban Distribution Wire, 16 pair plus steel wire	after 1953	Farmer, 7/8/59

	Date	*Reference*
Drop Wire		
14 gauge copper, twisted pair, insulated with rubber, cotton braid, and asphalt	to 1910	Mon. 1781, p. 1 BLR, 18, p. 333
Copper-clad steel, trial	ca. 1910	Mon. 1781, p. 1 BLR, 18, p. 333
Parallel wires	late 1920's	
17 gauge, tin dipped tin-bronze, extruded rubber, braid (BR Type)	1931	Mon. 1781, p. 1
18 gauge, tin composition on tin-bronze, rubber, heavy cotton braid (TP Type)	1940	
Copper-coated steel (TP and TR Types)	1942	Bishop, 7/7/59

Insulation (see also OUTSIDE PLANT, Cable)

Loading Coil		
Bituminous enamel, Harris	ca. 1912–14	Brobst, 7/8/59
Black varnish enamel and cotton (introduced with permalloy on 612 Type Coil)		
Trial	1926	Mon. 1970, p. 67
Commercial	1927	
Polyvinyl formal (no cover braid required) in use for toroidal coils	ca. 1940	Brobst, 7/8/59
Nylon enamel (solder-through enamel) first use on 500 Type Combined Set	1950	Brobst, 7/8/59
Polyurethane in use for loading coils and inductances	ca. 1957	Brobst, 7/8/59
Drop Wire		
Rubber, cotton braid, and asphalt	to 1910	Mon. 1781, p. 1
Extruded		
BR Type, extruded rubber, braid	1931	
Rubber, heavy cotton braid, TP Type	1940	
Buried		
Rubber-covered rural, recent	1941	BLR, 19, March, p. v
Neoprene covered, first installation, Atlantic City, N. J.	1941	Mon. 1781, p. 3
Tree wire, GRS rubber and neoprene	1949	BLR, 27, p. 382

WIRE (Cont'd)

	Date	*Reference*
Joints		
Western Union† twisted wire	to 1906	BLR, 19, p. 89
Double sleeve, twisted	1906	
Single sleeve, rolled	1931*	BLR, 10, p. 75
Wire Guards		
Aerial wire guards (tree guards)		
Wooden	before 1951	BLR, 19, p. 497
Plastic		
S (over neoprene drop wire)		BLR, 19, p. 499
Standard	1951	
P (slit, same as S)		
Standard	1951	
L (over open wire)		
Standard	1951	

† Non-Bell System
* 1927, BLR, 19, p. 90

BAND WIDTH (Message Band)

	Date	*Reference*
New York–San Francisco, loaded line, 900-cycle band	1915	Mon. 486, p. 1
Non-loaded 1800-cycle band	1920	
Maximum frequency cutoff, 2300 cycles	before 1924	Mon. 1970, p. 61
Maximum frequency cutoff, 2800 cycles	1924	
250–2750 cycles	1925–30	Mon. 1970, p. 38
Maximum frequency cutoff, 3500 cycles	1932	
50–8000 cycles (program circuit)	1927	Mon. 1970, p. 49
Trial installation	1929	Mon. 1970, p. 50
Commercial use	1930	
Maximum frequency cutoff, 15,000 cycles (frequency modulation)	1948	Mon. 1970, p. 51
Exchange trunks		
Maximum frequency		
Cutoff, 2300 cycles	before 1924	Mon. 1970, p. 71
Cutoff, 2800 cycles	1924	
Cutoff, 3500 cycles	1932	

EFFECTIVENESS

Equal to		
Long Distance		
Shouting 400–500 ft. across a grass field (Original transcontinental line)	1915	C. H. G. Gray (Seacord)
Talking at 70–80 ft.	1920	AT&T tests (Seacord) from Mapes, AT&T
35 ft.	1930	
15 ft.	by 1955	
Local		
Talking at 25 ft.	1930	
10–12 ft.	by 1955	

RANGE

	Date	*Reference*
Experimental Open Wire		
8 miles, one way only, Brantford–Paris, Ont. Double-pole membrane transmitter, iron box receiver	Aug. 1876	Rhodes, p. 35 Pan. of Tel. Prog. p. 7
2 miles, two way, Boston–Cambridgeport	Oct. 1876	Rhodes, p. 37
16 miles, two-way Boston–Salem	Nov. 1876	Rhodes, p. 38
200 miles, Boston–North Conway, N. H.–Salem (loop)	Nov. 1876	Rhodes, p. 39 AIEE, III, p. 76
Over 100 miles, Boston–North Conway, N. H. (direct line)	Dec. 1876	Rhodes, p. 39
First line built for the telephone, Williams office to home, 3 miles	1877	AIEE, III, p. 74
235 miles, Boston–New York	1877	Rhodes, p. 41
3650 miles, New York–San Francisco (Vail, AT & T, to McFarland, Pac. Tel. & Tel.)	1914	BLR, 11, p. 351 BLR, 18, Sept., p. ii
Commercial Open Wire		
2 miles, Boston-Somerville	1877	Rhodes, p. 87
20 miles, Boston–Lowell	1879	Casson, p. 171
45 miles, Boston–Providence	1881*	Tel. in Am., p. 33
235 miles, Boston–New York	1884†	75 Years of Service p. 28 Tel. in Am., p. 75 Early Corp. Dev. Tel., p. 24
900 miles, New York–Chicago	1892	Tel. in Am., pp. 33, 75 BLR, 1, p. 143
2100 miles, New York–Denver	1911	Quarter Cent. Trans. Tel. Serv., p. 7
3650 miles, New York–San Francisco	1915	Tel. in Am., pp. 33, 75 BLR, 1, p. 143
Long Lines		
Over 20 miles, less than 50	1880	AIEE, III, p. 75
Over 50 miles, less than 500	1886	

* 1880, Things Worth Knowing About the Telephone, pp. 31, 62
† 1885, BSTJ, 37, p. 309

	Date	Reference
Cable		
Proposed, Bell	1878	Mon. 313, p. 1
Experimental (per Barton, W. E. Pres.)	ca. 1878	Rhodes, p. 101
Experimental, aerial, Brooklyn Bridge	1879	
Aerial cable,		
7 miles	1880	Rhodes, p. 130
28 miles, Boston–Lowell,	after 1901	Rhodes, p. 133
44 miles, Boston–Worcester	1904	Rhodes, p. 141
Underground cable in wood boxes, Pittsburgh, ¼ mile	1881	Rhodes, p. 107 Tel. in Am., p. 75
Underground cable experimentally plowed in	1882	Ev. Tel. Hist., p. 10
Underground cable		
90 miles, New York–Philadelphia, toll	1906	Rhodes, p. 141
Combined aerial and underground cable		Tel. in Am., p. 38
861 miles, storm-proof, New York–Chicago	1925	BLR, 1, p. 70 Tel. in Am., pp. 76, 33 Ev. Tel. Hist., pp. 33
Underground, transcontinental	1942	Circuits for Victory, p. 13
Submarine Telephone		
1 mile, New York–New Jersey	1883	Rhodes, p. 134
4-½ miles, San Francisco–Oakland	1884	Rhodes, p. 135
England–France	1891	BSTJ, 37, p. 322
First continuously loaded cable, Denmark–Sweden¶	1902	Mon. 703, p. 2
Key West–Havana, first deep-sea telephone cable, continuous iron wire loaded, coaxial construction	1921	Mon. 147, p. 2 Tel. in Am., p. 33 Mon. 1970, pp. 128, 129
First submarine carrier telephone cable, to Catalina Island, 6 channel	1923*	BSTJ, 37, p. 322 Mon. 2434, p. 2
First submarine deep-sea cable carrier, Key West–Havana, 3 circuits (later 7 circuits) coaxial, paragutta insulation, non-loaded	1930†	Mon. 1346, p. 13 Mon. 1970, p. 129
Polyethylene insulation proposed, England¶	before 1939	Mon. 2434, p. 4

¶ Non-Bell System
* 1926, Mon. 222, p. 2
† 1931, BLR, 89, p. 150

RANGE (Cont'd)

	Date	*Reference*
Submarine Telephone (Cont'd)		
First submarine telephone cable repeater developed, BTL	1942	BLR, 20, p. 275
First submarine cable telephone repeaters, Anglesey, Wales–Isle of Man¶	1943	BSTJ, 37, p. 323
First deep-water submarine cable telephone repeaters, Key West–Havana	1950‡	Post-war Achievements, p. 9 Mon. 2045, p. 9 BSTJ, 37, p. 323
Built-in repeaters, Scotland–Scandinavia¶	1954	Mon. 2434, Ev. Tel. Hist., p. 43
Transatlantic telephone cable Completed	1955	Mon. 2434, p. 6
In service	1956	Ev. Tel. Hist., p. 44 Mon. 2434, p. 6
Submarine Telegraph		
Loading		
Continuous wire or tape wound inductance proposed, Krarup¶	1902	BLR, 1, p. 58
First loaded submarine cable in the United States, Love Point–Sandy Point, Maryland	1910	First Loaded Submarine Cable, Cunningham
Bermuda pressure-equalized, continuously permalloy loaded deep-sea type	1923	Mon. 1970, p. 130
New York–Azores, high speed, permalloy loaded, 2640 letters/min	1924	Hist. Firsts, p. 23 Mon. 1970, p. 130 BLR, 20, p. 238
Automatic printing telegraph, 5 channel	1926	Mon. 310, p. 7

VOICE FREQUENCY

Wire (see OUTSIDE PLANT, Wire)

Transposition of Wires

Bell patent, simple twisted pairs	1876	Rhodes, p. 93
Experiments, Barrett	1885	Rhodes, p. 98
Invented, Barrett	1886	BLR, 28, p. 392
Twisted pair cable	1887	Things Worth Knowing, p. 34

¶ Non-Bell System
‡ 1949, Mon. 1815, p. 1

	Date	*Reference*
Patent, Barrett, "ABC System"	1888	Rhodes, p. 93
Induction theory, Carty	1891	Rhodes, p. 98
Standard system (4-arm)	1898	BLR, 27, p. 256
Standardized, Blackwell	1908	BLR, 18, p. 155
Exposed line type	1917	BLR, 18, p. 156

Metallic Circuit

Patented, Bell	1878	Rhodes, p. 92
Experiment, Boston–Providence, Carty	1881	Rhodes, p. 94
First commercial use, Boston–Providence	1881	Rhodes, p. 95
First line of Long Distance Co., predecessor of AT&T Long Lines, New York–Philadelphia, 12 metallic circuits	1886	BLR, 27, p. 255
First metallic circuits in cable	1888	BLR, 3, p. 148
First standard switchboard for metallic circuits	1889	Hist. Inf., W. E.

Phantom Circuit

(A phantom circuit provides 3 voice frequency circuits from 2 pairs of wires)

Artificial line for balancing	1854	BLR, 1, p. 52
Artificial line with capacitance	1862	
Invented, Jacob† (would not balance)	1883*	Rhodes, p. 189
Repeating coil and phantom circuit, Carty	1886	Rhodes, p. 191; BSTJ, 37, p. 311
Inductive artificial line proposed, Spencer	1892	BLR, 1, p. 54
Inductive artificial line built, Pupin†	1899	BLR, 1, p. 55
First field test, Lewiston, Me.–Berlin, N. H.	1902–03	Rhodes, p. 193
Toroidal coils for phantom use	1903	
First regular commercial use (37A Repeating Coil)	1904	
Quadded cable, Dieselhorst† & Martin†, England	1905	Rhodes, p. 195
Phantom group loading, experimental	1907	Mon. 1970, p. 11
First practical phantomed cable, Boston–Neponset	1910	Rhodes, p. 194; Mon. 1970, p. 11
First commercial quadded cable, Philadelphia–Washington	1911	Rhodes, p. 194

* 1882, BSTJ, 37, p. 311

VOICE FREQUENCY (Cont'd)

	Date	*Reference*
4-Wire Circuit		
First long distance tests	1913	BLR, 17, p. 116
First commercial use, Boston–Washington, 13 gauge wires	1915	BLR, 17, p. 117
Field trial, 19 gauge, extra light loading, New York–Reading, Pa.	1919	BLR, 17, p. 119
Medium heavy loading commercial	1922	
Echo suppressor in use	1923	
Extra light loading, commercial use	1925	
New York–Chicago all-cable circuits	1925	BLR, 17, p. 120
Loading		
Theory of frequency distortion and correction, Heaviside¶, England	1887	Mon. 145, p. 4
Proposed, Heaviside¶, England	1887	Rhodes, p. 146
Loading coils proposed, Vaschy¶, France	1889	Rhodes, p. 146
Discussion of impedance matching, Heaviside¶	1893	Mon. 145, p. 5
Continuous, theory, John Stone Stone, based on bimetallic wire cable	1897	Mon. 1970, p. 127
Loading coil spacing rules, Pupin¶ (first) and Campbell, independently	1899	Rhodes, p. 140 Mon. 1970, pp. 3,127
Pupin¶ Patented	1900	BLR, 30, p. 264
Equivalence to uniform inductance, Campbell	1899	
"Experiments have been made", Campbell (air core coils)	1899	Campbell, p. 11
Iron core coils shown preferable, Campbell	1899	
First line, with air-core coils, Jamaica Plain–West Newton, Mass.	1900	Rhodes, p. 140 Mon. 1970, p. 5
Toroidal Coils	1901	Rhodes, p. 140
Iron-wire-core coils in use, New York–Chicago, Warren	1901	Mon. 1970, p. 266 BLR, 30, p. 268

