UNIVERSIDADE ESTADUAL DE CAMPINAS

INSTITUTO DE FÍSICA “GLEB WATAGHIN”

F 609 – TÓPICOS DE ENSINO DE FÍSICA I

Coordenador: Profº Dr. Jose Joaquín Lunazzi

TELEFONE COM DIAPASÃO: UMA DAS PATENTES DE ALEXANDER GRAHAM BELL

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1) RESULTADOS ATINGIDOS

Após a coleta dos materiais necessários e a busca por fontes de informação sobre o tema, foram alcançados como resultados uma bem-sucedida realização do experimento do telefone com diapasão e uma discussão da parte histórica envolvida no surgimento do telefone. Ou seja, foi possível, assim como fez originalmente Alexander Graham Bell, transmitir o som de um diapasão através de fios elétricos e ouvi-lo com o auxílio de um alto-falante; e realizar um trabalho sobre a evolução das telecomunicações focado principalmente no telefone e nos protagonistas de seu desenvolvimento. Deve-se ressaltar que, ao menos a priori, não há restrições no que diz respeito ao público-alvo deste trabalho.

2) FOTOS DA EXPERIÊNCIA

Seguem logo abaixo as fotos dos materiais utilizados:

Figura 1: Diapasão de garfo

Figura 2: Bateria de 9 Volts

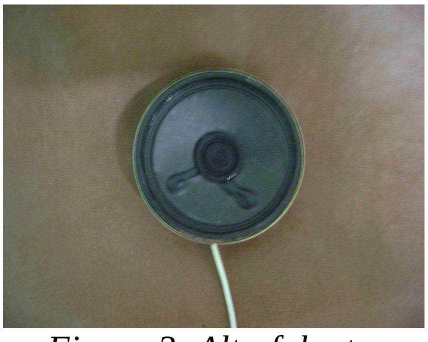

Figura 3: Alto-falante

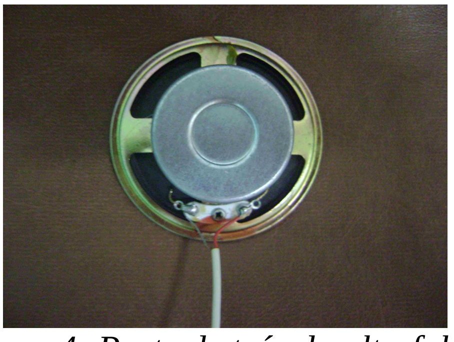

Figura 4: Parte de trás do alto-falante

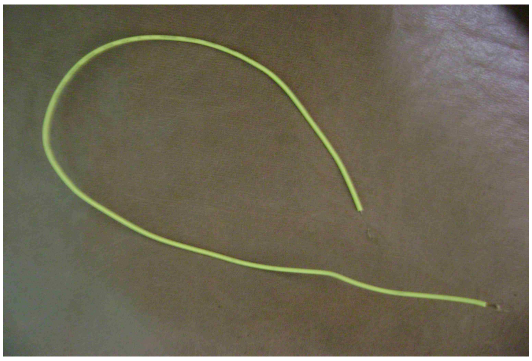

Figura 5: Tipo de fio elétrico usado

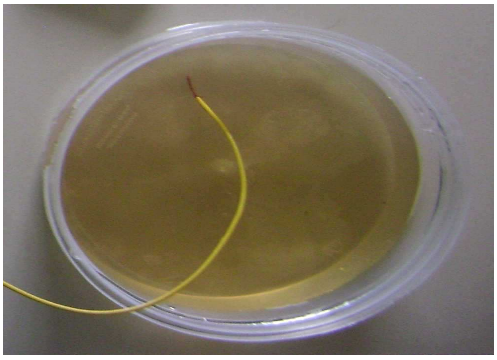

Figura 6: Recipiente com água e vinagre

Com os materiais acima, montamos o experimento:

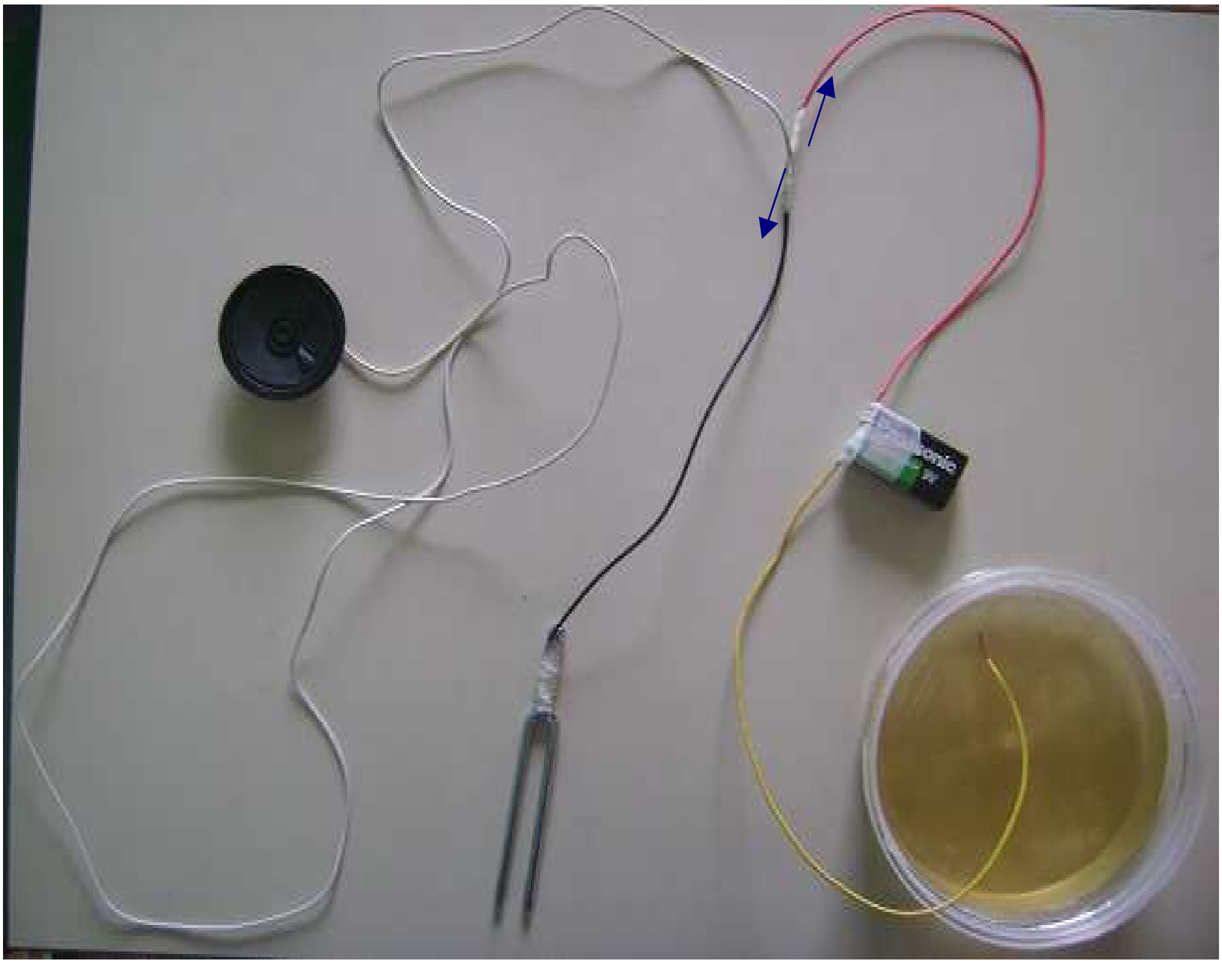

Figura 7: Montagem experimental – as setas azuis indicam que dois fios compõem o fio branco do alto-falante, um deles deve ser ligado ao diapasão e o outro à bateria

3) DIFICULDADES ENCONTRADAS

Na etapa de coleta de materiais houve certa dificuldade em encontrar um alto-falante que pudesse ser usado, então, o retiramos de uma “caixinha” de som (de computador). Os outros materiais foram encontrados com razoável facilidade: o diapasão foi comprado em uma loja de instrumentos musicais e a bateria num supermercado; os fios (três pequenos pedaços) foram conseguidos com um eletricista. Houve dificuldade também na montagem do experimento: é preciso observar bem a maneira como os componentes do circuito são interligados, em especial o alto-falante, que, como pode ser visto na *figura 4*, possui dois fios conectados a ele, os quais devem ser conectados a dois elementos diferentes do circuito.

Para a realização da discussão histórica talvez a maior dificuldade tenha sido filtrar as informações mais confiáveis, pois há grande disponibilidade de fontes, principalmente na internet. Além disso, boa parte das referências está em inglês, o que requer certo conhecimento dessa língua.

4) PESQUISA REALIZADA - REFERÊNCIAS

Através do website de busca “Google” foram encontradas referências utilizando como palavras-chave (em português e em inglês): “Alexander Graham Bell”, “invenção do telefone”, “história do telefone”, “Antonio Meucci”, “telefone com diapasão”, “experimentos de Bell” e “patentes do telefone”. Além disso, alguns desses websites visitados fornecem links para outros websites que também tratam do assunto. A referência [1] foi encontrada através de uma busca no website do Sistema de Bibliotecas da Unicamp e as referências [54], [55] e [56] através de uma busca no website da SpringerLink (http://www.springerlink.com).

A seguir são explicitadas brevemente as funções de cada referência. Todas as páginas virtuais foram acessados pela última vez em 05/11/09 por volta das 17 horas e algumas delas ([4], [6], [9], [10], [11], [12], [14], [16], [18], [28], [31], [32], [33], [34], [35], [36], [37], [43], [50] e [53]) constituem o apêndice deste relatório.

[1] SHIPPEN, Katherine Binney. **Alexander Graham Bell.** Tradução de Neil R. da Silva. Volume 4. Belo Horizonte: Difusão Pan-Americana do Livro, 1964. – *narra, inclusive, através de diálogos, a história de Bell a partir de sua chegada à Boston em 1871 (em português).*

[2] http://www.juliantrubin.com/bigten/telephoneexperiments.html - *fala sobre a invenção do telefone e sobre dois dos experimentos de Bell, inclusive o com diapasão (em inglês).*

[3] http://www.kidcyber.com.au/topics/agbell.htm - *fala um pouco sobre Meucci e o reconhecimento dado à ele na invenção do telefone (em inglês).*

[4] http://en.wikipedia.org/wiki/Alexander_Graham_Bell - VER APÊNDICES - *descrição detalhada sobre a vida de Bell (em inglês).*

[5] http://pt.wikipedia.org/wiki/Alexander_Graham_Bell - *pequena biografia de Bell (em português).*

[6] http://www.ieee.org/web/aboutus/history_center/biography/bell.html - VER APÊNDICES - *biografia de Bell (em inglês).*

[7] http://www.independenciaoumorte.com.br/node/1864 - *biografia de Bell (em português).*

[8] http://www.antiquetelephonehistory.com/scienceliquid.html - *fala sobre o experimento do transmissor líquido, realizado por Bell após o experimento com diapasão (em inglês).*

[9] http://atcaonline.com/phone/sciencefork.html - VER APÊNDICES - *descrição um pouco mais detalhada sobre o experimento com diapasão (em inglês).*

[10] http://en.wikipedia.org/wiki/Invention_of_the_telephone - VER APÊNDICES - *fala sobre a invenção do telefone e sobre diversos personagens dessa história (em inglês).*

[11] http://en.wikipedia.org/wiki/Canadian_Parliamentary_Motion_on_Alexander_Graham_Bell - VER APÊNDICES - *fala sobre o reconhecimento de Bell como o inventor do telefone, o qual foi reiterado pelo Canadá recentemente (em inglês).*

[12] http://www2.iath.virginia.edu/albell/introduction.html - VER APÊNDICES - *descrição dos trabalhos de Bell envolvidos com a invenção do telefone (em inglês).*

[13] http://www2.uol.com.br/debate/1109/cadd/cadernod05.htm - *fala sobre o reconhecimento recente nos EUA da invenção do telefone por Meucci e não por Bell (em português).*

[14] http://www.guardian.co.uk/world/2002/jun/17/humanities.internationaleducationnews - VER APÊNDICES - *matéria do dia 17 de junho de 2002 do jornal britânico "The Guardian" sobre o reconhecimento nos EUA de Meucci como o inventor do telefone (em inglês).*

[15] http://en.wikipedia.org/wiki/Tuning_fork - *explica o que é, como funciona e como calcular a freqüência de um diapasão (em inglês).*

[16] http://www.fisica.net/feirasdeciencias/telefone_de_bell.php - VER APÊNDICES - *descrição resumida do experimento com diapasão (em português).*

[17] http://www.acoustics.org/press/156th/korman.html - *fala sobre demonstrações utilizando o som e, muito brevemente, sobre o experimento com diapasão (em inglês).*

[18] http://www.scitechantiques.com/belltelephone/pages/Variable_Restance_Microphones.htm - VER APÊNDICES - *fala um pouco sobre microfones de resistência variável, inclusive sobre o experimento com diapasão (em inglês).*

[19] http://pt.wikipedia.org/wiki/Antonio_Meucci - *pequena biografia de Meucci (em português).*

[20] http://en.wikipedia.org/wiki/Elisha_Gray - *fala sobre Elisha Gray que também é tido por alguns como inventor do telefone (em inglês).*

[21] http://www.ufsm.br/gef/Ondas16.htm - *fala sobre ondas e a física da música (em português).*

[22] HALLIDAY, D.; RESNICK, R.; WALKER, J.. **Fundamentos de Física.** Volume 3, 6ª edição. Rio de Janeiro: Livros Técnicos e Científicos Editora, 2002. – *fala no capítulo 27 sobre corrente e resistência elétrica (em português).*

[23] http://www.school-for-champions.com/senses/hearpitch.htm - *fala sobre as freqüências sonoras ouvidas por diferentes animais (em inglês).*

[24] http://www.scitechantiques.com/belltelephone/index.htm - *traz algumas datas importantes para a construção do telefone e contém muitas fotos interessantes (em inglês).*

[25] http://www.nossosaopaulo.com.br/Reg_SP/Barra_Escolha/B_AntonioMeucci.htm - *biografia de Meucci (em português).*

[26] http://pt.wikipedia.org/wiki/Telefone - *define o telefone e trata um pouco da história dele (em português).*

[27] http://www.privateline.com/TelephoneHistory/History1.htm - *descrição longa e detalhada sobre a história do telefone (em inglês).*

[28] http://members.fortunecity.com/cibercultura/vol11/vol11_richardwise.htm - VER APÊNDICES - *trata da evolução da rede multimídia, inclusive da telefonia (em português).*

[29] http://telefonesdotempo.blogspot.com/ - *fala sobre a vida de Graham Bell e contém muitas fotos de telefones antigos (em português).*

[30] http://www.modulatedlight.org/Modulated_Light_DX/ModLightBiblio.html - *percurso histórico das comunicações através da óptica (em inglês).*

[31] http://www.lifeinitaly.com/heroes-villains/antonio-meucci.asp - VER APÊNDICES - *fala sobre Meucci e a invenção do telefone (em inglês).*

[32] http://hnn.us/articles/802.html - VER APÊNDICES - *matéria do dia 20 de junho de 2002 da History News Network que fala sobre o reconhecimento dado à Meucci na invenção do telefone e traz a resolução original do Congresso dos EUA (em inglês).*

[33] http://www.nap.edu/html/biomems/abell.pdf - VER APÊNDICES - *biografia de Bell que consta na National Academy of Sciences (NAS) dos EUA (em inglês).*

[34] http://www.google.com/patents?id=crhRAAAAEBAJ&printsec=abstract&zoom=4&source=gbs_overview_r&cad=0#v=onepage&q=&f=false - VER APÊNDICES - *patente nº 174.465 dos EUA: original de Bell para o telefone (em inglês).*
[35] http://www.fundacaotelefonica.org.br/museu/O-telefone-alexander-graham-bell.aspx - VER APÊNDICES - *fala sobre os trabalhos de Bell relacionados ao telégrafo e ao telefone (em português).*
[36] http://www.fundacaotelefonica.org.br/museu/Linha-do-tempo.aspx - VER APÊNDICES - *linha do tempo dos fatos que estão envolvidos com a telefonia (em português).*
[37] http://www.fundacaotelefonica.org.br/museu/Personagens.aspx - VER APÊNDICES - *fala sobre alguns dos personagens da história do telefone (em português).*
[38] http://www.fundacaotelefonica.org.br/museu/Funcionamento.aspx - *fala sobre a transmissão do som pelo ar (em português).*
[39] http://www.museumphones.com/index.shtml - *website de um museu do telefone (em inglês).*
[40] http://www.antiquetelephonehistory.com/ - *website que contém muitas informações sobre o desenvolvimento do telefone (em inglês).*
[41] http://www.taolongetaoperto.org.br/Web/a-exposicao/nucleo-ciencia-tecnologia.aspx - *fala um pouco sobre os processos de inovação e desenvolvimento humano (em português).*
[42] http://www.siemens.com.br/templates/coluna1.aspx?channel=2935 - *cita alguns fatos que marcaram a história das telecomunicações (em português).*
[43] http://super.abril.com.br/superarquivo/2005/conteudo_125529.shtml - VER APÊNDICES - *breve linha do tempo da história das comunicações (em português).*
[44] http://www.uunhf.org/unitarian/famous/Alexander_Graham_Bell.jpg - *foto de Bell em cores.*
[45] http://en.wikipedia.org/wiki/Photophone - *fala sobre o fotofone, criado por Bell e precursor das fibras ópticas (em inglês).*
[46] http://www.utdallas.edu/~rms023000/Beginnings.html - *linha do tempo das fibras ópticas (em inglês).*
[47] http://en.wikipedia.org/wiki/Telegraphy - *fala sobre o telegrafo (em inglês).*
[48] http://www.del.ufms.br/PCI_T1/G9/TrabalhoTelegrafo/TelegrafoIndexMurilo.htm - *trabalho sobre o telégrafo (em português).*
[49] http://www.if.ufrgs.br/fis/EMVirtual/crono/morse.html - *fala sobre o telégrafo de Morse (em português).*
[50] http://www.fi.edu/learn/case-files/edison/telephone.html - VER APÊNDICES - *breve comentário sobre o transmissor de telefone criado por Thomas Edison (em inglês).*
[51] http://en.wikipedia.org/wiki/Thomas_Edison - *biografia de Thomas Edison, o qual ajudou a aperfeiçoar o telefone de Bell (em inglês).*
[52] http://imagecache5.art.com/p/LRG/20/2019/9XG4D00Z/portrait-of-thomas-edison.jpg - *imagem de Thomas Edison em cores.*
[53] http://www.thomasedison.com/Inventions.htm - VER APÊNDICES - *acontecimentos importantes da vida de Thomas Edison (em inglês).*