¶ Non-Bell System

	Date	*Reference*
Helical wire loading in use, Elsinore–Helsingborg, Denmark¶	1902	BSTJ, 37, p. 312
First iron-core coils on a cable circuit, New York–Newark	1902	BLR, 30, p. 268 Rhodes, p. 140 An. Report, Eng'g Dept., Am. Bell Tel. Co., 1902
First standard loading systems, exchange cables	1904	Mon. 196, p. 8
First standard loading system, open wire, with No. 501 Loading Coil, Warren	1905*	Mon. 1970, p. 5
Phantom group loading, Experimental Commercial	1907 1910	Mon. 1970, p. 11
Open wire phantom loading	ca. 1910	Mon. 196, p. 16
First commercially successful loading of phantom cable circuits (Campbell–Shaw design), Boston–Neponset, Mass.	1910	Mon. 153, p. 13
First non-loaded transcontinental circuits	in use 1920	Mon. 1970, p. 144
Splice loading (with coils inserted in conductors at splices on regular cable)	ca. 1950	BLR, 29, p. 2
Repeater		
First amplifier, Edison's carbon transmitter¶	1877	Rhodes, pp. 78, 79, 80
Granular carbon, Hunnings¶ (pulverized engine coke)	1878	Rhodes, p. 79
Granular carbon, Edison¶ (hard coal)	1886	Rhodes, p. 81
Carbon button repeater, experimental, Edison¶	before 1890	Private memo, Bowles
Mercury arc amplifier experiments, Cooper Hewitt¶	1902	Private memo, Bowles
Carbon button repeater, Shreeve Field test, Amesbury–Boston	1904	Quarter Cent. Trans. Tel. Serv., p. 11 BLR, 3, p. 33
Audion, De Forest¶	1907	BLR, 3, p. 33
21 Type Repeater	by 1911	Hist. Firsts, p. 29
Mercury arc repeater experiments (Bell System)	1912	BLR, 11, p. 352
Negative voltage on tube grid,' Lowenstein¶	1912	Private memo, Bowles

* 1906, Mon. 1970, p. 6

VOICE FREQUENCY (Cont'd)

	Date	*Reference*
Repeater (Cont'd)		
High vacuum tube†, Arnold (W. E.) and Langmuir¶	1913	Private memo, Bowles
First field trial of vacuum tube repeaters, New York–Philadelphia	1913	Ev. Tel. Hist., p. 19 Tech. Dev., p. 17
22 Type Repeater Invented, Richards	1895	Tel. Repeaters, p. 1296
Field trial, New York–Philadelphia	1914*	Quarter Cent. Trans. Tel. Serv., p. 22 BLR, 20, p. 20
Successful experiments with Shreeve carbon button, Arnold mercury arc, and vacuum tube repeaters on transcontinental line at Brushton, Pa.; Chicago; Omaha; Denver; Salt Lake City; and Winnemucca, Nev.	1914	BLR, 27, p. 6 Private memo, Bowles Trans. Tel. Line, p. 5
Negative feedback proposed, Langmuir¶	1914	Private memo, Bowles
Transcontinental line opened	1915	Quarter Cent. Trans. Tel. Serv., p. 23 Trans. Tel. Line, p. 1
Floor type repeater	1917	BLR, 27, p. 6
Reading type, New York–Pittsburgh	1920	
Type B Repeater	ca. 1921	Darrow
Voice operated repeater Experimental	1921	Darrow
44 Type Repeater (4 wire) In use	1926	Mon. 196, p. 32
Negative feedback perfected, Black	1927	Black, 6/3/59
Cord circuit repeater	before 1932	Mon. 674, p. 3
Pad controlled cord circuit repeater In use	1932	Mon. 674, p. 4
V1 Repeater	new 1941	BLR, 20, p. 20 BLR, 27, p. 6
E1 Repeater (local)	1948	Mon. 2320, p. 1
V3 Repeater	ca. 1948	BLR, 27, p. 6
Diamond amplifier (experimental)	1948	BLR, 26, p. 127

† See also APPARATUS, Vacuum Tube
¶ Non-Bell System
* 22A1 Repeater, 1923, BLR, 27, p. 6

	Date	*Reference*
Magnetic amplifier		
Available	1949	Mon. 1839, p. 1
Pole-mounted, for N1 Carrier		
In use	1953	BLR, 31, p. 397
Balancing		
Artificial line for balancing¶	1854	BLR, 1, p. 52
Artificial line with capacitance¶	1862	
Inductive artificial line proposed, Spencer	1892	BLR, 1, p. 54
Inductive artificial line built, Pupin¶	1899	BLR, 1, p. 55
Shielding to stabilize balanced circuit,		
Published, Campbell	1904	Campbell, p. 40
Networks, Hoyt		
Field trial	1912	BLR, 23, p. 413
Used in transcontinental line	1915	Hist. Firsts, p. 30
Far end crosstalk balancing, Chapman (made K carrier possible)	1922	BLR, 28, p. 218
First installation, Toledo–South Bend, K carrier	1937	BLR, 27, p. 141
Echo Suppressor (see APPARATUS, Echo Suppressor)		
Equalizer		
311A, to equalize transmission in subscribers' loops, new	1949	BLR, 29, p. 415
Filter		
Ladder type,		
Invented, Campbell	1915	BSTJ, 37, p. 314
Patented, Campbell	1917	BLR, 21, p. 445
First use, transcontinental line	1915	Mon. 976, p. 7
Crystal		
Elementary concept, Nicolson	1917	
Specific concept, Espenschied	early 1920's	BLR, 22, p. 504
Theory, Campbell	1922	Mon. 1867, p. 10 Mon. 103, p. 1 Campbell, p. 190
Lattice type, Campbell	1922	Campbell, p. 190 Mon. 1867, p. 10
Use of waveguides for filters, proposed, Carson	1924	Mon. 921, p. 2
Crystal		
Experimental, ladder type, Espenschied	1926	BLR, 22, p. 504
Lattice type, Mason	1929	Mon. 976, p. 11

VOICE FREQUENCY (Cont'd)

	Date	*Reference*
Filter (Cont'd)		
In use	1930	BLR, 22, p. 504
General theory	1934	Mon. 843, p. 1
Coaxial and balanced transmission lines as filters and transformers at high frequencies, theory, Mason and Sykes	1937	Mon. 1003, p. 1
In use, Provincetown–Green Harbor	by 1937	
Ferrites		
Material available	1945	Mon. 2224, p. 1
Waveguide filter for microwaves	ca. 1948	BLR, 29, p. 164
Active (experimental)	1953	Mon. 2221, p. 1
Plug-in type		
In use	1955	
Reversible (reversing interchanges bands)		BLR, 33, p. 137
In use	1955	

CARRIER

Carrier on Open Wire		
Carrier telephone circuit invented, Hutin[1] and Leblanc[1], France	1891	Carrier Current Tel. & Tel., p. 6 BSTJ, 37, p. 314
Experiments, Hayes and Stone (Bell System)	1892–94	Carrier Current Tel. & Tel., p. 8 Espenschied, MM-54-122-3
Modulation of a carrier wave, Hayes, Cram, and Thompson Patented	1897	Espenschied memo on E. R. Cram, in Museum records
First vacuum tube carrier experiment, Heising	1914	Espenschied, MM-54-122-3 BLR, 1, p. 154
Single sideband transmission proposed, Carson	1915	BLR, 31, p. 148 Mon. 1616, p. 1
Field trial, Maumee, O.–South Bend, Ind.	1917	BLR, 1, p. 154 BSTJ, 37, p. 314
Single sideband standard	ca. 1918	Mon. 1616, p. 1
Balancing out unwanted sideband, Hartley	1928	Mon. 1616, p. 3

[1] Non-Bell System

	Date	*Reference*
Type A		
First line, Pittsburgh–Baltimore 5–25 kc, open wire, 4 channel and voice frequency, carrier and one sideband suppressed, balanced 2-wire	1918	BSTJ, 37, p. 314 Mon. 1616, p. 1 BLR, 1, pp. 156, 189
Telegraph, first commercial, Pittsburgh–Harrisburg (see Telegraph)	1919*	BLR, 26, p. 58
Type B		
First line, Harrisburg–Detroit, 6–21 kc, 3 channel and voice frequency, different frequencies in the two directions, carrier transmitted	1920	BLR, 1, pp. 157, 190 BLR, 16, p. 208
Voice frequency carrier telegraph on telephone line, New York–Pittsburgh	1923	BLR, 1, p. 190
Special Power Line Carrier Telephone Equipment, first installation 50–150 kc, 1 channel, small use (Georgia Railway & Power Co., Anniston, Ga.)	1924	BLR, 7, p. 451 Mon. 116, p. 24
Type C		
First installation, Pittsburgh–St. Louis, 5–30 kc, 3 channel and voice frequency, single sideband, carrier suppressed. Widely used (about 600 installed)	1925**	BLR, 1, p. 159
Type D (Short Haul, 50–200 miles)		BLR, 6, p. 353
Amarillo–Borger, Texas In use 3–10.3 kc, 1 channel and voice frequency; widely used; separate frequencies for two ways; carrier suppressed. Replaced by Type H	1926†	Mon. 359, p. 32

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* 1918, Mon. 1220, p. 1

** 1924, BLR, 18, p. 354

† "First installation," Watertown-Syracuse, N. Y., 1927, BLR, 16, p. 209

CARRIER (Cont'd)

	Date	*Reference*
Carrier on Open Wire (Cont'd)		
Type E (Power Line Carrier Telephone Equipment), First experimental installation on Pacific Gas & Electric Co. lines, 50–150 kc, 1 channel, voice frequency switching, same frequency in both directions (little used)	1928	BLR, 10, p. 350
Type F (also known as CF) Single channel with Type C equipment		BLR, 16, p. 210
Type G (very short haul, 25 miles) 1 channel plus voice frequency, 6.5–14.1 kc	1936	BLR, 14, p. 393 BLR, 16, p. 210
First to use copper oxide rectifiers for modulation and demodulation.		
Type H (short haul, 50–200 miles) 1 channel; upper sideband one way, lower the other; carrier suppressed; repeatered	ca. 1936	Mon. 1007, p. 1 BLR, 16, p. 77
Replaced Type D Extensively used (about 4,000 installed)	ca. 1937	BLR, 16, p. 210
Type J First use, Dallas–San Antonio, 36–142 kc, 12 channel, single sideband, carrier suppressed Can be added above some earlier type such as C	1938	BLR, 16, p. 211
Type M (Power Line Carrier Telephone Equipment) (Also used for regular carrier) 155–420 kc, 5 channel		
Trial, Hutchinson, Kansas	1945	BLR, 25, p. 363
First public (customer) trial, Jonesboro, Ark.	1945	BLR, 25, p. 364 BLR, 24, p. 72
Field test (regular carrier), Appleton–Manitowoc, Wis.	1947	BLR, 25, p. 348
Type O* 16 channel, single sideband, plug-in units		BLR, 32, p. 215

* OAI, OBI, OCI, ODI are 4-channel segments of Type O

	Date	*Reference*
First commercial use, Richwood–Sutton, West Virginia	1952	BLR, 30, p. 252
Type P		
First field trial, Americus, Ga. For farmer lines. Battery powered transistorized repeaters and terminals on poles; 12–96 kc, 4 channel	1954	BTL Press Rel., 3/11/54 BLR, 32, p. 158 Berger, 6/4/59
Carrier on Cable		
Experimental, Morristown, N. J.	1933	Mon. 738, p. 1
Type K		
First installation, Toledo–South Bend	1937†	BLR, 27, p. 141 Mon. 1055, p. 1 Mon. 1307, p. 3 BLR, 20, p. 277
12–60 kc, 12-channel, non-loaded, separate or group-shielded cables for two directions, varistor modulation and demodulation, no voice frequency, negative feedback stabilization, crystal filters		
Field trial, N. Y.–Boston Commercial use	1941 1946	BLR, 26, p. 377
Type N		
Trial installation, Madison–Milwaukee, Wis.	by 1950	N&I Rel., 11/3/50
First commercial installation, Harrisburg–Sunbury, Pa.	1950	N&I Rel., 11/3/50
Inexpensive short-haul cable carrier (20–200 miles), 44–140 and 164–260 kc, 12 channels on 2 pairs in same cable, double sideband, compandor		BLR, 30, p. 277
Type ON		
(O type signals on N type equipment)		
Available	1953	Mon. 2296, p. 1
Type ON/K		
Development	1954	Case 36801

† 1938, BLR, 16, p. 212

CARRIER (Cont'd)

	Date	*Reference*
Carrier on Coaxial Cable		
Coaxial construction known	ca. 1850	BLR, 13, p. 323
Studied by Lord Kelvin¶, Russell¶ and others		
Studies initiated by Espenschied and Affel	1920	BLR, 13, p. 323
Experimental	1926	
Espenschied and Affel		
Coaxial cable, Espenschied and Affel		
Patent application	1929	Hist. Firsts, p. 33
Theory of low frequency coaxial cables, Carson	by 1929	BLR, 13, p. 324
Tests, Phoenixville, Pa.	1929	BLR, 13, p. 324
Used for short wave radio connections	1932	BLR, 11, p. 117
Practical theory, Schelkunoff	1934	Mon. 831, p. 1
Field trial, New York–Phila.	1936	BSTJ, 37, p. 315
(also Berlin–Leipzig, Germany¶)	1936	BLR, 20, August, p. v
Commercial use, New York–Philadelphia	1941	
Type L1		
New York-Princeton tests	1939	BLR, 17, Nov., p. ii
First commercial installation Minneapolis–Stevens Point, Wis.	1941	BLR, 19, Nov., p. iii
Emergency use before completion	1940	BLR, 19, April, p. iv
64–2064 kc, 480 (later 600) channels, separate coaxials in two directions		
Large coaxial conductor (0.375 inch)		
"In place", Fort Worth–Dallas	1946	BLR, 24, p. 394
Type L3		
Experimental installation, New York–Philadelphia	1952	Mon. 2090, p. 807 BSTJ, 37, p. 317
First commercial installation Newark–Philadelphia	1953	Inf. Bull., 3/19/53 BLR, 31, p. 147
New York–Chicago	1954	BLR, 32, p. 478
1860 channels per pair of conductors		