[54] PAVATE, K. D.. **Thomas Alva Edison Contributions to Entertainment and Communications.** Resonance, Vol 5, nº 1, Springer India in co-publication with Indian Academy of Sciences, Janeiro 2000. http://www.springerlink.com/content/034k860566120m98/fulltext.pdf - *artigo do periódico de educação em ciências "Resonance" que fala sobre Thomas Edison (em inglês).*
[55] TAYLOR, A.; VINCENT, J.. **Mobile World Past Present and Future.** Springer London, 2005.
http://www.springerlink.com/content/u36l3640843t7413/fulltext.pdf - *capítulo do livro "Mobile World", que fala sobre telefone e, mais especificamente sobre telefonia celular (em inglês).*
[56] GORMAM, M. E.; ROBINSON, J. K.. **Using History to Teach Invention and Design: The Case of the Telephone.** Science and Education, Volume 7, nº 2, Springer Netherlands, Março 1998.
http://www.springerlink.com/content/jw371v6707v97186/fulltext.pdf - *artigo da revista "Science and Education" que fala sobre o uso da história do telefone no ensino (em inglês).*
[57] http://www.ca.ufsc.br/qmc/alunos/trabalhos1anos/vinagre/vinagre.htm - *fala sobre o vinagre, o qual é um dos "materiais" utilizados no experimento (em português).*

5) DESCRIÇÃO DO TRABALHO

Introdução

Desde a antiguidade, os povos se preocupam, dentro das possibilidades conhecidas à época, em se comunicar da maneira mais ágil e eficiente. Como resultado dessa antiga e permanente necessidade, a contínua evolução das telecomunicações promoveu e continua a promover o encurtamento das distâncias geográficas e a redefinição de relacionamentos sociais e estruturas urbanas em todo o planeta.

Talvez, juntamente com a internet, o maior representante contemporâneo dessa realidade seja o telefone moderno, que é produto da contribuição de diversos pesquisadores, diversas mentes trabalhando em paralelo, as quais, ao longo da história, despontam como grandes aglutinadoras de conhecimentos. Ou seja, diferentemente do que muitas vezes pensamos, as invenções e inovações não são eventos pontuais, pois surgem a partir de um processo de maturação de ideias e de um esforço coletivo que busca proporcionar determinado avanço em relação ao que se tem à época. [41]

Apesar disso, até hoje há uma enorme discussão sobre quem, de fato, inventou o primeiro telefone: embora Alexander Graham Bell tenha sido o primeiro a patenteá-lo como um “aparato para transmitir voz e outros sons telegraficamente” e, por isso, costumeiramente levar o crédito pela invenção, em 2002, nos EUA, foi reconhecido que Antonio Meucci já o havia criado. [2] [3]

Os primórdios da comunicação e o telégrafo

As maneiras de se comunicar usando sinais, como a linguagem escrita e falada, passaram por inúmeras transformações ao longo do tempo. Os povos antigos costumavam se comunicar utilizando artifícios naturais e engenhosidades, como fumaça e bandeiras. Estima-se que as primeiras inscrições em cavernas datam de 8000 anos antes de Cristo. Posteriormente, mensageiros e pombos-correio passaram a ser as estratégias adotadas. Porém, esses recursos não permitiam uma comunicação rápida à distância. Por volta de 1450, apareceram os jornais impressos na Europa e, no fim do século XVIII, uma significativa evolução é alcançada com o telégrafo, que permite a transmissão de mensagens escritas à distância. Muitas pessoas trabalharam nessa área e por volta de 1835, o telégrafo elétrico é criado por Samuel Morse. O famoso sistema de signos “código Morse” permitia enviar e depois “decifrar” as mensagens, ou seja, interpretar, o que as linhas traçadas pelo telégrafo significavam. O sistema era usado principalmente por grandes companias, homens de negócios e pessoas ricas que sabiam operar a máquina e conheciam o código Morse. Porém, havia algumas características passíveis de melhora no telégrafo, como, por exemplo, o fato de as conversas não serem instantâneas, diretas, isto é, levava certo tempo para decifrar as mensagens. Mesmo assim, ele obteve considerável e rápido sucesso devido, em boa parte, a aperfeiçoamentos realizados por outros cientistas. Em 1860, o alemão Johann Philipp Reis criou um aparelho elétrico com o qual era possível transmitir música cantada à distância, mas, embora as notas musicais da melodia pudessem ser distinguidas (as diferentes freqüências), as variações de intensidade do som, as características da voz do cantor e as palavras não eram reproduzidas. Ou seja, era, essencialmente, um tipo de telégrafo que, ao invés de enviar sinais batendo com o dedo sobre um interruptor, enviava sinais a partir da vibração de uma membrana, a qual batia no interruptor. Pode-se dizer, então, que Reis inventou o primeiro aparelho para transmitir sons à distância por meio da eletricidade. Os anos foram se passando e com o advento do telefone, foi possível transmitir também a voz à distância. Com isso, o telégrafo experimentou acentuado declínio, especialmente no século XX, afinal, o telefone permite conversas diretas e não requer o conhecimento de sistemas de signos que não a própria linguagem falada. [35] [37] [43] [47] [48] [49] [55]

Sobre Bell e o telefone

Alexander Graham Bell nasceu em Edimburgo, Escócia, em 1847. Foi o segundo dos três filhos de seus pais. Sua mãe pintava retratos e era musicista, seu pai era professor e ensinava surdos-mudos a falar e a escrever através de um método aperfeiçoado por ele (“linguagem visível”). Bell cresceu circundado por um ambiente de estudo da voz e dos sons e se interessou por esse campo seguindo os passos do pai. Após a precoce morte por tuberculose de seus irmãos mais novo e mais velho, Bell, que já havia concluído seus estudos na Universidade de Edimburgo, se mudou juntamente com os pais, em 1870, para o Canadá. Aperfeiçoou-se em anatomia humana para melhor conhecer os órgãos da fala e da audição, o que interessava à sua profissão de professor de crianças mudas e de califasia (correção de defeitos da fala). Foi aos EUA à convite para ensinar o método de ensino do pai e após algum tempo se tornou professor de Fisiologia Vocal e Elocução na universidade de Boston. Gostava de seu trabalho como professor, mas esperava ansiosamente a noite, quando fazia em sua casa experiências com vibrações no ar. As pesquisas de Bell se basearam inicialmente nos trabalhos de Helmholtz, que havia mostrado como era possível sintetizar sons articulados a partir de notas musicais, ou seja, que diferentes notas musicais podem ser usadas para enviar diferentes mensagens telegráficas ao mesmo tempo e por um único fio, ou seja, um “telégrafo harmônico”. Porém, paralelamente, Bell levava consigo o pensamento de que se pudesse transmitir notas musicais através da eletricidade, conseguiria, também, transmitir a voz. Tendo como grande auxiliar Thomas Watson, um empregado de uma oficina elétrica de Boston que gostava e havia estudado eletricidade, Bell, após muitos experimentos, entrou com o pedido de patente para o projeto de um “telégrafo acústico” em fevereiro de 1876. No mês seguinte, Bell teve a confirmação de sua patente e, ainda em março de 1876, conseguiu enviar e ouvir o som de um diapasão conectado a um circuito elétrico simples. Bell estava certo de que poderia agora, então, enviar a voz humana por meio de um fio de telégrafo. A célebre frase: “Senhor Watson, venha aqui, quero te ver”, marca a primeira bem sucedida ligação telefônica desenvolvida por Bell naquele mesmo mês de 1876. Em junho desse ano, na Filadélfia, ele apresentou seu invento na Feira do Centenário da Independência dos EUA. Entre os convidados de honra do evento estava D. Pedro II, imperador do Brasil, o qual, assim como os juízes, elogiou muito o telefone. Apesar disso, os jornais da época classificavam o telefone como um brinquedo. Bell passava por dificuldades financeiras e tentou vender a patente para a compania telegráfica, que não se interessou. Em 1877, casa-se e vai para a Europa, onde realiza diversas conferências e demonstrações, inclusive para a rainha da Inglaterra. Volta aos EUA para defender juridicamente sua patente e se torna um dos sócios fundadores da Bell Telephone Company. Nos arredores de Boston houve rápido crescimento do telefone e, em 1915, ele já interligava as costas leste e oeste dos EUA. No Brasil, o primeiro telefone foi instalado já em 1877, no Rio de Janeiro e, em 1878, foi instalado nos EUA o primeiro telefone público. Outros cientistas contribuíram para o aperfeiçoamento do telefone de Bell, destaque para Thomas Edison, que desenvolveu um transmissor melhor *(ver seção: "Thomas Edison e o telefone")*. Dando continuidade às suas pesquisas no ramo das comunicações, Bell patenteou o fotofone, que é o precursor das modernas fibras ópticas, pois permite a transmissão da fala por meio da luz *(ver seção: "Um pouco sobre o fotofone")*. Ao todo existem trinta patentes em seu nome (doze delas divididas com colaboradores), as quais abrangem também outras áreas como a aviação. Após uma vida dedicada à trabalhos científicos, Bell morreu em agosto de 1922. [1] [4] [5] [6] [7] [8] [9] [35] [36] [37] [42] [56]

A guerra das patentes

Muitas pessoas, além de Graham Bell, reivindicam a invenção do telefone, destaque para o estadunidense Elisha Gray e o italiano Antonio Meucci que, por volta de 1855 nos EUA, teria instalado a primeira linha telefônica da história para se comunicar à distância com sua esposa parcialmente paralisada. O invento de Meucci foi noticiado em 1861 pelo jornal "L'Eco d'Italia", publicado por italianos em Nova York. Por ausência de recursos financeiros, ele não teria obtido a patente final de seu "teletrofone" – aparelho de transmissão da voz à distância através da eletricidade. Elisha Gray, que também trabalhava com pesquisas na área, entrou no mesmo dia em que Bell submeteu uma patente para seu projeto, com um pedido preliminar de patente ("caveat") para um aparelho de transmissão elétrica de voz, um "telégrafo falante". Porém, o documento de Bell cobria o tema transmissão da voz e explicitava a possibilidade de trabalhar com resistências variáveis para criar correntes ondulatórias. Devido a isso, o escritório de patentes declarou interferência entre os documentos e ao final do processo, a patente foi concedida, por ter chegado antes, à Bell, que foi, então, acusado por muitos de ter roubado as ideias. Especula-se que as conversas de Bell com o examinador de patentes possa ter mudado a direção de suas experiências, que passaram a buscar soluções pela eletricidade e não pela acústica. À época, ao todo cerca de 600 processos foram movidos contra Bell, porém, todos os vereditos foram em seu favor. Porém, em 2002, nos EUA, as contribuições de Meucci na invenção do telefone foram reconhecidas *(ver abaixo a tradução da resolução)* devido à existência de evidências que mostram que ele já utilizava e demonstrava o funcionamento do aparelho antes de Bell, Gray e outros. Apesar disso, alguns dias após esse reconhecimento, Bell foi reiterado no Canadá como o inventor do telefone. É provável que a discussão nunca acabe, pois todos os lados têm argumentos a seu favor. Tendo isso em vista, resta-nos apenas a possibilidade de agradecer à todos que contribuíram para o desenvolvimento das telecomunicações. [1] [4] [5] [10] [11] [12] [13] [14] [36] [37] [56]

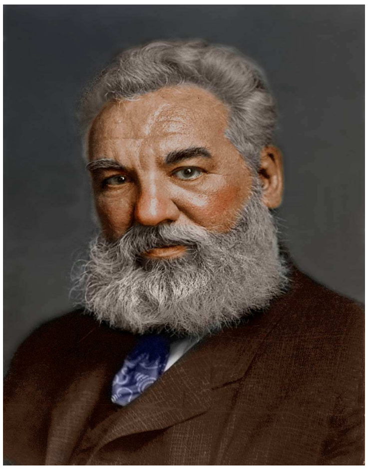

Figura 8: Retratos de Bell [44], Meucci [19] e Gray [20], respectivamente.

Tradução da Resolução do Congresso dos EUA sobre Meucci (a partir da referência [32])

Resolução 269
Câmara dos Deputados do Congresso Americano
11 de junho de 2002

Considerando que Antonio Meucci, o grande inventor italiano, teve uma carreira que foi tanto extraordinária quanto trágica;

Considerando que, quando imigrou para Nova York, Meucci continuou a trabalhar com vigor incessante em um projeto que havia iniciado em Havana, Cuba, uma invenção que mais tarde ele denominaria "teletrofono" e que envolvia comunicação eletrônica;

Considerando que Meucci estabeleceu uma forma rudimentar de comunicação em sua casa em Staten Island, que conectava o porão com o primeiro andar, e que depois, quando sua esposa passou a sofrer de artrite deformante, ele criou uma conexão permanente entre seu laboratório e o quarto de sua esposa, no segundo andar.

Considerando que, tendo esgotado a maior parte de suas economias no desempenho de seu trabalho, Meucci ficou impossibilitado de comercializar sua invenção, apesar de tê-la demonstrado em 1860 e de ter a sua descrição publicada em um jornal de língua italiana em Nova York;

Considerando que Meucci nunca aprendeu inglês bem o bastante para circular pela complexa comunidade dos negócios americanos;

Considerando que Meucci foi incapaz de levantar fundos suficientes para ele próprio registrar a patente de sua invenção, tendo que se contentar com uma intenção de patente, requerida pela primeira vez em 28 de dezembro de 1871, e que deveria ser renovada anualmente.

Considerando que Meucci depois ficou sabendo que o laboratório filiado à Western Union relatou a perda dos seus protótipos, e Meucci, que àquela altura já vivia com auxílio de assistência social, foi incapaz de renovar a intenção de patente depois de 1874;

Considerando que em março de 1876 Alexander Graham Bell, que realizava experiências no mesmo laboratório onde os materiais de Meucci estavam armazenados, conseguiu a patente e posteriormente o crédito por haver inventado o telefone;

Considerando que em 13 de janeiro de 1887 o Governo dos Estados Unidos solicitou a anulação da patente concedida a Bell por fraude e falsa declaração, uma causa que a Suprema Corte julgou procedente e passível de julgamento;

Considerando que Meucci faleceu em outubro de 1889, a patente de Bell expirou em 1983, e a causa foi suspensa sem nunca ter sido atingida a questão subjacente do verdadeiro inventor do telefone com direito à patente; e

Considerando que, se Meucci tivesse sido capaz de pagar a taxa de US$ 10 para manter a intenção de patente depois de 1874, nenhuma patente poderia ter sido concedida a Bell: agora, por conseguinte, fica aqui

Decidido que é do entendimento desta Câmara dos Deputados que deve-se dar apreço à vida e às realizações de Antonio Meucci, e seu trabalho para a invenção do telefone deve ser reconhecido.

Thomas Edison e o telefone

O telefone, desenvolvido por Bell em 1876, convertia as ondas sonoras da voz humana em impulsos elétricos, os quais eram conduzidos por um fio e convertidos de volta para a voz humana. Seu transmissor original era feito de uma membrana que vibrava em resposta às ondas sonoras. Um botão de metal conectado à membrana enviava os movimentos variados à um ímã e uma corrente elétrica correspondente às vibrações era induzida. Essa corrente induzida ia para o dispositivo receptor, onde o processo era revertido, ou seja, a eletricidade causava o movimento de um ímã que, então, fazia vibrar uma membrana emitindo o som original. Porém, havia um problema: o transmissor não era suficientemente sensível - a fraca intensidade do sinal elétrico limitava a qualidade e a distância da mensagem. Localizando-se aí, a contribuição de Thomas Alva Edison, cientista, inventor e homem de negócios nascido nos EUA em 1847 e considerado por muitos o mais produtivo inventor da história, possuindo mais de 1000 patentes só nos EUA. Edison é tido, também, como um dos precursores da revolução tecnológica do século XX, visto que ajudou a sociedade a avançar da "Era do Vapor" para a "Era da Eletricidade". Seus trabalhos visavam, sobretudo, aplicar na prática a ciência desenvolvida. Certamente, algumas de suas valiosas ideias amadureceram durante seu trabalho como operador de telégrafo Morse. Entre os anos de 1876-1878 (mais ou menos na mesma época em que trabalhava no desenvolvimento da lâmpada), Edison trabalhou para melhorar o transmissor do telefone de Bell, o qual foi substituído por um disco granular de carbono (carvão) comprimido colocado entre placas de metal, ou seja, um microfone de carbono - a resistência elétrica do carbono é muito sensível às variações de pressão causadas pelas ondas sonoras, o que faz a corrente flutuar mais "fielmente" com o som. Isso possibilitou que o som reproduzido tivesse boa intensidade e pudesse ser ouvido claramente, o que contribui muito para o sucesso comercial do telefone. Esse microfone transmissor foi componente básico do telefone até por volta da década de oitenta do século XX, ou seja, durante mais ou menos cem anos, tendo sido substituído por microfones elétricos. Além disso, essa invenção auxiliou no desenvolvimento do rádio e de diversos dispositivos elétricos como os transistores. Outras das invenções de Edison são: a lâmpada elétrica incandescente, o fonógrafo (similar ao telégrafo, mas, ao invés da grafia, reproduz sons por processos mecânicos), a primeira câmera cinematográfica bem-sucedida e