WAVEGUIDES

	Date	*Reference*
Waveguide, theory, Lord Rayleigh¶, England	1897	Mon. 921, p. 1
Dielectric wire, Hondros¶ and Debye¶	1910	
Experiments started	1920	BLR, 14, p. 285
Use of hollow pipes suggested, Hartley	1931	Mon. 921, p. 2
Devised by Southworth	1931	Mon. 921, p. 2
Waveguide experiments successful, Southworth (first public announcement)	1936	Mon. 927, p. 1
Circular waveguide		
Theory	1954	Mon. 2344, p. 1
Experimental	1955	BLR, 33, p. 113
Helical waveguide	1955	BLR, 33, p. 113

RADIO (see also APPARATUS)

General

First transmission, Henry¶	1842	Sci. Am. 7/54, p. 76
Radio transmission, Hertz¶, Germany	1887*	Brief Chron., HM16068 Circuits for Victory p. 15
First radio telegraph transmission, Marconi¶, Italy	1895	Mon. 2026, p. 3 Brief Chron., HM16068
Millimeter waves, Lebedev¶, Russia	1895	Mon. 1799, p. 2
First transatlantic radio telegraph transmission, Marconi¶, Italy	1901	Mon. 1346, p. 6 Tel. Almanac, 1956 Mon. 2434, p. 1
Early radio telephone experiments, Fessenden¶, DeForest¶, Majorana¶, Vanni¶, Poulsen¶, etc.		BSTJ, 37, p. 319
Commercial transatlantic radio telegraph	1908	Mon. 2434, p. 1

¶ Non-Bell System
* 1888, Career of A. C. Bell, p. 21; 1887-91, BLR, 28, p. 129

RADIO (Cont'd)

	Date	*Reference*
General (Cont'd)		
First 2-way air-ground radio telegraphy	1914	Release of 9256th Air Reserve Squadron, 1004 Broad St., Newark 2, N. J., ca. 6/28/57
Experimental radio telephone system, Bell System	ca. 1914	Mon. 1021, p. 6
First radio telephone circuit, Montauk–Wilmington, Del.	1915	Mon. 1255, p. 2
First transatlantic radio telephone transmission, Arlington, Va.–Paris	1915	Mon. 1346, p. 6 Tel. in Am., p. 41
Single sideband theory, Carson	by 1915	Mon. 1616, p. 1
First radio telephone on a battleship	1916	Circuits for Victory, p. 17
First ship-to-ship radio telephone	1917	Ev. Tel. Hist., p. 21
First aircraft radio telephone	1917	BLR, 15, p. 398 W. E. Co. Untechnical Talks–E10
Radio reflection system, basis of radio altimeters and radar, Espenschied	1919	Mon. 872, p. 22
First commercial radio telephone link, to Catalina Island	1920	Tel. in Am. pp. 33, 75 Avalon–LA, pp. 1, 4
First single sideband radio transmission, Espenschied	about 1922	Mon. 1616, p. 1
Public demonstration	1923	
Discovery that fading is due to interference from multiple paths, Bown, Martin, and Potter	1925	Mon. 166, p. 1
Discovery of radio shadows of steel frame buildings, Bown, Martin, and Potter	1925	Mon. 166, p. 1
First two-way conversation across the Atlantic	1926	Mon. 1255, p. 3 BLR, 29, p. 135
First commercial long-wave transatlantic radio telephone circuit, 60 kc (transmitter, Rocky Point; receiver, Houlton, Me.)	1927	Mon. 1255, p. 3 Transoceanic Tel. Serv., p. 3

	Date	*Reference*
Theory of common-frequency broadcasting	1927	Mon. 249, p. 1
One way (west to east) experimental short-wave transatlantic radio telephone (from Deal)	1927	BLR, 6, p. 405 BLR, 7, p. 484
First commercial short-wave transatlantic radio telephone circuit (Lawrenceville transmitter, Netcong receiver)	1928*	Mon. 2434, p. 1 Transoceanic Tel. Serv., pp. 4, 5
Double sideband shortwave transatlantic transmission	up to 1934	Mon. 872, p. 3
Single sideband shortwave transatlantic transmission	1933	
Short-haul Links		
Catalina Island, first commercial radio link in the Bell System, 638 and 750 kc		
Installed	1920	Avalon–LA, p. 1
Privacy system added	by 1923	BSTJ, 37, p. 322 Mon. 2434, p. 2 HM2599
Microwave radio telephone across English channel, Clavier† and others	1934	BSTJ, 37, p. 322
Provincetown–Green Harbor 60 mc, unattended radio link	1934	Mon. 873, p. 10 BLR, 28, p. 102
Crisfield, Md.–Smith Island, Md.–Tangier Island, Va., Installed	1941	BLR, 19, No. 8, p. ii
160 mc, (12-channel carrier)		
Catalina Island		
First commercial multi-channel UHF microwave radio telephone system	1946	Ev. Tel. Hist., p. 34
Mt. Wilson–Hollywood		
TE-1 television transmission equipment	1946	Mon. 1461, p. 6 BLR, 24, p. 382
Akron, Col.–Anton, Colo.		
Experimental	1949	A.T.T., O.&E., Radio Notes, 7/7/49
150 mc		
Installed instead of pole line on economic basis		

* 1929, BLR, 7, pp. 435, 484
† Non-Bell System

RADIO (Cont'd)

	Date	*Reference*
Short-haul Links (Cont'd)		
Akron, Col.–Anton, Colo. (Cont'd)		
Previous short-haul links had bridged bodies of water		
Over-the-horizon microwave radio link, U. S.–Cuba		
Experimental	1950	Mon. 2060, p. 1
First commercial	1957	BSTJ, 37, p. 320
Special Services		
Ship-to-shore		
Experimental	1917	BSTJ, 37, p. 21
Experimental, Deal and Green Harbor to S.S. Ontario	1920	Radio Extension, p. 8
First commercial installation, S.S. *Leviathan*	1929	Mon. 1255, p. 5 BSTJ, 37, p. 320 BLR, 8, p. 204
Coastal and Harbor		
First transmission during World War I	1916	Ev. Tel. Hist., p. 21
New York fireboat	1930	BLR, 9, p. 139
Coast Guard	1932	BLR, 19, p. 4
Green Harbor (commercial)	1932	BLR, 11, p. 64
Aircraft		
First transmission (U. S. Army, using Bell System equipment)	1917	BLR, 11, p. 21
Mobile (Automobile)		
Police		
Radio telegraph, New York, KUVS, first installation	1916	Mon. 751, p. 1
Experimental	1921	
New York Police Department system, WLAW, first installation	1924	
UHF, Newark	1935	BLR, 14, p. 66
Private and commercial service, First use, St. Louis 40 and 150 mc	1946	BSTJ, 37, p. 320 75 Years of Service, p. 28
Emergency		
Florida hurricane Airplane type, Key West–Havana	1935	Bell Tel. Mag., 21, p. 228

	Date	*Reference*
New England hurricane		
Ship type, Gardner, Mass.–Keene, N. H.	1938	Bell Tel. Mag., 21, p. 229
Police type, also		
Standard Emergency Radio Unit		
Available	1938	Bell Tel. Mag., 21, p. 230
In use	1940	
Emergency Announcement		
Air raid alert, etc.		
In use	1953	Mon. 2213, p. 4
Rural		
Cheyenne Wells installation		
100 mc	1946	Mon. 1476, p. 1 BLR, 26, p. 49
Broadcasting		
2XB, Bell Laboratories, experimental*	1919	BLR, 26, p. 420
WEAF	ca. 1922	
Broadcasting started by Bell System, WEAF	1922	
Crystal-controlled broadcasting, WEAF	1924	
Network broadcasting started (commercial)	1923†	Mon. 456, p. 1
First radio program sent by telephone, New York–Boston	1923	Magic of Comm., p. 40 (1952)
Railroad		
Patent, Smith¶	1881	Ev. Tel. Hist., p. 10
Experiments by Consolidated Railway Telegraph Co., of New York		
Telegraph	1885	
Telephone	ca. 1885	
H1 Carrier, trial installation	by 1938	BLR, 16, p. 222
Radio link, first commercial link, New York–Washington (Penn. and B.&O. railroads)	1947	Mon. 1607, p. 1 BLR, 30, p. 269

* Some confusion has existed about 2XB, 2XY, WEAF, WBAY. 2XB appears to have been the original, and later experimental, designation of WEAF at Bell Laboratories, see above. 2XY appears to have been the original or experimental designation of WBAY at 32 Sixth Avenue (24 Walker St.), N. Y., (see Monos. C8, B38, 213, 230)

† 1922, Things Worth Knowing, p. 49

¶ Non-Bell System

RADIO (Cont'd)

	Date	Reference
Microwave		
Pre-World War II		
Waveguide experiments, Started	1920	BLR, 14, p. 285
Waveguide devised, Southworth	1931	Mon. 921, p. 2
Studies of generation and control, Southworth	1930–34	
System across English Channel, Clavier[†] and others	1934	BSTJ, 37, p. 322
First public announcement, Southworth	1936	Mon. 927, p. 1
World War II		
See Military		
AN/TRC-6		
Experimental public demonstration	1945	
Used in Catalina Island link, First commercial multi-channel UHF radio telephone system	1946	Ev. Tel. Hist., p. 34
TE		
First commercial use, Baltimore–Washington	1946	
TDX		
New York–Boston		
Trial	1947	Mon. 1880, p. 1 BSTJ, 37, p. 322
First commercial use	1948	Mon. 1880, p. 1
TD2	1950*	BLR, 28, p. 442
New York–Chicago 4,000 mc frequency		
Transcontinental	1951	Mon. 1880, p. 1 BLR, 29, p. 427
TH Radio Relay System, in 6,000 mc band, under developemnt	1954	Case 35460
TJ Radio Relay System, in 11,000 mc band, under development	1955	BLR, 33, p. 401

SPECIAL WIRE SERVICES

Time of Day		
Operator	1920–25	BLR, 33, p. 364
Sound on film	after 1925	
Magnetic recording on rubber tape		
Available	1955	

† Non-Bell System
* 1949, WE, VII, No. 5, p. 15

	Date	*Reference*
Call Announcer		
Available	ca. 1930	Mon. 2213, p. 1
Weather Forecast		
Introduced	1939	Mon. 2213, p. 1
Delay Quote		
In use	1953	Mon. 2213, p. 4
Recorded Intercept		
(Error in dialing, etc.)	before 1951	Mon. 2213, p. 3
Emergency Announcement		
(Air raid alert, etc.)		
In use	1953	Mon. 2213, p. 4
Telemobile		
(Mobile public telephones in bus or trailer)		
In use	1943	Bell Tel. Mag., 22, p. 29
Program Transmission (see also SPECIAL SERVICES, Broadcasting)		
Broadcasting		
For radio broadcasting	1922	Mon. 419, p. 2
First network (Red Network, NBC)	before 1929	
Television (see also BY-PRODUCTS,)		
Selenium discovered	early 19th Cent.	Mon. 2363, p. 11
Photoconductive properties of selenium discovered, Smith†, England	1873	
Scanning disc		
Invented, Nipkow†	ca. 1880	Mon. 2363, p. 1
Plotnow	1884	Mon. 274, I, p. 6
Photoelectric effect discovered, Hertz†, Germany	1887	Mon. 2363, p. 12
Cathode ray tube		
Proposed, Hess†, France	1894	Mon. 639, p. 6
First tube, Braun†, Germany	1897	
Photocells available	ca. 1900	Mon. 2363, p. 12
Cathode ray tube television receiver, Dieckmann†, Germany	1906	Mon. 2363, p. 1
Mosaic photoelectric camera tube proposed, Swinton†, England	1911	Mon. 2363, p. 3
Secondary emission, Hull†		
Patent application	1915	Mon. 2363, p. 12

† Non-Bell System

SPECIAL WIRE SERVICES (Cont'd)