Figura 9: Retrato de Thomas Edison [52]

um aparelho elétrico para votação (espécie de urna eletrônica). Foi, também, o primeiro a gravar fala e música em um meio que se movimenta mecanicamente - princípio de reprodução de música que continua a ser utilizado de forma muito melhor, é claro, nos “compact discs” (CD’s). [50] [51] [53] [54]

Um pouco sobre o fotofone

Após ter sucesso na transmissão da fala através da eletricidade, Bell tentou transmiti-la através da luz (onda eletromagnética). E obteve sucesso. Com a ajuda de seu assistente Charles Tainter, em 1880 ele transmitiu a primeira mensagem telefônica sem a utilização de fios, utilizando apenas feixes de luz solar. Seu “fotofone”, como foi denominado, utilizava células cristalinas de selênio no ponto focal de um receptor parabólico. A resistência elétrica do selênio varia inversamente com a luminosidade, isto é, sua resistência é maior no escuro e menor quando é exposto à luz. A ideia básica do fotofone é iluminar as células de selênio (as quais convertem a energia luminosa em corrente elétrica) com um raio de luz modulante, fazendo, assim, com que a resistência elétrica e consequentemente a corrente elétrica variem. Com a ajuda de um receptor telefônico é possível, então, regenerar os sons capturados. O raio de luz utilizado era modulado mecanicamente pelas ondas sonoras da voz através de um espelho fino vibrante que podia variar de côncavo a convexo, isto é, um espelho que podia focar ou dispersar a luz. Em suma, o telefone e o fotofone partem do mesmo princípio, porém, um utiliza a eletricidade e o outro a luz. Quatro das trinta patentes de Bell dizem respeito ao fotofone, o qual era considerado por ele sua principal invenção, apesar de sua relevância não ser reconhecida à época. Bell pensava que o fotofone poderia ser usado, por exemplo, por navios em alto mar e via como sua maior vantagem em relação ao telefone a não necessidade de instalação de linhas telefônicas. Porém, isso se mostrou impossível devido a problemas oriundos na transmissão da luz: interferências externas como nuvens, neblina, chuva, etc, facilmente podem perturbar o sinal. Assim, até o desenvolvimento das tecnologias do laser moderno e das fibras ópticas* - que contribuíram para a segurança da transmissão da luz, o fabuloso invento de Bell foi praticamente inutilizável. [45] [46]

* Fibras ópticas são finos filamentos de vidro onde a luz viaja por um processo de reflexão interna, sendo utilizadas especialmente na telecomunicação, na medicina e na indústria. São capazes de transportar uma quantidade de informações (voz, imagens e outros tipos de dados) dezenas de milhares de vezes maior que a de um fio de cobre e numa velocidade próxima à da luz. [46]

Teoria envolvida no experimento do telefone com diapasão

Ondas sonoras são ondas mecânicas longitudinais e o que chamamos de som é a percepção auditiva de uma onda sonora. Um objeto vibrante, como a membrana de um alto-falante, por exemplo, através de seu movimento repetitivo para frente e para trás gera regiões de compressão e rarefação (variação de pressão) que se propagam como uma onda sonora. Cada movimento de "vai e vem" constitui uma oscilação. Ao se propagar, o som perde intensidade por se espalhar para todos os lados. Porém, há uma forma de evitar (ou minimizar) essa perda: fazendo com que o som se propague dentro de um tubo, similarmente ao que ocorre nos trilhos das linhas ferroviárias, que impedem que o som se disperse tornando possível, por exemplo, escutar o som de um trem que está distante. A freqüência (f) da onda é definida como o número de oscilações por unidade de tempo, já o período (T) é definido como o intervalo de tempo de uma oscilação completa. A altura do som, isto é, se ele é mais grave ou agudo é determinada pela freqüência da onda sonora: quanto maior a freqüência, mais agudo é o som. E, embora possa variar de uma pessoa para outra e com a idade, sabe-se que o ouvido humano pode captar ondas sonoras com freqüências entre cerca de 20 Hz e 20.000 Hz *(ver abaixo figura 10).* A característica do som coloquialmente conhecida como "volume" está associada à intensidade da onda, ou seja, à quantidade de energia transportada, a qual, por sua vez, é proporcional ao quadrado da amplitude da onda. Quanto à velocidade, apesar de rápidas, as ondas sonoras não são instantâneas. No ar, a velocidade delas varia entre cerca de 330 a 360 metros por segundo, dependendo da temperatura e da umidade do ar. Já na água, a velocidade do som é bem maior, em torno de 1500 metros por segundo. [21] [38].

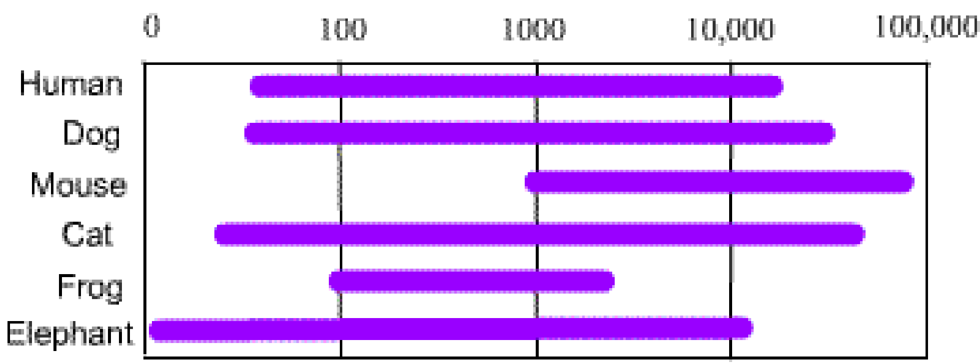

Figura 10: Faixa de freqüência sonora (em Hz) captada por diferentes animais [23]

Mas, afinal, o que é um diapasão? O diapasão é um ressonador acústico de metal em forma de U – ver *figura 1* (muitas vezes chamado de diapasão de garfo, pois já existem "diapasões digitais"). O som gerado por um diapasão quando batido em outra superfície depende do comprimento das duas partes que o formam e do material de que é feito. Foi criado no século XVIII e é usado principalmente para afinar instrumentos musicais. Um diapasão (assim como qualquer outro objeto) possui uma freqüência natural própria de oscilação. Quando forçado a oscilar com uma freqüência diferente por um impulso periódico externo, ele o fará com uma amplitude pequena. Porém, se a freqüência externa coincidir com a freqüência natural, ele oscilará com amplitude cada vez maior – esse fenômeno é denominado ressonância. [15] [21]

A corrente elétrica (i) é uma grandeza física definida como cargas elétricas em movimento ordenado. A corrente elétrica em um condutor é a quantidade de carga dq que atravessa a seção transversal dele em um intervalo de tempo dt, ou seja: $i=dq/dt$. A resistência elétrica (R) entre dois pontos quaisquer de um condutor é determinada aplicando-se uma diferença de potencial V entre esses pontos e medindo a corrente elétrica resultante (i). Assim: $R=V/i$, ou seja, a resistência elétrica é inversamente proporcional à corrente elétrica: quanto maior a resistência elétrica menor a corrente elétrica para uma dada diferença de potencial. Vemos, também, que ao variar a resistência elétrica e manter a diferença de potencial constante, estaremos variando a corrente elétrica (fato que ocorre no experimento). Uma propriedade similar à resistência elétrica mas que diz respeito à materiais e não à objetos é a resistividade elétrica (ρ) que é o inverso da condutividade elétrica (σ): $\rho=1/\sigma$. [22]

<u>O experimento do telefone com diapasão</u>

Após conseguir a patente do projeto do telefone em 1876, Bell procurou, através de um experimento provar que poderia ouvir o som produzido por um instrumento qualquer quando a variação da resistência e conseqüentemente da corrente elétrica de um circuito ocorresse na freqüência do próprio som. Para isso, ele realizou o experimento ilustrado no esquema experimental da *figura 11*, utilizando um diapasão, uma bateria, um recipiente com ácido, um receptor (alto-falante) e fios elétricos para conectar os materiais.