	Date	*Reference*
Program Transmission (Cont'd)		
Television (Cont'd)		
Secondary emission tube, Nicolson		
Patent application	1915	Guenther
Flying spot scanner proposed, Zworykin¶		
Patent application	1923	Mon. 2363, p. 5
Storage camera tube, Zworykin¶		
Patent application	1923	Mon. 2363, p. 8
First all-electronic television experiment, Zworykin¶	1924	Mon. 2363, p. 3
BTL laboratory tests produce recognizable picture (with detail)	1925	BLR, 30, p. 179
Laboratory demonstration, BTL	1926	BLR, 30, p. 180
First public demonstration, Baird¶, England	1926	Ev. Tel. Hist., p. 26
First public demonstration of telephone transmission of television, New York–Washington, BTL (Ives)	1927	Mon. 2363, p. 13
Dissector camera tube, Farnsworth¶		
Patent application	1927	Mon. 2363, p. 7
Complete tube	1934	
Continuous projector with rotating mirrors	by 1928	Mon. 2363, p. 12
First out-of-door demonstration, BTL	1928	BLR, 6, p. 402
First color demonstration, Baird¶, England	1928	BLR, 30, p. 288
First by Bell System	1929	Tel. in Am., p. 60 BLR, 7, p. 439
First two-way demonstration, BTL	1930	Tel. in Am., pp. 60, 76 BLR, 8, p. 398
Flying spot scanner transmitter, von Ardenne¶	1931	Mon. 2363, p. 4
Early iconoscope¶	1934	Mon. 2363, p. 8
First commercial television service, New York–Philadelphia, 240 lines	1937	Mon. 2363, p. 13 BLR, 30, p. 182
Image iconoscope¶	1939	Mon. 2363, p. 9
Orthicon¶	1939	Mon. 2363, p. 10
Coaxial line television service with 441 lines	1940	Mon. 2363, p. 13

¶ Non-Bell System

	Date	*Reference*
Fast-decaying phosphors¶ (less than 1 microsecond)	1940	Mon. 2363, p. 6
Television standards adopted and effective, 525 lines	1941	Mon. 2363, p. 13
Image orthicon¶	1946	Mon. 2363, p. 11
Experimental commercial microwave radio transmission, New York—Washington	1946*	Mon. 2045, p. 14
Mt. Wilson–Hollywood	1946†	BLR, 24, p. 382
Microwave relay television	1947	Mon. 2363, p. 14
Commercial network television	1948	
First coast-to-coast service, commercial	1951	
Picture Phone experiment	1956	Ev. Tel. Hist., p. 44
Industrial low-quality telephone line television system	1957	Ev. Tel. Hist., p. 45

Municipal Emergency

Reporting system, fire and police	1955	BLR, 33, p. 359

Picture Transmission (telephotography)

First practical light valve, Wente	1922	Mon. 675, p. 2
Single ribbon light valve, commercial	1924	
First demonstration, New York–Cleveland	1924	Ev. Tel. Hist., p. 24
Commercial service, New York–Chicago–San Francisco, 4-½ x 6-½ inches	1925	Mon. 961, p. 1
11 x 17 inches	1936	

Teletype (see Telegraph)

Experimental, first Bell System	ca. 1909	Mon. 422, p. 3
Commercial use in United States	1917	Ev. Tel. Hist., p. 20
First Switchboard	1931	Tel. in Am., p. 59; BLR, 10, p. 145
No. 1 Teletypewriter Switchboard	ca. 1931	BLR, 15, p. 7
Automatic switching	1940**	BLR, 19, July, p. v
High speed	1944	BLR, 22, p. 521
Aircraft use	1946	BLR, 24, p. 396
Reperforator-transmitter for teletype relay	ca. 1948	BLR, 26, p. 106

Answering Service (see STATION PLANT, Answering Set)

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* 1948, BLR, 32, p. 81
† 1947, BLR, 30, p. 182
** 1941, BLR, 26, p. 20

PULSE TRANSMISSION

	Date	*Reference*
Ordinary simplex telegraph		
Conceived by Morse¶	1832*	
Built, Morse¶, Baltimore–Washington	1844	BLR, 1, p. 51
Time division multiplex telegraph		
Farmer¶	1852	
Variable pulse		
Used in picture transmission and TV, one pulse per picture line, varying as signal amplitude	1927	
Pulse position modulation (PPM)		
(also called pulse time modulation) available	1946	Mon. 1491, p. 1, 5
Signal sampled at fixed intervals		
Pulse width constant, time of start of pulse varies with amplitude of signal sample		
Catalina Island link		
Nantucket link		
Pulse amplitude modulation (PAM)		
Signal sampled at fixed intervals		
Pulse amplitude varies as signal amplitude		
Used in TASI (Time Assignment Speech Interpolation)		
Experimental	1957	Test, Bell Tel. Labs.
Pulse width modulation (PWM)		
[also called pulse duration modulation (PDM) and pulse length modulation (PLM)]		
Signal sampled at fixed intervals		
Pulse width (or length) varies with amplitude of signal sample		
Pulse code modulation (PCM)		
Signal sampled at fixed intervals		

¶ Non-Bell System
* 1824, Mon. C4, p. 6; 1836, Mon. 2026, p. 3

	Date	*Reference*
Pulse amplitude is constant, signal amplitude is represented by coded series of pulses		
Eliminates interference of less than half signal strength		
Invented, Reeves,¶ I.T. and T. Co.	1939	BSTJ, 37, p. 319
First public demonstration (put in use), Goodall type	1947	BLR, 29, p. 209

MEASUREMENT

Mile of standard cable		
19 gauge AWG, 0.054 mf/loop mile		
First use	before 1904	Mon. C13, p. 1
Reference standard	until 1929	Mon. 404, p. 3
TU (Transmission Unit)	1924	Mon. 93, p. 1
(24 TU = 24 miles of standard cable)		
First transmission measuring set	before 1924	Mon. 93, p. 4
Articulation test		
In use	1924	Mon. 108, p. 7
Reference system, condenser transmitter, moving coil receiver, high quality lines, standard for Bell System and C.C.I. in Europe		
First adopted with preliminary system	1926	Mon. 404, p. 23
Standard	1928	Mon. 598, p. 7
	General	
Two-wire circuit theory, Hughes¶	1886	AIEE, III, p. 80
Probability theory for irregularities, Mills	1912	Mon. 164, p. 1
Communication theory		
Early studies		
Nyquist	1924	Mon. 1598, p. 1
Hartley	1928	
General theory, Shannon	1948	
Balancing		see Voice Frequency
Echo Suppressor		
Equalizer		
Filter		
Loading		
Repeater		

TELEGRAPH

(See also THE BACKGROUND OF THE INVENTION OF THE TELEPHONE, Early Electric Telegraph)

	Date	*Reference*
Local private line[¶]	1873	BLR, 23, p. 373
Printing telegraph, Gray[¶]	before 1879	Mon. 422, p. 3
First inter-city private line[¶] New York–Philadelphia, New York–Boston	ca. 1879	BLR, 23, p. 373
Composite (simultaneous telephony and telegraphy)		
First practical demonstration, Van Rysselberghe[¶], Belgium	1882	Brief Chronology, p. 24 Ev. Tel. Hist., p. 10
Combined private line telephone and telegraph, New York–Philadelphia	1887	Teleg. Dev., p. 1 BLR, 23, p. 375 Tech. Dev., p. 11
Simplex (2-wire phantom circuit with ground return), New York–Philadelphia	1887*	Teleg. Dev., p. 1 BLR, 23, p. 375 Tech. Dev., p. 11
Simplex		
Retardation coil type	1888	Teleg. Dev., p. 3
Repeating coil type	ca. 1900	
Private network telegraph	ca. 1890	Mon. 958, p. 1
Composite (Combined telephone and telegraph circuit, frequency separated)		
First use, emergency (Bell System)	1891	BLR, 23, p. 421
Regular service (Bell System)	1892	BLR, 23, p. 421 Mon. 1456, p. 3
Standardized (Bell System)	1896	BLR, 23, p. 420
Single line neutral (voltage on or off) repeater		
Commercial types purchased	1892	Teleg. Dev., p. 5
Bell System repeaters	1893	
Duplex (simultaneous sending in both directions on one line)		
Experiments	1900	Teleg. Dev., p. 5

¶ Non-Bell System

* 1888, BLR, 23, p. 420; note also "Simplex, Retardation coil type"

	Date	*Reference*
Composite ringer (to pass telephone signals over composited circuits)		
First use, 135 cycle, commercial	1902	Teleg. Dev., p. 4 BLR, 23, p. 422
With coil	1907	Memo, Shanck, 11/14/23
Time division multiplex, Miner¶	1903	Espenschied, MM-54-122-3
1-A Repeater (Athearn)	1904	Teleg. Dev., p. 5
Bridge polar duplex (polar transmission uses voltage plus and minus, not just on and off)	1904	Teleg. Dev., pp. 5, 6
Duplex composite	1904	Teleg. Dev., p. 5
Neutral (voltage on or off) operation	to 1904	Teleg. Dev., p. 4
Resonant shunt to reduce interference	1905	Teleg. Dev., p. 8
Neutralizing transformers to reduce interference	1905	Teleg. Dev., p. 8
Telegraph printer, Creed¶	ca. 1908	Mon. B1, p. 7
First Bell System Teletypewriter system, experimental	ca. 1909	Mon. 422, p. 3
Multiplex with tape transmission and page printing, Murray¶	ca. 1910	Mon. B1, p. 34
Ground potential compensator (to equalize for ground voltages at the two ends of a line)	1913	Teleg. Dev., p. 7
Carrier		
Experimental	1914	BLR, 26, p. 58
First commercial installation (high frequency, 3000–11,000 cycles), Pittsburgh–Harrisburg	1918*	Mon. 1220, p. 1
"Start-stop" printing (Teletype) system	1915	Teleg. Dev., p. 15
Commercial Teletypewriter service in United States		
First long-line private wire multi-station TWX circuit, start-stop page printing, Boston–New York	1917	Ev. Tel. Hist., p. 20
Nation-wide service available	1931	Mon. 958, p. 1 Teleg. Dev., p. 14

* 1919, BLR, 26, p. 58; 1920, Teleg. Dev., p. 10

	Date	*Reference*
Metallic circuit		
Start of commercial use, 2-wire	1919	Teleg. Dev., p. 1
Polar duplex	ca. 1923	Mon. 1970, p. 33 Mon. B6, p. 1
Composite in cables	1923	Teleg. Dev., p. 4
4-wire	1927†	BLR, 25, p. 271
1-way transmission, grounded circuit, polar	1919	BLR, 25, p. 372 Teleg. Dev., p. 6
Voice frequency telegraph		
Development started	1920	BLR, 26, p. 59
First commercial cable use, New York–Pittsburgh	1923	Mon. 1220, p. 1
Superseded high-frequency carrier	1930	BLR, 26, p. 59
Moving type, stationary paper page printer (No. 10A)	1921	Mon. 1456, p. 5
Carrier on submarine cable, Key West–Havana	1921	Teleg. Dev., p. 10
Single line polar repeater		
Started	1925	BLR, 25, p. 374
Available	1926	Teleg. Dev., p. 6
In service	1927	Teleg. Dev., p. 5
Rack-mounted	1928	Teleg. Dev., p. 6
Metallic circuit rack-mounted repeater	1925	Teleg. Dev., p. 9
Regenerative repeater for Teletypewriter	1925	Teleg. Dev., p. 16
Differential duplex (on grounded circuit)	1927	Teleg. Dev., p. 5 BLR, 25, p. 370
Telegraph on Type C Carrier, 4-wire metallic voice frequency	1928	Teleg. Dev., p. 13
TWX exchange service		
Available	1929	Mon. 422, p. 20
First use	1931	Mon. 2045, p. 13
Combination differential duplex and 2-path 1-way polar	1930	Teleg. Dev., p. 6
Level compensator	1931	Teleg. Dev., p. 12
First Teletypewriter switchboard	1931	Tel. in Am., p. 59 BLR, 10, p. 145
No. 1 Teletypewriter Switchboard	ca. 1931	BLR, 15, p. 7
Teletypesetter		
First use, Newburgh, N. Y.	1932	BLR, 31, p. 183
Drainage coils for protectors, trials	1933	Teleg. Dev., p. 11

† 1924, Teleg. Dev., p. 9

	Date	*Reference*
Repeater for "split-loop" operation	1933	Teleg. Dev., p. 7
Repeater for modified duplex or 2-path polar, trial	1934	Teleg. Dev., p. 7
Automatic Teletypewriter switching	1940*	BLR, 33, p. 321 BLR, 19, March, p. v
First fully automatic TWX switching system, Republic Steel Corp.	1941	Mon. 1837, p. 1
High-speed Teletype	1944	BLR, 22, p. 521
Aircraft use	1946	BLR, 24, p. 396
Reperforator-transmitter for Teletype relay	ca. 1948	BLR, 26, p. 106
Superspeed Teletypewriter In use, New York–Boston	1954	BLR, 32, p. 307
First semi-automatic Teletypewriter relay system, Portland, Ore.	1955	BLR, 33, p. 438
Magnetic tape machine for high-speed Teletype, 1000 words per minute	1957	Ev. Tel. Hist., p. 45

* 1941, BLR, 26, p. 20

CIRCUITS

GENERAL

	Date	*Reference*
Vacuum tube diode voltmeter circuit, Edison[¶]		
Patent application	1883	U. S. pat. 301, 371
Patent issued	1884	
Vacuum tube diode radio detector circuit, Fleming[¶], England	1904	Collier's Enc., 7, p. 209 Private memo, Bowles
Three element vacuum tube (Audion), DeForest[¶]		
Control element outside envelope		
Patent application	1906	U. S. pat. 841,387
Patent issued	1907	
Control element on opposite side of cathode from plate		
Patent application	1906	U. S. pat. 841,387
Patent issued	1907	
Control element between cathode and plate		
Patent application	1907	U. S. pat. 879,532
Patent issued	1908	
Theory of networks, Campbell	by 1911	Mon. 1867, p. 10
Negative voltage on vacuum tube grid, Lowenstein[¶]	1912	Private memo, Bowles U. S. pat. 1,231,764
First radio frequency vacuum tube voltmeter, Heising		
Patent application	1915	Hist. Firsts, p. 35
"Master-oscillator" transmitter (modulation at low level, then amplified), Arnold and Van der Bijl		
Used	1915	BLR, 27, p. 24
Theory of anti-sidetone circuits, Campbell	by 1920	Mon. 1867, p. 10
Automatic gain control	1923	BLR, 28, p. 98
Automatic frequency control	after 1923	
Single sideband, carrier eliminated, first public demonstration, Carson	1923	Mon. 131, p. 1

¶ Non-Bell System

	Date	*Reference*
Crystal frequency control, Marrison	1924	Ev. Tel. Hist., p. 25
Negative feed-back perfected, Black	1927	Black
Single-sideband transmission		
Tests (transatlantic radio)	1934	BLR, 18, p. 84
In use	1939	
Doherty amplifier		
Invented	1936	BLR, 22, p. 386
Patent issued	1940	Hist. Firsts, p. 11
FM negative feedback, Chaffee	1939	Mon. 1155, p. 1

STATION

General

Bell		
"Harp" apparatus	1874	Rhodes, p. 11
Harmonic telegraph	June 2, 1875	Bell Dep., Am. Bell Tel. Co. vs. Peoples Tel. Co., p. 72; Watson, p. 67
Gallows phone	June 3, 1875	Rhodes, p. 24
Patent 174,465 (telephones)	Mar. 7, 1876	U. S. pat. 174,465; Rhodes, p. 14
Liquid transmitter	Mar. 10, 1876	Rhodes, p. 28
Induction coil, Berliner[¶]	1877	BSTJ, 37, p. 305
Repeating coil, isolating station apparatus from line (originally from metallic to grounded line), Watson		
Patent application	1877–81	BLR, 26, p. 168
Protector		
Sawtooth plate type (Boston Express Set)	1877	Photo Inf. 497
Polarized ringing, Anders	1879	Rhodes, p. 184
Harmonic ringing	1882	BLR, 12, p. 160
Bridging ringer, Carty	1890	Rhodes, p. 180
Anti-sidetone circuit, Scribner	1893	BLR, 17, p. 347
Two-party selective ringing, Pickernell	1893	Rhodes, p. 187
Interrupted ac ringing, Hibbard		
Patent issued	1895	BLR, 28, p. 392
Four-party selective ringing, Hibbard	1895	BLR, 28, p. 392
Patented	1896	Rhodes, p. 187
Dial, first finger wheel (Strowger[¶] and Automatic Electric Co.[¶])		
Invented	1895	Note by Lowe
Installed, Milwaukee, Wis.	1896	

STATION (Cont'd)

	Date	*Reference*
General (Cont'd)		
Superimposed ringing (dc plus ac), Drake	1904	BLR. 8, p. 116
Vacuum tube selective ringing	1936	BLR, 15, p. 111
Adjustable volume (C type Ringer)		
Trial installation	1948	BLR, 29, p. 414
In service	1949	
Tone ringing		
Field trial, Americus, Ga.	1954	BLR, 35, p. 51
Power		
Bell		
Battery	June 2, 1875	BLR, 15, p. 138
Permanent magnet		
Concept	1876	Rhodes, p. 33
Experimental	1876	Rhodes, p. 38
In use	1878	BLR, 15, p. 140
Local Battery	1878	BLR, 15, p. 141
Magneto generator, Watson	1878	Rhodes, p. 177
Repeating Coil, metallic to grounded line, through coil, Watson		
Patent application	1877–81	BLR, 26, p. 168
Common battery, experimental, Hayes	1888	Rhodes, p. 163
Storage batteries, charged from central office	1891	BLR, 15, p. 141
Dry cells		
Standardized	soon after 1900	BLR, 15, p. 143
Protector		
Sawtooth plate type (Boston Express Set)	1877	Photo Inf. 497
Plug, telegraph type	by 1878	

CENTRAL OFFICE

Holmes* switchboard	1877	Rhodes, p. 147
Wet battery, experimental	1877	
Ringing battery, wet	1878	Rhodes, p. 167
New Haven* switchboard	1878	
Universal switchboard	1879	Rhodes, p. 171

* Non-Bell System, but Bell licensed.

	Date	*Reference*
Battery, commercial, ringing and operator's transmitter	1879	Rhodes, Fig. 33; p. 171
"Standard" switchboard	1880	Rhodes, p. 173
Central ringing battery	1880	Rhodes, p. 163
Phantom		
Resistance circuit, Jacob¶		
Patented	1883	Rhodes, p. 190
Repeating coils, Carty		
Patented	1886	Rhodes, p. 191
Common battery, experimental, Hayes	1888	Rhodes, p. 163
Early common battery cord circuit	ca. 1892	Mon. C4, p. 11 Rhodes, p. 164
Anti-sidetone circuit, Scribner		
Invented	1893	BLR, 17, p. 347
In use	before 1938	Mon. 1082, p. 2
Line and cutoff relay, schematic circuit	before 1910	Mon. C4, p. 12
3-element simple balancing network, Hoyt	1912	BLR, 23, p. 413
Filter (see APPARATUS, Filters)		
Echo suppressor		
In use	1925	BLR, 17, p. 119

OUTSIDE PLANT

Phantom		
Resistance circuit, Jacob¶		
Patented	1883	Rhodes, p. 190
Repeating coils, Carty		
Patented	1886	Rhodes, p. 191
Carrier telephone circuit invented, Hutin¶ and Leblanc¶, France	1891	BSTJ, 37, p. 314
Modulation of a carrier wave, Hayes, Cram, and Thompson		Espenschied memo on E. R. Cram in Museum files
Patented	1897	
First vacuum tube carrier experiment, Heising	1914	BLR, 1, p. 154
Single sideband carrier, Carson	1915	BLR, 31, p. 148

¶ Non-Bell System

MODULATION

	Date	*Reference*
Vacuum Tube Modulator		
To control alternator, Alexanderson¶, (GE)	1913	Mon. 1021, p. 5 Mon. C1, p. 59 Espenschied, MM54-122-3
Colpitts oscillator-modulator	1914	Espenschied, MM54-122-3
Patent issued	1915	Espenschied, MM54-122-3
Van der Bijl grid modulation, full wave Patent application	1915	BLR, 26, p. 251 BLR, 23, p. 6
Grid modulation, oscillating wave, Heising Patent application	1916	BLR, 26, p. 251
Rectifier-modulator, half wave, Heising Patent application	1916	BLR, 26, p. 251
Constant current modulation, Heising	1916	Mon. 1021, p. 8
Coupled plate, Heising	ca. 1917	BLR, 23, p. 7
Regenerative modulation, Horton	1919	Mon. 1593, p. 31
Copper Oxide Modulator		
C. R. Keith	1929	BLR, 23, p. 200
Bridge type, Cowan Patent issued	1934	
Ring type, Cowan Patent issued	1935	
Non-linear Coil Type		
In use	1945	BLR, 24, p. 102

OSCILLATOR

Vacuum Tube Oscillator		
Strauss¶ Patent application	1912	Mon. 1593, p. 17
Cathode ray tube oscillator, Germany (Von Lieben¶ tube)	1913	Espenschied, MM54-122-3
Armstrong regenerative oscillator¶	1914	
Colpitts oscillator-modulator	1914	

¶ Non-Bell System

	Date	*Reference*
Colpitts oscillator	1914	Mon. 170, p. 60
Hartley oscillator	1914	Espenschied, MM54-122-3
Crystal oscillator, Nicolson		
Patent application	1918	BLR, 22, p. 601
Electromagnetic harmonic oscillator		
In use	1936	BLR, 22, p. 533
Bridge-stabilized oscillator, Meacham	ca. 1938	Mon. 1593, p. 42
Start-stop oscillator		
Patent application	1942	BLR, 26, p. 212

MATERIALS

CONTACT

	Date	*Reference*
Platinum	before 1859†	BLR, 2, p. 8
First Bell System use	1876	Liquid Transmitter, Bell
Brass	before 1875†	Telegraph Instruments
First Bell System use	1875	Rhodes, Fig. 3
Iron	1877	Rhodes, Fig. 8
Plumbago	1877	Rhodes, p. 78
Carbon	1878	Rhodes, p. 79
Gold	by 1885	Rhodes, p. 81
No. 1 Metal (Gold, silver, platinum)		
Field trials	1912–17	BLR, 2, p. 11
Adopted	1917	BLR, 2, p. 11
Palladium (No. 2 Metal)		
Tests	1913	BLR, 18, p. 278 Gumley, 6/29/59
Adopted	1917*	BLR, 2, p. 11
No. 4 Metal (palladium alloy)		
Available	1923	BLR, 2, p. 12
Silver	1937	BLR, 18, p. 278 BLR, 27, p. 50

CRYSTAL (SEE ALSO APPARATUS, CRYSTAL)

EDT (Ethylene diamine tartrate)		
First prepared, Colson†, France	1892	Mon. 1562, IV 2
Commercial, BTL	1946	Mon. 1562, IV 2
Synthetic quartz at Spezia†, Italy	1908	BLR, 31, p. 241
Quartz in use	ca. 1917	BLR, 22, p. 282
Silicon		
Crystal detector		
Experimental	ca. 1938	BLR, 26, p. 152
Limited use	by 1941	BLR, 26, p. 153
British design† (present type), (limited by use of poor silicon	1940–41	BLR, 26, p. 153
Bell Laboratories improvement	ca. 1942	BLR, 26, p. 153

† Non-Bell System
* 1925, BLR, 27, p. 50

	Date	*Reference*
ADP (Ammonium dihydrogen phosphate)	1941–45	BLR, 25, p. 357
Artificial (synthetic) quartz (Commercial quality crystals)	1948	BLR, 26, p. 384

INSULATOR

Wood	ca. 1878	Museum exhibit
Wood, metal covered cap	ca. 1878	Museum exhibit
Glass	ca. 1878	Rhodes, p. 97
Ceramic		
Using		
Stone china	ca. 1878–85	cf. Rhodes, p. 97
Steatite		
In use	1941	Mon. 1325, pp. 1, 2
Cordierite		
In use	1941	
Titanium dioxide		
In use	1941	

MAGNETIC

Permalloy, Elmen	1916*	BLR, 21, p. 340; Hist. Firsts, p. 2
Cobalt steel, Takagi¶ and Honda¶, Japan	1917	Sci. Rept., Tohoku Imp. Univ., 9, pp. 417–22
Perminvar (Fe, Ni, Co)	1921	Mon. 350, p. 1
Permendur (50 Fe, 50 Co)	1926	Chegwidden
Patent application	1927	U. S. pat. 1,739,752
Remalloy (Fe, Co, Mo, or W)		
Seljesator and Rogers, (W. E.)	1931	Mon. 1445, p. 15; Mon. 1605, p. 8
Vanadium Permendur (Fe, Ni, V)		
Patent application	1931	U. S. pat 1,862,559
Ferrites		
Lodestone (Fe_3O_4, magnetite)¶	B.C.	BLR, 29, p. 203
Japanese¶ (magnetic oxides), Kato¶ and Takei¶	1933	Journal, Inst. EE Japan, 53, pp. 408–12
Non-magnetic oxides plus Fe_3O_4, Philips Co.¶, Holland	1946	BLR, 29, p. 204
Molybdenum Permalloy		
Available	1935	Mon. 908, p. 4

* 1913, Mon. 1445, pp. 10, 13

MAGNETIC (Cont'd)

	Date	*Reference*
Vicalloy		
Discovered, Nesbitt	1936	Mon. 1401, p. 1
Patent issued	1940	BLR, 29, p. 36
Supermalloy (Fe, Ni, Mo, heat treated in hydrogen)	1944†	Mon. 1445, pp. 11, 13

MISCELLANEOUS

Vibralloy (for bells), recent	1952	BLR, 30, p. 345
Metal whiskers discovered, recent	1954	BLR, 32, p. 417

RUBBER AND OTHER SUBSTANCES

Rubber		
Formula discovered, Faraday¶	1826	Mon. 1405, p. 2
Vulcanization, Goodyear¶	1839	Mon. 1646, p. 2
Isoprene isolated, Williams¶	1860	Mon. 1405, p. 2
Isoprene polymerized, Bouchardat¶	1879	
Paragutta		
Kemp, BTL	ca. 1930	Mon. 542, p. 1
First use, Key West–Havana Cable No. 4	1931	BLR, 9, pp. 417, 422
Solder		
Lead-tin-arsenic, new	1940	BLR, 18, p. 303
B Sealing		
In use	1950	BLR, 28, p. 297

† 1941-1943, BLR, 26, p. 111
¶ Non-Bell System

ACOUSTICS

	Date	*Reference*
Acoustic filter proposed, Herschel†	1833	Mon. 256, p. 1
Phenomenon of howling telephone (transmitter against receiver), Hughes†, England	before 1879	BLR, 31, p. 21
Thermophone (thermal telephone receiver), precise sound source, Arnold and Crandall	by 1917	BLR, 22, p. 105
Parallel to electric filters, Stewart, (AT&T)	ca. 1922	Mon. 256, p. 1
Experiment on electrical synthesis, Stewart, (AT&T)	1922	Mon. 1148, p. 4
Proposal of the SU (Sensation Unit) (now the db) for measuring hearing	1922	Mon. 152, p. 2
Determination of musical pitch in absence of the fundamental, Fletcher	1923	Mon. 61, p. 1
Experiment in electrical synthesis, Fletcher	1924	Mon. 1148, p. 4
Properties of tube filters, Mason	1927	Mon. 256, p. 1
"Oscar" (stereophonic) demonstration, American Academy of Music, Philadelphia	1932	BLR, 11, p. 286
Synthesis of speech	1936	BLR, 15, p. 98
Visible speech, Potter	1945	N&I Rel., 11/8/45 Mon. 1368, p. 1 Mon. 1415, p. 1
Tone synthesizer	1946	Mon. 1397, p. 1
Acoustic lens demonstrated, Kock and Harvey (refraction of sound)	1949	BLR, 27, p. 351 Mon. 1700, p. 1