Figura 11: rascunho feito por Bell para o esquema experimental [18]

Figura 12: esquema com elementos identificados

O experimento de Bell funciona da seguinte maneira: aproximamos o diapasão já vibrando o mais paralelamente possível da solução ácida (condutora), de forma que ele apenas toque levemente a superfície, “fechando”, assim, o circuito elétrico. O diapasão, mesmo sem percebermos entra e sai do líquido rapidamente (a profundidade varia) fazendo com que a resistência elétrica (ou seja, a capacidade de se opor à passagem de corrente elétrica) entre ele e a solução e, conseqüentemente, a resistência elétrica do circuito, varie, o que, por sua vez, faz com que a corrente elétrica através do circuito flutue na mesma freqüência do diapasão. Logo, será possível ouvir no alto-falante conectado ao circuito o som do próprio diapasão. Bell também constatou que se aumentarmos a resistência elétrica o sinal produzido será mais fraco e que quanto menor o contato vibratório melhor o resultado. [2] [9] [16] [17] [18] [56]

Uma foto do experimento sendo realizado (original da referência [9]) é mostrada abaixo *(ver também figura 7).*

Figura 13: foto do experimento sendo realizado [9]

O diapasão por nós utilizado foi adquirido (R$ 15,00) em uma loja de instrumentos musicais e sua freqüência nominal é 440 Hz (nota musical lá). A bateria utilizada é de 9 Volts e foi adquirida em um supermercado (R$ 7,00). O alto-falante foi retirado de uma "caixinha" de som de computador e os três pequenos pedaços de fios conseguidos com um eletricista. Como dispositivo para ouvir o som, poderíamos ter usado o receptor de um telefone velho, o alto-falante de um rádio velho, ou qualquer outro aparato do gênero. A solução ácida foi feita com água e vinagre** e mantida num recipiente de plástico. As ligações devem ser feitas com atenção tendo como referência o que é ilustrado nas *figuras 7, 11, 12* e *13*. Assim, poderemos ouvir claramente o som emitido pelo diapasão através do alto-falante.

** O vinagre é um condimento antigo utilizado de diversas maneiras e que tem como um de seus principais componentes o ácido acético ou etanóico (H_3C – COOH), o qual é um ácido orgânico (apresenta o radical carboxila) e por ter apenas um hidrogênio ionizável é classificado como monoácido. O pH (nível de acidez medido pela concentração de íons H^+) do vinagre pode variar entre 2 e 3,5 (<7, ou seja, uma solução ácida) e a concentração de ácido acético nele entre 4% a 8%. Adicionar vinagre à água faz dela melhor condutora de eletricidade. [57]

Observações:

- É indiferente o pólo da bateria que será ligado ao alto-falante;
- Deve-se colocar o alto-falante próximo ao ouvido a fim de perceber nitidamente o som do diapasão;
- O fio que sai de um dos pólos da bateria, em nosso caso, deve ser deixado dentro da solução ácida, pois o recipiente não é metálico, ou seja, só poderíamos deixar o fio encostado na parede do recipiente se este fosse metálico (condutor de eletricidade);
- Deve-se colocar o diapasão (já vibrando) o mais paralelamente possível da solução ácida, fazendo, porém, com que apenas um dos lados do garfo, isto é, uma das metades do "U", toque levemente a superfície do líquido. Se colocá-lo perpendicularmente à superfície da solução (como um "U" invertido), ou com as duas partes do garfo tocando o líquido (ou seja, com o diapasão todo paralelo à superfície da solução) o som não é ouvido;
- Não se deve afundar muito o diapasão na solução, pois dessa forma, as vibrações dele são amortecidas e o som cessa muito rapidamente;
- Não há diferença em termos da montagem do circuito entre os dois fios que compõe o alto-falante;
- Ao invés de água com vinagre podemos usar somente água, porém, o som do diapasão será ouvido numa intensidade menor;

- O experimento pode ser realizado, também, com uma pilha de 1,5 V ao invés da bateria de 9V, porém, o sinal obtido se torna mais fraco, afinal, a intensidade da corrente diminui.

Considerações finais

Com este trabalho esperamos contribuir para a apreciação da ciência e de sua história, para o desenvolvimento de uma cultura científica e para a formação de pessoas cientes da maneira como ocorre o desenvolvimento científico e tecnológico, desmistificando o processo de invenção, tido muitas vezes como genialidade de uns ou sorte de outros, quando, na verdade, o que existe é o estudo, o trabalho e a dedicação de muitos – a ciência e a invenção são frutos do trabalho humano. Procuramos, também, evidenciar o fato de que o caminho até uma invenção é estreito, envolve combinações de sucessos e frustrações, as quais, muitas vezes, precedem os sucessos. Quanto ao experimento realizado, cremos que ele possa auxiliar no estudo de conceitos como ondas sonoras, resistência elétrica, corrente elétrica, freqüência e, sobretudo, que ele detenha características motivacionais, ao passo que: é de fácil entendimento; os materiais podem ser conseguidos sem maiores problemas; pode ser realizado em qualquer lugar e por qualquer pessoa; foi um dos experimentos realizados por Bell; e está relacionado à um dispositivo contemporâneo amplamente utilizado: o telefone. [56]

6) DECLARAÇÃO DO ORIENTADOR

O meu orientador realizou os seguintes comentários:
"Excelente o trabalho desenvolvido. O experimento funcionou bem e a pesquisa histórica realizada é bastante adequada ao propósito de ilustrar como uma inovação se realiza. Realizar o experimento e acompanhar os fundamentos científicos subjacentes é acessível a um público amplo, a pesquisa histórica é certamente de interesse a uma boa parcela desse público e a leitura do relatório é bastante instigante. Muito bom o levantamento bibliográfico."

7) COMENTÁRIOS FEITOS PELO COORDENADOR

- Comentário sobre o projeto:
"Projeto aprovado. Apenas inclua, já no RP, a referência ao reconhecimento oficial nos EUA da invenção do telefone, de onde Bell teria tomado conhecimento."

- Comentário sobre o relatório parcial:
"RP aprovado, mas precisa definir melhor o que quer dizer com 'funcionou conforme o esperado', descrever o resultado. Muito interessante a pesquisa sobre Meucci."

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Alexander Graham Bell

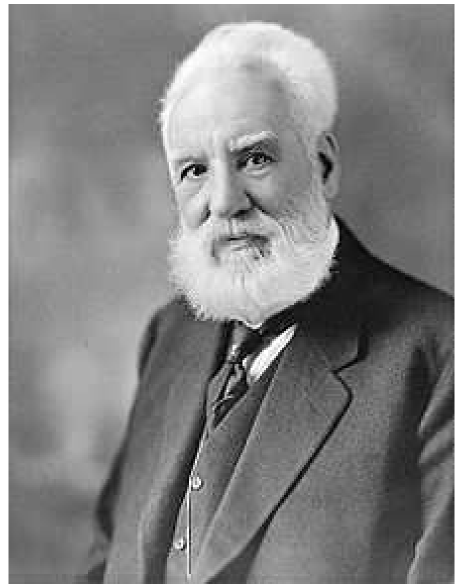
From Wikipedia, the free encyclopedia

Alexander Graham Bell (March 3, 1847 – August 2, 1922) was an eminent scientist, inventor, engineer and innovator who is credited with inventing the first practical telephone.

Bell's father, grandfather, and brother had all been associated with work on elocution and speech, and both his mother and wife were deaf, profoundly influencing Bell's life's work.[1] His research on hearing and speech further led him to experiment with hearing devices which eventually culminated in Bell being awarded the first U.S. patent for the telephone in 1876.[2] In retrospect, Bell considered his most famous invention an intrusion on his real work as a scientist and refused to have a telephone in his study.[3]

Many other inventions marked Bell's later life, including groundbreaking work in optical telecommunications, hydrofoils and aeronautics. In 1888, Alexander Graham Bell became one of the founding members of the National Geographic Society.[4]

Alexander Graham Bell



Portrait of Alexander Graham Bell c. 1910

Born	March 3, 1847 Edinburgh, Scotland, UK
Died	August 2, 1922 (aged 75) Beinn Bhreagh, Nova Scotia, Canada
Cause of death	Diabetes
Education	University of Edinburgh University College London
Occupation	Inventor, Scientist, Engineer, Professor (Boston University), Teacher of the Deaf
Known for	Inventor of the telephone
Spouse(s)	Mabel Hubbard (married 1877–1922)
Children	(4) Two sons who died in infancy and two daughters
Parents	Alexander Melville Bell Eliza Grace Symonds Bell
Relatives	Gardiner Greene Hubbard (father-in-law)

Contents

Early years

Alexander Bell was born in Edinburgh, Scotland on

March 3, 1847.[5] The family home was at 16 South Charlotte Street, Edinburgh, Scotland, and now has a commemorative marker at the doorstep, marking it as Alexander Graham Bell's birthplace. He had two brothers: Melville James Bell (1845–1870) and Edward Charles Bell (1848–1867). Both of his brothers died of tuberculosis.[6] His father was Professor Alexander Melville Bell, and his mother was Eliza Grace (née Symonds).[7] Although he was born "Alexander", at age ten, he made a plea to his father to have a middle name like his two brothers.[8] For his 11th birthday, his father acquiesced and allowed him to adopt the middle name "Graham", chosen out of admiration for Alexander Graham, a Canadian being treated by his father and boarder who had become a family friend.[9] To close relatives and friends he remained "Aleck" which his father continued to call him into later life.[10]

Gilbert Hovey Grosvenor (son-in-law)
Melville Bell Grosvenor (grandson)

Signature

First invention

As a child, young Alexander Graham Bell displayed a natural curiosity about his world, resulting in gathering botanical specimens as well as experimenting even at an early age. His best friend was Ben Herdman, a neighbour whose family operated a flour mill, the scene of many forays. Young Aleck asked what needed to be done at the mill. He was told wheat had to be dehusked through a laborious process and at the age of 12, Bell built a homemade device that combined rotating paddles with sets of nail brushes, creating a simple dehusking machine that was put into operation and used steadily for a number of years.[11] In return, John Herdman gave both boys the run of a small workshop within which to "invent".[11]

From his early years, Bell showed a sensitive nature and a talent for art, poetry and music that was encouraged by his mother. With no formal training, he mastered the piano and became the family's pianist.[12] Despite being normally quiet and introspective, he reveled in mimicry and "voice tricks" akin to ventriloquism that continually entertained family guests during their occasional visits.[12] Bell was also deeply affected by his mother's gradual deafness, (she began to lose her hearing when he was 12) and learned a manual finger language so he could sit at her side and tap out silently the conversations swirling around the family parlour.[13] He also developed a technique of speaking in clear, modulated tones directly into his mother's forehead wherein she would hear him with reasonable clarity.[14] Bell's preoccupation with his mother's deafness led him to study acoustics.