ELECTRICITY

Electrical analog theory, Wegel	1921	Mon. 1867, p. 15
Theory of electro-acoustic converters	1925	Mon. 1867, p. 15

† Non-Bell System

ELECTRICITY (Cont'd)

	Date	*Reference*
Johnson Noise (Johnson Effect), J. B. Johnson	1927	Mon. 2324, p. 1

CHEMISTRY AND METALLURGY

Magnetostriction		
Observed by sound, Page†, U. S.	1837	Mon. 187, p. 2
Described, Joule†	1842	Mon. 187, p. 3
Theory, J. J. Thompson†, England	1886	Mon. 187, p. 6
Theory, Ewing†	1890	Mon. 187, p. 7
Theory, McKeehan	1926	
Vitamin B1		
Theory, Eykman†	1896	BLR, 15, p. 1
Probable nature proposed, Funk†	1911	
Discovered	1926	
Improved isolation process, Williams, BTL, private research	1933	
Synthesis, Williams, BTL, private research, and Merck & Co.†	1936	
High power metallography, Lucas	1924	Mon. 187, p. 1
EDT (Ethylene diamine tartrate)		
Frequency control crystals	1947	N&I Rel., 7/19/47
Artificial quartz, Buehler and Walker	1948*	N&I Rel., 8/2/48
Lead-calcium storage battery	1951	N&I Rel., 1/23/51
Zone refining, Pfann		
Alloy freezing from one end, Bridgeman†	1925	Mon. 2000, p. 1
Zone melting, Pfann	1952	
Continuous zone melting	1955	Mon. 2388, p. 1
Metal whiskers discovered, recent	1954	BLR, 32, p. 417

GENERAL

Probability		
Elements of theory, Pascal†, France	1654	Mon. 854, p. 1
Discovery of distribution curve for calls, Blood	1898	Mon. 2040, p. 5
Theory of probability applied to calls, Rorty	1903	
Trunking theory, Molina	1908	
Statistical quality control, Shewhart, new	1925	Mon. 181, p. 1

† Non-Bell System
* 1953, Mon. 2146, p. 1

	Date	*Reference*
Theory of probability in telephone trunking, Molina	1927	Mon. 263, p. 1
Electrons		
Wave diffraction by crystals, von Laue¶, with X-rays	1912	Mon. 263, p. 1
Wave properties proposed for electrons, de Broglie¶	1924	Mon. 263, p. 3
Diffraction of electrons suggested, Elsasser¶	1925	Mon. 263, p. 4
Diffraction of electrons demonstrated, Davisson and Germer, BTL (Davisson received Nobel Prize for this research)	1927	Mon. 281, p. 1 Mon. 395, p. 4
Coronavisor, device for observing solar corona by electric scanning, proposed, Skellett	ca. 1934	Mon. 807, p. 1
Measurement		
Precision measurement of oscillator rates, Marrison	1929	Mon. 1593, p. 45
PHYSICS		
Atom bomb		
How to make	1940	Mon. 1218, p. 1
Discovery of Johnson effect (thermal noise), J. B. Johnson	ca. 1926	BLR, 22, p. 59
RADIATION		
Sun-spot effect on radio, Anderson	1923	BLR, 28, p. 253
Ionosphere measurements, Schafer and Goodall		
Step on the way to radio altimeter and radar	1926	N&I Rel., 1/24/46
Refraction of radio signals discovered	1925–30	Mon. 764, p. 101
Ionized Heaviside layer measurements by radio pulse echo, using cathode ray oscilloscope, Schafer and Goodall (precursor of radar)	1931	Mon. 590, p. 1 Mon. 688, p. 1
Radio astronomy		
Detection of galactic radio signals, Jansky	1931*	BLR, 11, No. 6, p. i BLR, 28, pp. 101, 120

* 1931-32, Mon. 764, p. 1

TRANSMISSION

	Date	*Reference*
Probability theory for line irregularities, Mills	1912	Mon. 164, p. 1
Wave filter, Campbell	1915	BSTJ, 37, p. 314
Theory of filters, Campbell	1922	Campbell, p. 190 Mon. 1867, p. 10
General theory of filters	1934	Mon. 843, p. 1
Coaxial and balanced transmission lines as filters and transformers at high frequencies, theory, Mason and Sykes	1937	Mon. 1003, p. 1
Clogston laminated conductor	1951	Mon. 1891, p. 1 Mon. 2120, p. 1

	Date	*Reference*
Audiogram		
Available	1922	BLR, 24, p. 58
Audiometer		
Experimental	1922	Rec. Imp. in Hearing Aids, p. 4
64–16384 cycles	1923	Mon. 79, p. 1
Single frequency	1923	
Hearing Test		
Pulse-tone test first used, New York World's Fair	1939	Mon. 1510, p. 1
Audiphone		
First, 10A	ca. 1923	Rec. Imp. in Hearing Aids, p. 4; BLR, 10, p. 362
Bone conduction receiver	ca. 1935	BLR, 13, p. 364
Orthotechnic	1939	BLR, 18, p. 8
Models 64, 65, 66	1947	BLR, 25, p. 384; BLR, 26, p. 30
Microphone		
Condenser, Wente	ca. 1916	BLR, 21, p. 394
Crystal, Nicolson	1919	Mon. 874, p. 13
Double carbon button	1921	Mon. 82, p. 7; Mon. 538, p. 11
Dynamic (moving coil), No. 618A	1931	Mon. 630, pp. 2–3; BLR, 14, p. 34
Lapel, No. 619A	1931	Mon. 695, p. 1; Photo 155515
Eight-ball, No. 630A	1936*	Mon. 941, pp. 1, 2
"Machine gun"	1936	BLR, 16, p. 52; Photo 155515
Salt Shaker, No. 633A	1937	BLR, 16, p. 80
Cardioid, No. 639 Type		
First public use	1938	BLR, 17, January, p. i
High fidelity condenser	1938	

* 1935, BLR, 14, p. 34, and Photo 155515

	Date	*Reference*
Microphone (Cont'd)		
Ribbon		
First Bell System type	1940	Photo 155515
FM Cardioid	1941	
Throat	by 1944	BLR, 23, p. 196
Lip	by 1944	BLR, 23, p. 197
Loud Speaker		
Crystal, Nicolson	ca. 1917	BLR, 22, p. 282
Published	1919	BLR, 28, p. 221
Horn type	1920	Mon. 41, p. 31
Tweeter		
Available	1930	Mon. 522, p. 1
Public Address System		
High power, New York, Liberty Loan	1919	Mon. 1021, p. 15
Small theater reproducing system	1930	Mon. 549, p. 1
Phonograph		
Sound recording on drum		
Proposed, Young¶	1807	
Used, Wertheim¶	1842	
Phonautograph, Scott¶	1847	
Ear drum and smoked glass, Bell	1874	Mon. 689, p. 2
Phonograph, Edison¶	1876	
Patent issued	1877	
Tinfoil records¶	1876	
Engraved vertical cut phonograph record on pasteboard cylinder coated with wax, Bell and Tainter		
Patent issued	1886	
Graphophone produced, Bell and Tainter	1887	Mon. 689, p. 2
Wax cylinder record, Edison¶	ca. 1887	
Gramophone, disc record, lateral cut, Berliner¶	1887	Mon. 689, p. 3
Coated wax, permitting plating and duplication, Edison¶	ca. 1900	
Magnetic tape recording (longitudinal magnetization), Poulsen¶, Denmark	1907	BLR, 16, p. 2
Electric recording and reproducing of phonograph records		
Proposed, Arnold	1915	BLR, 24, p. 301

¶ Non-Bell System

	Date	*Reference*
Crystal phonograph pick-up		
Nicolson	ca. 1917	BLR, 22, p. 282
Published	1919	BLR, 28, p. 221
Electrical recording, BTL		
Maxfield and McKenzie		
Commercial stage	1924	Bell Tel. Mag., 34, p. 236; Mon. 689, p. 4
Commercial contracts	1925	BLR, 24, p. 290
Orthophonic phonograph, Harrison, first demonstration	1925	Hist. Firsts, p. 38; BLR, 1, p. 95
Electric recording, vertical cut	1931	BLR, 10, Jan., p. vii
Magnetic tape recording, perpendicular magnetization, Hickman	1937	Mon. 990, p. 1
1A Phonograph Recorder, vertical cut, introducing feedback	ca. 1938*	Mon. 1645, p. 1
Field trial finished	by 1940	BLR, 18, p. 173
Stereophonic Music		
Demonstration, Washington	1933	BLR, 11, p. 259
Demonstration, Carnegie Hall, N.Y.C., recorded and reproduced, with enhancement	1940	BLR, 18, p. 258
Sound Pictures		
Synchronized film and phonograph, Experimental, Edison¶	1922	BLR, 2, p. 201
Photographic sound recording on film by light valve		
First practical valve, variable density, Wente	1922	Mon. 377, IV, p. 1; Mon. 675, p. 2
Single ribbon light valve, commercial	1924	Mon. 675, p. 2
First commercial picture, "Don Juan", Vitaphone¶ (BTL patents)	1926	BLR, 2, p. 200
First feature length talking picture, "The Jazz Singer"	1927	Tel. Alm., 1959, p. 14
3D	1932	BLR, 10, p. 367
High precision recording	ca. 1937	Mon. 1009, p. 1
Stereophonic recorded music, Carnegie Hall	1940	Stereo. Recordings

* Ca. 1939, BLR, 18, p. 171

	Date	*Reference*
Sound Pictures (Cont'd)		
Stereophonic film demonstration, Rochester, New York	1941	Mon. 1327, p. 1
See also *Phonograph*		
Voder		
Used at New York World's Fair	1939	BLR, 17, p. 170 Mon. 1734, p. 16
Vocoder		
Available	ca. 1939	Mon. 1169, p. 1 Mon. 1171, p. 1
Visible Speech		
First demonstration	1945	BLR, 23, p. 483
Artificial Larynx		
W. E.—Mackenty¶		
Developed	1924	Mon. 94, p. 5
Second type, Riesz	1930	Mon. 469, p. 2
Tape Recording		
Magnetic wire recording (longitudinal magnetization), Poulsen¶, Denmark	ca. 1907	BLR, 16, p. 2
Magnetic powder tape,¶ experimental, Germany	1932	Mon. 1992, p. 2
Perpendicular magnetization, Hickman	1937	Mon. 990, p. 1
Rubber tape, BTL, first use, Cleveland, in 3A Announcement System	ca. 1952	Mon. 1992, p. 3
Electric Stethoscope		
Earliest electrical test, Einthoven¶	1907	Mon. 104, p. 5
Heart sounds reproduced	1910	
Heart sounds amplified, Squier¶	1921	
Multiple electric stethoscope, Drs. Cabot¶ and Gamble¶ (with W. E., N.Y. Engineering Dept.)	1923	Mon. 104, p. 6
1A	pub. 1924	Mon. 104, p. 6
Portable	1925	BLR, 1, p. 42
Mine and Explosive Atmosphere Telephone		
First	1888	BLR, 2, p. 238

	Date	*Reference*
Bank Vault Alarm		
In use	1927	BLR, 4, p. 363
Radio		
Signal to call operator to Coast Guard transmitter and receiver, recent	1924	Mon. 151, p. 1
Transistor, experimental	1953	Mon. 2234, p. 1
Broadcasting		
First BTL experiments, 2XB (later WEAF)	1919	BLR, 26, p. 420
First regular broadcast, Conrad, KDKA (Westinghouse)¶	1920	Tel. Alm., 1959, p. 23 Mon. 1021, p. 14
2XY (later WBAY)	1921	BLR, 3, p. 46
WEAF, changed letters from 2XB	by 1922	BLR, 26, p. 420 Stereo. Recordings
Broadcasting started by Bell System, WBAY (replaced by WEAF the same year)	1922	Hist. Firsts, p. 51 BLR, 26, p. 420
Crystal-controlled broadcasting, WEAF	1924	BLR, 26, p. 420
Network broadcasting		
In use	1924	Mon. 120, p. 10
Theory of common-frequency broadcasting	1927	Mon. 249, p. 1
Radio Altimeter		
Radio reflection system, basis of radio altimeter and radar, Espenschied		
Patent application	1919	Hist. Firsts, p. 41
Suggested, Espenschied	1926	BLR, 26, p. 18
Patent application, Espenschied	1930	
Demonstration, BTL, W. E., United Air Lines	1938	BLR, 26, p. 19
Aircraft Control Systems and Equipment		
Weather and beacon set		
Available	1930	Mon. 471, p. 34
Two-way telephone		
Available	1930	Mon. 471, p. 12
111-A Key Equipment for airport control towers	1947–49	BLR, 27, p. 396

¶ Non-Bell System

	Date	*Reference*
Aircraft Control Systems and Equipment (Cont'd)		
CAA Type Retardation Coil, adjustable core to control inductance over wide limits		
Available	1953	BLR, 31, p. 302
Loran		
Continuous phase shifters for precision timing signals proposed	1925	Mon. 1593, p. 45
Use of continuous phase shifter to control time system, Marrison		
Patent application	1934	Mon. 1593, p. 45
Patent issued	1937	
Commercial Radar Navigation		
Trial, Duluth, Minn.–Cincinnati, O.	1946	BLR, 25, p. 181
Crystal Frequency Standard (See also APPARATUS, Crystals)		
Piezoelectric control of oscillator, Nicolson	1917	Mon. 1593, p. 25
Patent application	1918	
Frequency control, Marrison (frequency divider) used to control broadcasting	1924	Mon. 1593, p. 27 Hist. Firsts, p. 51
Crystal clock, Marrison	1927	Hist. Firsts, p. 10 BLR, 22, p. 335 BLR, 30, p. 443
Zero temperature coefficient, ring crystal, Marrison (less than 1 part per million per °C, zero at 1 temperature)		
Patent application	1928	BLR, 23, p. 70 Mon. 1593, p. 32
GT Cut, Mason (1 part per 10,000,000 per °C for 30° range, 1 part per 1,000,000 per °C for 0°–100°C)		
Patent application	1937	BLR, 23, p. 71
Wire mounted	1938	BLR, 30, p. 433
Patent application	1940	BLR, 23, p. 246

	Date	*Reference*
Improved mount, Loran use	1942–45	BLR, 30, p. 433
100 kc Bureau of Standards model	ca. 1949	
Electric Precision Clock		
Piezoelectric control of oscillator, Nicolson	1917	Mon. 1593, p. 25
First full-electric vacuum tube operation of tuning fork, Horton, Ricker, and Marrison	1923	Mon. 1593, p. 19
Special cuts of quartz, Pierce	1923	Mon. 1593, p. 26
First frequency divider, Marrison (frequency control)	1924	Mon. 1593, p. 27
First quartz crystal clock, Marrison*	1927	Hist. Firsts, p. 10 BLR, 22, p. 335 BLR, 30, p. 433
Crystal precision clock, Marrison	1930	Mon. 1593, p. 35
Atomic or molecular clock control proposed, Marrison	1947	Mon. 1593, p. 71
Watch Rate Comparator		
In use	1933†	BLR, 12, p. 90
High-Speed Motion Pictures (Fastax)		
2000 frames/sec (Herriott)	1934	BLR, 22, p. 1
4000 frames/sec	1936	
Fastex, 8000 frames/sec (8 mm.) 4000 frames/sec (16 mm.) Developed experimentally	before 1941	BLR, 22, p. 1 N&I Rel., 5/1/46
Ribbon-Frame Camera		
In use	1945	BLR, 23, p. 40 Mon. 1379, p. 1
Kirby Two-Eyed Camera		
Photo racing timer	1932	BLR, 11, p. 27
Television (See also TRANSMISSION)		
Scanning disc		
Nipkow	ca. 1880	Mon. 2363, p. 1
Plotnow¶	1884	Mon. 274, I, p. 6
Cathode ray tube receiver, Nicolson		
Patent issued	1923	BLR, 28, p. 221
Flying spot scanner, Gray	ca. 1925	BLR, 31, p. 196
First public demonstration, Baird¶, England	1926	Ev. Tel. Hist., p. 26

* Horton and Marrison, Mon. 1593, p. 29
† 1937, BLR, 15, p. 202
¶ Non-Bell System

	Date	*Reference*
Television (Cont'd)		
First public demonstration of telephone transmission of television, New York–Washington	1927	Tel. in Am., p. 60 BLR, 19, p. 3
First out-of-door demonstration	1928	BLR, 6, p. 402
First color demonstration by Bell System	1929	Tel. in Am., p. 60 BLR, 7, p. 439
First two-way demonstration	1930	Tel. in Am., p. 60 BLR, 8, p. 398
Two simultaneous signal TV system, Gray Patent issued	1930	BLR, 31, p. 196
First commercial transmission by coaxial cable, New York–Philadelphia	1937	Tel. in Am., p. 61
First experimental use of video on telephone circuits, for NBC	1939	BLR, 18, p. 34
TV over coaxial, Philadelphia–New York, Army–Navy game, first *major* direct sports pick-up	1945	BLR, 24, p. 24
Network service, New York-Washington	1946	Mon. 2045, p. 14
Experimental microwave radio transmission, Mt. Wilson–Hollywood	1946	BLR, 24, p. 382
Commercial microwave radio service	1948	Mon. 1880, p. 1
Transcontinental service	1951	Bell Tel. Mag., 34, p. 236
Color television network established	1954	Report to W. E. Employees, 1953
Picture phone experiment	1956	Ev. Tel. Hist., p. 44
Industrial low-quality telephone line system	1957	Ev. Tel. Hist., p. 45
Coronavisor		
Producing "eclipse" of the sun by TV	before 1940	BLR, 18, p. 162
Solar Battery		
Invented	1954	Ev. Tel. Hist., p. 42
First demonstration	1955	Ev. Tel. Hist., p. 43 BLR, 33, p. 241
Railroad Warning Signal		
Impedance irregularity from broken rail, or train on		

	Date	*Reference*
track, Espenschied Patent application	1919	BLR, 26, p. 18
Train Dispatching		
First by telephone, Boston, Revere Beach & Lynn Railroad	1879	BLR, 3, p. 108
No. 60 Selector for selective ringing	1916	BLR, 3, p. 109
First Bell System set	1917	Mon. 51, p. 8
Electric Voltage Regulator		
Invented, Stoller Patent application	1918	Hist. Firsts, p. 39
Start-Stop Oscillator		
Used in radar	ca. 1942	Hist. Firsts, p. 44
Computer		
Mechanical Digital Type		
Abacus¶	Prehistoric	Mon. 2084, p. 1
Basic logic, Aristotle¶	4th Century B.C.	BLR, 32, p. 321
Pascal¶	1642	Mon. 2084, p. 1
Multiplication, Leibnitz¶	1694	Mon. 2084, p. 2
Jacquard loom¶	18th cent.	
Improved, Thomas¶	1820	
Digital type proposed, Babbage¶, England	1822	
Forerunner of comptometer¶ Patented	1850	Mon. 2084, p. 6
Printing adding machine¶	1872	
Comptometer, Felt¶	1887	
Single-operation multiplier, Bollée¶	1888	
Adding and listing, commercial¶	1889	
Mechanical Analog Type		
Slide rule¶	ca. 1600	Mon. 2084, p. 1
Planimeter¶	ca. 1814	
Harmonic synthesizer, Lord Kelvin¶, England	1872	
Harmonic analyzer, Lord Kelvin¶, England	1876	
Ball-and-disk integrator, James Thomson¶	1876	Mon. 2084, p. 3
General purpose analyzer (multiple integrator) Lord Kelvin¶, England	1876	
Gunfire control, antiaircraft¶	1914–18	Mon. 2084, p. 3

¶ Non-Bell System.

	Date	Reference
Computer (Cont'd)		
Mechanical Analog Type (Cont'd)		
Ball-and-disk integrator type differential analyzer for naval gunfire control, Ford†	after 1918	Mon. 2084, p. 3
Antiaircraft computer, Wilson†	1918	
Large differential analyzer, Bush†	1925	
Mechanical-Electrical Type		
First electric machine, U. S. Census, Hollerith†	1890	Mon. 2084, p. 3
Cash register, electric drive†	ca. 1910	
IBM machines†, punched card type	after 1910	
Electric Analog Type		
Servo drive†	1930–40	Mon. 2084, p. 3
Shaped potentiometer windings	ca. 1941	BLR, 22, p. 158 BLR, 32, p. 171
Electrical gun director		
Development started	1940	BLR, 22, p. 158
Tested	ca. 1941	
In production	1942	
In use	by 1943	
Electrical Digital Type		
First automatic digital computer for pure scientific computing, Stibitz and Williams	1938	Mon. 1972, p. 1 Mon. 2084, p. 3
First remote control computer demonstration, New York–Hanover, N. H.	1940	Mon. 1972, p. 1
Modern Types		
Theory, Turing†	1936	Mon. 2150, p. 3
First electronic type, Mauchly† and Eckert†	1941–45	J. R. Pierce, World Enc., 5, pp. 167–8
First 100% self-checking (and stopping in case of error), Model III (BTL)	1944	Mon. 1972, p. 2
Error correcting, Hamming	1950	N&I Rel., 4/20/50
Tradic (Transistor Digital Computer)		
Phase 1 (first in operation)	1954	BLR, 36, p. 223
Flying model	1955	N&I Rel., 3/14/55
Leprechaun	1957	BLR, 24, p. 24
Page-turner		
Chin-operated, Mallina	1946	N&I Rel., 3/29/46

† Non-Bell System

MILITARY EQUIPMENT*

ACOUSTIC EQUIPMENT

	Date	*Reference*
First Battle Announcing System, U.S.S. Arizona	1916	BLR, 9, p. 270
Inertia microphone for submarine detection, World War I	1917–18	BLR, 4, p. 363
Sound detection (and approximate location) of airplanes	1917–18	Some War-time Contrib. to Sci. Advnct. pp. 14, 18
Beachmaster Announcing Equipment, PAB-1	1944	BLR, 24, p. 261
"Polly" high-power airborne public address system First model	1944	BLR, 24, p. 305

AIR RAID SYSTEMS AND EQUIPMENT

Air raid siren, Wente	before 1941	Mon. 1438, p. 1
Air raid Warning System In use	1941	BLR, 20, p. 87
Air raid siren, BTL–Chrysler	1942	BLR, 20, p. 200
Information Center System SCS-5	ca. 1942	BLR, 23, p. 415
Operations Center TC-15	1942–45	
Operations Center AN/TTQ-1, new	1945	
Air Raid Warning System (Bell and Lights)	ca. 1951	BLR, 29, p. 482; BLR, 32, p. 59; BLR, 36, p. 222
AN/TSQ7 Coordinate Data Set		
AN/TSQ8 Coordinate Data Set (First transistorized military equipment by W. E. Co.)	ca. 1951	BLR, 36, p. 222
White Alice, antenna, trial	1955	BLR, 34, p. 37
Dew Line completed	1957	Ev. Tel. Hist., p. 45

* Bell System equipment for military use by the Army, Navy, Air Force, Marines, or others, was developed to the specifications and with the advice and cooperation of the Armed Services.

COMPUTERS AND GUN DIRECTORS

	Date	*Reference*
M9 Electrical Gun Director		
Development started	1940	BLR, 22, p. 158
Tested	ca. 1941	
In production	1942	
In use	by 1943	
Shaped potentiometer windings for analog computers (gun directors)	ca. 1941	BLR, 32, p. 171
Mark 22 (BTL Model IV)		BLR, 22, p. 158
Computer	1945	Mon. 1972, p. 2
Tradic (Transistor Digital Computer)		
Phase 1 (first in operation)	1954	Mon. 2395, p. 1 BLR, 36, p. 223
Flying model	1955	N&I Rel., 3/14/55 BLR, 33, p. 155
Binary digital code wheel for gun computers	ca. 1954	BLR, 32, p. 126

FLIGHT TRAINERS

PBM3 ("Mariner") Operational Flight Trainer	ca. 1944	BLR, 23, p. 33
PB4 Y-2 Operational Flight Trainer	ca. 1944	
F6F5 Operational Flight Trainer	ca. 1944	

MISSILES AND ASSOCIATED FACILITIES

Bat glider bomb (partial radar control)	1945	N&I Rel., 3/8/46 BLR, 24, p. 137
Nike Systems		
Atlas		
First form	1951	N&I Rel., 5/31/51
First field use, Fort Meade, Md.	1954	BLR, 32, p. 74
Hercules	1958–59	
Zeus		
Under development	1959	
Cape Canaveral, Florida–Puerto Rico submarine telephone cable, military missile range	1955	BLR, 33, p. 437
Special tracking camera	by 1956	BLR, 34, p. 137

	Date	*Reference*
Control Systems		
Atlas missile		
Under development	1956	
Thor missile		
Under development	1956	N&I Rel., 1956
Titan missile		
Under development	1956	
ICBM		
Under development	1956	

RADAR AND SONAR

General

Chief scientists in development of radar:		Radar, p. 43
Sir Watson-Watt¶, England		
Major-Gen. R. B. Cotton¶, U.S.A.		
Dr. A. H. Taylor¶, Naval Research Lab		
Discovered echoes	1922	Radar, p. 43
Early studies of radar by U. S. Army¶ and Navy¶	ca. 1930–35	Radar, p. 6
Bell Laboratories asked to study problems (no contract)	1937	Radar, p. 7
First Laboratories experimental model, 60 cm wave length	1939	Radar, p. 10 BLR, 21, p. 363
Magnetron brought to the U. S. by the British¶	1940	Radar, p. 14
Polyrod antennas	1943	Renegotiation Show Booklet
"Dinosaur Brush", etc.		BLR, 26, p. 64
"Rocking Horse" antenna	1943	Renegotiation Show Booklet BLR, 28, p. 103
Cutler antenna feed (for airborne radar)	1943	BLR, 28, p. 103
Model O		
In use	1945	Radar, p. 47
Universal Bombsight	1945 or later	Renegotiation Show Booklet

Army Radar

SCR-268, search and warning, ground use		
Redesign for production only	1941	Radar, p. 26

¶ Non-Bell System

RADAR AND SONAR (Cont'd)