His family was long associated with the teaching of elocution: his grandfather, Alexander Bell, in London, his uncle in Dublin, and his father, in Edinburgh, were all elocutionists. His father published a variety of works on the subject, several of which are still well known, especially his *The Standard Elocutionist* (1860),[12] which appeared in Edinburgh in 1868. *The Standard Elocutionist* appeared in 168 British editions and sold over a quarter of a million copies in the United States alone. In this treatise, his father explains his methods of how to instruct deaf-mutes (as they were then known) to articulate words and read other people's lip movements to decipher meaning. Aleck's father taught him and his brothers not only to write Visible Speech but also to identify any symbol and its accompanying sound.[15] Aleck became so proficient that he became a part of his father's public demonstrations and astounded audiences with his abilities in deciphering Latin, Gaelic and even Sanskrit symbols.[15]

Education

As a young child, Bell, like his brothers, received his early schooling at home from his father. At an early age, however, he was enrolled at the Royal High School, Edinburgh, Scotland, which he left at age 15, completing only the first four forms.[16] His school record was undistinguished, marked by absenteeism and lacklustre grades. His main interest remained in the sciences, especially biology, while he treated other school subjects with indifference, to the dismay of his demanding father.[17] Upon leaving school, Bell travelled to London to live with his grandfather, Alexander Bell. During the year he spent with his grandfather, a love of learning was born, with long hours spent in serious discussion and study. The elder Bell took great efforts to have his young pupil learn to speak clearly and with conviction, the attributes that his pupil would need to become a teacher himself.[18] At age 16, Bell secured a position as a "pupil-teacher" of elocution and music, in Weston House Academy, at Elgin, Moray, Scotland. Although he was enrolled as a student in Latin and Greek, he instructed classes himself in return for board and £10 per session.[19] The following year, he attended the University of Edinburgh; joining his older brother Melville who had enrolled there the previous year.

First experiments with sound

Bell's father encouraged Aleck's interest in speech and, in 1863, took his sons to see a unique automaton, developed by Sir Charles Wheatstone based on the earlier work of Baron Wolfgang von Kempelen.[20] The rudimentary "mechanical man" simulated a human voice. Aleck was fascinated by the machine and after he obtained a copy of von Kempelen's book, published in German, and had laboriously translated it, he and his older brother Melville built their own automaton head. Their father, highly interested in their project, offered to pay for any supplies and spurred the boys on with the enticement of a "big prize" if they were successful.[20] While his brother constructed the throat and larynx, Aleck tackled the more difficult task of recreating a realistic skull. His efforts resulted in a remarkably lifelike head that could "speak", albeit only a few words.[20] The boys would carefully adjust the "lips" and when a bellows forced air through the windpipe, a very recognizable "Mama" ensued, to the delight of neighbors who came to see the Bell invention.[21]

Intrigued by the results of the automaton, Bell continued to experiment with a live subject, the family's Skye Terrier, "Trouve".[22] After he taught it to growl continuously, Aleck would reach into its mouth and manipulate the dog's lips and vocal cords to produce a crude-sounding "Ow ah oo ga ma ma." With little convincing, visitors believed his dog could articulate "How are you grandma?" More indicative of his playful nature, his experiments convinced onlookers that they saw a "talking dog."[23] However, these initial forays into experimentation with sound led Bell to undertake his first serious work on the transmission of sound, using tuning forks to explore resonance. At the age of 19, he wrote a report on his work and sent it to philologist Alexander Ellis, a colleague of his father (who would later be portrayed as Professor Henry Higgins in *Pygmalion*).[23] Ellis immediately wrote back indicating that the experiments were similar to existing work in Germany. Dismayed to find that groundbreaking work had already been undertaken by Hermann von Helmholtz who had conveyed vowel sounds by means of a similar tuning fork "contraption", he pored over the German scientist's book, *Sensations of Tone*. Working from his own errant mistranslation of the original German edition, Aleck fortuitously then made a deduction that would be the underpinning of all his future work on transmitting sound, reporting: *"Without knowing much about the subject, it seemed to me that if vowel sounds could be produced by electrical means so could consonants, so could articulate speech"*, and also later remarking: *"I thought that Helmhotz had done it ... and that my failure was due only to my ignorance of electricity. It was a valuable blunder ... If I had been able to read German in those days, I might never have commenced my experiments!"*[24][25]

Family tragedy

In 1865, when the Bell family moved to London,[26] Bell returned to Weston House as an assistant master and, in his spare hours, continued experiments on sound using a minimum of laboratory equipment. Bell concentrated on experimenting with electricity to convey sound and later installed a telegraph wire from his room in Somerset College to that of a friend.[27] Throughout the fall and winter of 1867, his health faltered mainly through exhaustion. His younger brother, Edward "Ted," was similarly bed-ridden, suffering from tuberculosis. While Bell recovered (by then referring to himself in correspondence as "A.G. Bell") and served the next year as an instructor at Somerset College, Bath, Somerset, England, his brother's condition deteriorated. Edward would never recover. Upon his brother's death, Bell returned home in 1867. His older brother, "Melly" had married and moved out. With aspirations to obtain a degree at the University College London, Bell considered his next years as preparation for the degree examinations, devoting his spare time at his family's residence to studying.

Helping his father in Visible Speech demonstrations and lectures brought Bell to Susanna E. Hull's private school for the deaf in South Kensington, London. His first two pupils were "deaf mute" girls who made remarkable progress under his tutelage. While his older brother seemed to achieve success on many fronts including opening his own elocution school, applying for a patent on an invention, and starting a family, Bell continued as a teacher. However, in May 1870, Melville died from complications due to tuberculosis, causing a family crisis. His father had also suffered a debilitating illness earlier in life and had been restored to health by a convalescence in Newfoundland. Bell's parents embarked upon a long-planned move when they realized that their remaining son was also sickly. Acting decisively, Alexander Melville Bell asked Bell to arrange for the sale of all the family property,[28] conclude all of his brother's affairs (Bell took over his last student, curing a pronounced lisp),[29] and join his father and mother in setting out for the "New World."[30] Reluctantly, Bell also had to conclude a relationship with Marie Eccleston, who, he had surmised, was not prepared to leave England with him.[30]

Canada

In 1870, at age 23, Bell, his brother's widow, Caroline (Margaret Ottaway),[31] and his parents travelled on the *SS Nestorian* to Canada.[32] After landing at Quebec City, the Bells boarded a train to Montreal and later to Paris, Ontario to stay with the Reverend Thomas Henderson, a family friend. After a brief stay with the Hendersons, the Bell family purchased a 10-and-a-half acre farm at Tutelo Heights (now called Tutela Heights), near Brantford, Ontario. The property consisted of an orchard, large farm house, stable, pigsty, hen-house and a carriage house, which bordered the Grand River.[33]

At the homestead, Bell set up his own workshop in the converted carriage house[34] near to what he called his "dreaming place", a large hollow nestled in trees at the back of the property above the river.[35] Despite his frail condition upon arriving in Canada, Bell found the climate and environs to his liking, and rapidly improved.[36] He continued his interest in the study of the human voice and when he discovered the Six Nations Reserve across the river at Onondaga, he learned the Mohawk language and translated its unwritten vocabulary into Visible Speech symbols. For his work, Bell was awarded the title of Honorary Chief and participated in a ceremony where he donned a Mohawk headdress and danced traditional dances.[37]

After setting up his workshop, Bell continued experiments based on Helmholtz's work with electricity and sound.[34] He designed a piano, which, by means of electricity, could transmit its music at a distance. Once the family was settled in, both Bell and his father made plans to establish a teaching practice and in 1871, he accompanied his father to Montreal, where Melville was offered a position to teach his System of Visible Speech.