	Date	*Reference*
Army Radar (Cont'd)		
SCR-517, navigation and search		
Developed	1941	Radar, p. 23
In use	1942	Renegotiation Show Booklet
SCR-296, ground use, fire control against ships	1942	Renegotiation Show Booklet
SCR-717, search	1942*	
Night fighter radar, production design only (used for ship and plane anti-submarine work)	1942	Radar, p. 22
SCR-545, anti-aircraft search, warning, and fire control	1943	BLR, 25, p. 380 Radar, p. 27 Renegotiation Show Booklet
SCR-720, night fighter search, Used in Mosquito and P-61 (Black Widow). Brought plane into *sight* of enemy plane	1943	Renegotiation Show Booklet Radar, p. 22
SCR-584, not Bell System, but used our director		
SCR-784, not Bell System, but used our director		
SCR-519	after 1945	Renegotiation Show Booklet
Navy Sonar		
First sonar studies by Bell Laboratories	before 1941	Mon. 1543, p. 14
QJA	1941–45	BLR, 30, p. 55
Navy Radar		
CXAS, search		
Started	1939	Radar, p. 11
Concluded	1940	
FC (Mark 3), big guns	1941	BLR, 25, p. 64
FD (Mark 4), 5 inch guns	1941	
SJ, submarines		
Started	1941	BLR, 24, p. 402
In use	1942	BLR, 24, p. 402 Renegotiation Show Booklet

* 1942-3, Radar, p. 23

	Date	*Reference*
Mark 3 (originally FC) surface use only. Main battery fire control	1941	BLR, 25, p. 64 Radar, p. 14
Mark 4 (originally FD) surface use only. 5-inch gun fire control	1941	BLR, 25, p. 64 Radar, p. 13
Mark 16, search and warning	after 1941	Radar, p. 27
SL, 10 cm. search		
Destroyer Escorts and landing operations		
Started	1942	BLR, 24, p. 353
Delivered	1943	BLR, 24, p. 353 Renegotiation Show Booklet
Mark 9, machine gun fire control	1942–43	Renegotiation Show Booklet
Mark 10, machine gun fire control	1942–43	
Mark 19, machine gun fire control	1942–43	
Mark 8, main battery fire control (used polyrod–"Dinosaur Brush"–antenna)	1943	Radar, p. 19
Mark 12, 5-inch gun fire control	1943	Renegotiation Show Booklet
Mark 22, 5-inch gun fire control with Mark 4 or Mark 12 ("Banana Peel" or "Rocking Horse" antenna)	1943	Renegotiation Show Booklet
Mark 27, special fire control	1943	Renegotiation Show Booklet
SJ-1, submarines	1943	
Navigation, search, and interception set	1943–44	Radar, p. 23
Mark 13	1944	Radar, p. 19 Renegotiation Show Booklet
Mark 20, searchlight control	1944	Renegotiation Show Booklet
Mod. 0, double parabola antenna		
Mod. 1, wire bowl antenna		
Mark 25		
Started	1944	
Mark 28, machine gun fire control	1944	
Mark 34, machine gun fire control	1944	
SL-1, Destroyer Escorts and landing operation	1944	
ST, submarines	1944	
SS, submarines	1945	

RADAR AND SONAR (Cont'd)

	Date	*Reference*
Navy Radar (Cont'd)		
Anti-aircraft fire control Supplanted M9	1951	BLR, 29, p. 174
Joint Army-Navy		
ASH (later AN/APG-4)		
Light weight search and night fighter set		Radar, p. 24
Started	1942	BLR, 24, p. 321
In use	1944	Renegotiation Show Booklet
AN/TPS	after 1941	Radar, p. 27
AN/TPS-1, search	1943	Renegotiation Show Booklet
AN/CPS-5, not Bell System (Used our antenna only)		
AN/APQ-5 Bomb Sight		
Low altitude bombing		
Used with SCR-717 (search)	1943	Renegotiation Show Booklet
First type in use		BLR, 25, p. 16
AN/APQ-13 Bomb Sight		
High altitude bombing		
Developed from SCR-717, with extensive changes. Radome in plane belly. Weight 650 lbs.	1943	Renegotiation Show Booklet
AN/APQ-7 Bomb Sight		
High altitude bombing		
Taken over from Radiation Laboratory and completed. "Wing" antenna	1944	Renegotiation Show Booklet
AN/APA-16		
Low altitude bombing		
Used with ASB, AN/APS-3, and AN/APS-4, non-Bell System	1944	Renegotiation Show Booklet
AN/APG-1, night fighter		
Improved SCR-720. Allowed radar gun aiming	1944	Renegotiation Show Booklet
AN/APG-4 (originally ASH)		
Light weight search and night fighter set.		Renegotiation Show Booklet
Started	1942	Radar, p. 24
In use	1944	BLR, 24, p. 321

	Date	*Reference*
AN/APA-28, flight training	1945	Radar, p. 24; BLR, 24, p. 321; Renegotiation Show Booklet
AN/APA-33, flight training	1945	Renegotiation Show Booklet
AN/APA-44, Computer Used with AN/APQ-7 and AN/APQ-34	1945	
AN/APQ-13, Mod. 2 Automatic, except for training crosshairs on target	1945	
AN/APQ-10	1945	
AN/APQ-24 Shorter wave version of AN/APQ-34	1945	Renegotiation Show Booklet
AN/APQ-34 High altitude bombing	1945	
AN/APQ-23 AN/APQ-13 with synchronous bomb sight	after 1945	

RADIO

Radio telephone, 2-way, U.S.S. New Hampshire (Navy)	1916	Mon. 503, p. 2
SCR-68 Radio Set, for airplanes (Army)	1917–18	Some War-Time Contrib. to Sci., Advnct., p. 18
Airplane radio sets	1917–18	Some War-Time Contrib. to Sci. Advnct., pp. 18, 20, 22; BLR, 22, p. 221
Tank sets (Army)	1917–18	Some War-Time Contrib. to Sci. Advnct., p. 24
Radio-controlled airplane, Oswald	1918	BLR, 29, p. 318
SCR-508 Tank Radio Set (Army)	ca. 1941	BLR, 23, p. 1
SCR-528 Tank Radio Set (Army)	ca. 1941	
SCR-538 Tank Radio Set (Army)	ca. 1941	
AN/FGC Frequency Shift Radio Teletype	1941–44	BLR, 25, p. 442
AN/ARC-1 Radio Telephone Set	1941–45	BLR, 30, p. 236
FT-241A Crystal Unit Low frequency radio control (for tank set?)	ca. 1942	BLR, 25, p. 295
Improved crystal mount, Loran	1942–45	BLR, 30, p. 433
AN/USC-2 Discrete Address System (Navy)	1941–45	BLR, 36, p. 223

RADIO (Cont'd)

	Date	*Reference*
AN/TRC-6 Radio Equipment		
Development model	1943	BLR, 23, p. 460
Production	1944	BLR, 23, p. 461
AN/TRC-24 Radio Equipment	1954*	Mon. 2350, p. 7

ROCKETS

Rocket launchers		
Suggested (modern form)	1940	BLR, 24, p. 49
Design started	1943	BLR, 24, p. 52
First delivery	1944	
Bazooka, Hickman		
(Not a Bell System development. Hickman, BTL, was on leave for government rocket development when he developed this)	1942	
Rocket-bomb, Hickman	1943	N&I Rel., 1946
Rocket mortar	1941–45	
4.5-inch rocket, fire control by BTL	1942–45	
Rocket fire control systems	1942–45	
Rocket spinner	1945–46	

TELEGRAPH

W. E. telegraph equipment in Army service (Indian Campaigns)	1870's	Story of W. E., p. 53
Cipher military printing telegraph system	1917–18	Mon. 198, p. 1
Portable Army teletypewriter	1941	BLR, 20, p. 250
Cipher TWX modernized, BTL and Teletype	1941–42	Mon. 1620, p. 2
AN/FGC Frequency Shift Radio Teletype	1941–44	BLR, 25, p. 442
Military telegraph, weather-resisting	1942	Mon. 1620, p. 2
EE-97-A TWX	1941–45	
TG-7-B TWX	1941–45	Mon. 1620, p. 3
TC-16 Reperforator Set	1941–45	
TC-3 Telegraph C.O. Set	1941–45	

* By 1954, Mon. 2330, p. 1; 1955, BLR, 33, p. 274

	Date	*Reference*
BD-100 TWX Switchboard	1941–45	
TG-30 Repeater	1941–45	
TG-31 Repeater	1941–45	
X-61824-A Repeater	1941–45	Mon. 1620, p. 3
X-66031-A Regenerative Repeater	1941–45	
CF-2 Tactical Terminal	1941–45	
CF-6 Tactical Terminal	1941–45	
UN (Navy) short-haul radio TWX	1941–45	Mon. 1620, p. 5
UF (Navy) short-haul radio TWX	1941–45	
42B1 (Army) short-haul radio TWX	1941–45	Mon. 1620, p. 6
AN/FGC-1 single-channel long-haul radio TWX	1941–45	
FRF (Navy) Frequency Shift Receiver, TWX	1941–45	Mon. 1620, p. 8
AN/TRA-7 Frequency Shift Unit	1941–45	Mon. 1620, p. 9

TELEPHONE

Field telephone set	1917–1918	Some War-Time Contrib. to Sci., Advnct., p. 24
Dial PBX, U.S.S. Saratoga and Lexington	1929	BLR, 8, p. 458
EE8 Field Telephone Set	1941–45	N&I Rel., 10/51
Spiral 4 Cable	by 1943	BLR, 21, p. 251
Alcan Highway line	1943	Circuits for Victory, p. 35
Wire-laying by airplane, experiment	1944	BLR, 23, p. 145
Telephone receiver		
Standard ANB (Army, Navy, British)	by 1945	BLR, 23, p. 194
Audiphone type	by 1945	BLR, 23, p. 195
Microphone		
Throat	by 1945	
Noise-shield	by 1945	BLR, 23, p. 196
Oxygen-mask	by 1945	
Lip	by 1945	BLR, 23, p. 197

TELEPHONE (Cont'd)

	Date	*Reference*
Use of telephones in Naval ships	by 1945*	BLR, 23, p. 130
United Nations Conference service (pre-peace conference)	1945	BLR, 23, p. 208
Air Force facsimile network	1947	Mon. 2045, p. 13
4-Channel improved military Spiral 4	1945–51	BLR, 29, p. 221
12-Channel improved military Spiral 4	1945–51	
Dispatcher's PBX Switchboard, 508A First use, Bonneville Power Administration	1953	BLR, 34, p. 261
AN/TCC-3 Cable Carrier Equipment, 4-channel	1954	Mon. 2350, p. 1
AN/TCC-5 Cable Carrier Equipment, repeatered 4-channel	1954	
AN/TCC-7 Cable Carrier Equipment, 12-channel	1954	Mon. 2350, p. 2
AN/TCC-8 Cable Carrier Equipment, attended repeater	1954	
AN/TCC-11 Cable Carrier Equipment, unattended repeater	1954	
Military carrier system, 4 or 12 channel, up to 1000 miles extent	1955	N&I Rel., 2/21/55
Port Angeles-Ketchican, Alaska, submarine telephone cable	1955	BLR, 33, p. 358
Cape Canaveral, Florida–Puerto Rico submarine telephone cable, military missile range	1955	BLR, 33, p. 437

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* The number of telephones on naval vessels, by class:

Battleship, Iowa class	1956
Carrier, Essex class	1358
Light Cruiser, Cleveland class	902
Destroyer, Fletcher class	230
Destroyer Escort	169
Attack Transport	200
LST (Landing Ship, Tank)	63
LSM (Landing Ship, Medium)	32
LCI (Landing Craft, Infantry)	11
MTB (Motor Torpedo Boat)	10

MISCELLANEOUS

	Date	*Reference*
Portable field vacuum tube test set	1917–18	Some War-Time Contrib. to Sci. Advnct., pp. 4, 6, 8
Measuring equipment	1917–18	
Portable frequency standard for clock (proved superior to Arlington time in bad weather, in U.S.S. Barracuda tests in West Indies)	1939	BLR, 18, May, p. vi
Ribbon-frame camera	1941–45	BLR, 23, p. 40
Mine-clearing snake	1941–45	N&I Rel., 1946 BLR, 25, p. 270
Mine fuses, Navy, magnetic	1941–45	
Airborne magnetometer (Magnetic Airborne Detector–MAD) Developed by BTL	before 1942	Mon. 1478, p. 1
Optical proximity fuse started	1942	BLR, 25, p. 71
AN/ASQ-3 Airborne Magnetometer (Magnetic Airborne Detector–MAD)	1942–45	BLR, 25, p. 142 Mon. 1478, p. 1
AN/ASQ-3A Airborne Magnetometer	1942–45	Mon. 1478, p. 1
Flame thrower fire control system	1942–45	N&I Rel., 1946
Snooperscope	1943	BLR, 23, p. 219
High Frequency Oscilloscope		
BC910A (Army)	1943	BLR, 26, p. 69
BC1087A (Army)	1943	
CW60AAY (Navy)	1943	
TS34/AP (Army)	1943	
D-151326 (Army)	1943	BLR, 26, p. 70
6AK5 Vacuum Tube (developed from W. E. 384A)	1943	Mon. 1952, p. 1
AN/USC-2 Discrete Address System (Navy)	1941–45	BLR, 36, p. 223
Wide screen antenna, Air Force Trial installation	1955	BLR, 34, p. 37
Special tracking camera	by 1956	BLR, 34, p. 137
Transistors in new military telephone system Available	1956	BLR, 34, p. 207

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