Work with the deaf

Subsequently, his father was invited by Sarah Fuller, principal of the Boston School for Deaf Mutes (which continues today as the public Horace Mann School for the Deaf),[38] in Boston, Massachusetts, United States, to introduce the Visible Speech System by providing training for Fuller's instructors, but he declined the post, in favor of his son. Traveling to Boston in April 1871, Bell provided successful in training the school's instructors.[39] He was subsequently asked to repeat the program at the American Asylum for Deaf-mutes in Hartford, Connecticut and the Clarke School for the Deaf in Northampton, Massachusetts.

Returning home to Brantford after six months abroad, Bell continued his experiments with his "harmonic telegraph".[40] The basic concept behind his device was that messages could be sent through a single wire if each message was transmitted at a different pitch, but work on both the transmitter and receiver as needed.[41] Unsure of his future, he first contemplated returning to London to complete his studies, but decided to return to Boston as a teacher.[42] His father helped him set up his private practice by contacting Gardiner Greene Hubbard, the president of the Clarke School for the Deaf for a recommendation. Teaching his father's system, in October 1872 Alexander Bell opened his "School of Vocal Physiology and Mechanics of Speech" in Boston, which attracted a large number of deaf pupils with his first class numbering 30 students.[43][44] Working as a private tutor, one of his most famous pupils was Helen Keller, who came to him as a young child unable to see, hear, or speak. She was to later say that Bell dedicated his life to the penetration of that "inhuman silence which separates and estranges." [45]

Several influential people of the time, including Bell, viewed deafness as something that ought to be eradicated, and also believed that with resources and effort they could teach the deaf to speak and avoid the use of sign language, thus enabling their integration within the wider society many were often being excluded from.[46] However in several schools children were mistreated, for example by having their hands tied behind their backs so they could not communicate by signing —the only language they knew— and were therefore forced to attempt oral based communications.

Continuing experimentation

In the following year, Bell became professor of Vocal Physiology and Elocution at the Boston University School of Oratory. During this period, he alternated between Boston and Brantford, spending summers in his Canadian home. At Boston University, Bell was "swept up" by the excitement engendered by the many scientists and inventors residing in the city. He continued his research in sound and endeavored to find a way to transmit musical notes and articulate speech, but although absorbed by his experiments, he found it difficult to devote enough time to experimentation. While days and evenings were occupied by his teaching and private classes, Bell began to stay awake late into the night, running experiment after experiment in rented facilities at his boarding house. Keeping up "night owl" hours, he worried that his work would be discovered and took great pains to lock up his notebooks and laboratory equipment. Bell had a specially made table where he could place his notes and equipment inside a locking cover.[47] Worse still, his health deteriorated as he suffered severe headaches.[41] Returning to Boston in fall 1873, Bell made a fateful decision to concentrate on his experiments in sound.

Deciding to give up his lucrative private Boston practice, Bell only


Bell speaking into prototype model of the telephone

retained two students, six-year old "Georgie" Sanders, deaf from birth and 15-year old Mabel Hubbard. Each pupil would serve to play an important role in the next developments. George's father, Thomas Sanders, a wealthy businessman, offered Bell a place to stay at nearby Salem with Georgie's grandmother, complete with a room to "experiment". Although the offer was made by George's mother and followed the year-long arrangement in 1872 where her son and his nurse had moved to quarters next to Bell's boarding house, it was clear that Mr. Sanders was backing the proposal. The arrangement was for teacher and student to continue their work together with free room and board thrown in.[48] Mabel was a bright, attractive girl who was ten years his junior but became the object of Bell's affection. Losing her hearing after a bout of scarlet fever at age five, she had learned to read lips but her father, Gardiner Greene Hubbard, Bell's benefactor and personal friend, wanted her to work directly with her teacher.[49]

Telephone

Main article: Invention of the telephone

By 1874, Bell's initial work on the harmonic telegraph had entered a formative stage with progress it made both at his new Boston "laboratory" (a rented facility) as well as at his family home in Canada a big success.[50] While working that summer in Brantford, Bell experimented with a "phonautograph," a pen-like machine that could draw shapes of sound waves on smoked glass by tracing their vibrations. Bell thought it might be possible to generate undulating electrical currents that corresponded to sound waves.[51] Bell also thought that multiple metal reeds tuned to different frequencies like a harp would be able to convert the undulatory currents back into sound. But he had no working model to demonstrate the feasibility of these ideas.[52]

In 1874, telegraph message traffic was rapidly expanding and in the words of Western Union President William Orton, had become "the nervous system of commerce". Orton had contracted with inventors Thomas Edison and Elisha Gray to find a way to send multiple telegraph messages on each telegraph line to avoid the great cost of constructing new lines.[53] When Bell mentioned to Gardiner Hubbard and Thomas Sanders that he was working on a method of sending multiple tones on a telegraph wire using a multi-reed device, the two wealthy patrons began to financially support Bell's experiments.[54] Patent matters would be handled by Hubbard's patent attorney, Anthony Pollok.[55]

In March 1875, Bell and Pollok visited the famous scientist Joseph Henry, who was then director of the Smithsonian Institution, and asked Henry's advice on the electrical multi-reed apparatus that Bell hoped would transmit the human voice by telegraph. Henry replied that Bell had "the germ of a great invention". When Bell said that he did not have the necessary knowledge, Henry replied, "Get it!" That declaration greatly encouraged Bell to keep trying, even though he did not have the equipment needed to continue his experiments, nor the ability to create a working model of his ideas. However, a chance meeting in 1874 between Bell and Thomas A. Watson, an experienced electrical designer and mechanic at the electrical machine shop of Charles Williams, changed all that.

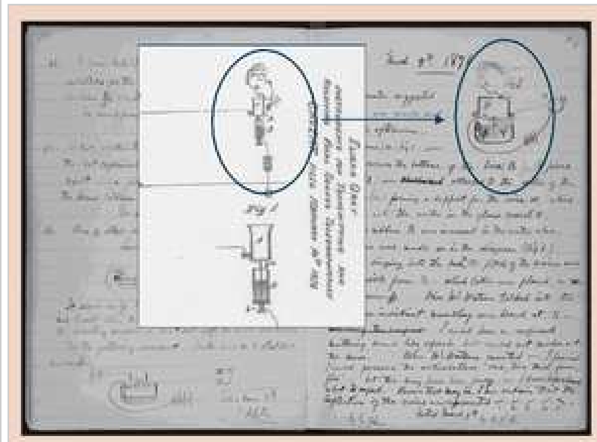
With financial support from Sanders and Hubbard, Bell was able to hire Thomas Watson as his assistant and the two of them experimented with acoustic telegraphy. On 2 June 1875, Watson accidentally plucked one of the reeds and Bell, at the receiving end of the wire, heard the overtones of the reed; overtones that would be necessary for transmitting speech. That demonstrated to Bell that only one reed or armature was necessary, not multiple reeds. This led to the "gallows" sound-powered telephone, which was able to transmit indistinct, voice-like sounds, but not clear speech.

The race to the patent office

Main article: Elisha Gray and Alexander Bell telephone controversy

In 1875, Bell developed an acoustic telegraph and drew up a patent application for it. Since he had agreed to share U.S. profits with his investors Gardiner Hubbard and Thomas Sanders, Bell requested that an associate attempt to patent it in Britain, instructing his lawyers to apply for a patent in the U.S. only after they received word from Britain. (Britain would only issue patents for discoveries not previously patented elsewhere.)

Meanwhile, Elisha Gray was also experimenting with acoustic telegraphy and thought of a way to transmit speech using a water transmitter. On February 14, 1876, Gray filed a caveat with the U.S. Patent Office for a telephone design that used a water transmitter. That same morning, Bell's lawyer filed Bell's application with the patent office. There is considerable debate about who arrived first and Gray later challenged the primacy of Bell's patent. Bell was in Boston on February 14, 1876.



Excerpts from Elisha Gray's patent caveat of February 14 and Alexander Graham Bell's lab notebook entry of March 8, demonstrating their surprising similarity

Bell's patent 174,465, was issued to Bell on March 7, 1876, by the U.S. Patent Office. Bell's patent covered "the method of, and apparatus for, transmitting vocal or other sounds telegraphically ... by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound"[56]

Bell returned to Boston the same day and the next day resumed work, drawing in his notebook a diagram similar to that in Gray's patent caveat.

On March 10, 1876, three days after his patent was issued, Bell succeeded in getting his telephone to work, using a liquid transmitter similar to Gray's design. Vibration of the diaphragm caused a needle to vibrate in the water which varied the electrical resistance in the circuit. When Bell spoke the famous sentence "Mr Watson—Come here—I want to see you" into the liquid transmitter,[57] Watson, listening at the receiving end in an adjoining room, heard the words clearly.[58]

Although Bell was accused, and is still accused, of stealing the telephone from Gray,[59] Bell used Gray's water transmitter design only after Bell's patent was granted and only as a proof of concept scientific experiment[60] to prove to his own satisfaction that intelligible "articulate speech" (Bell's words) could be electrically transmitted.[61] After March 1876, Bell focused on improving the electromagnetic telephone and never used Gray's liquid transmitter in public demonstrations or commercial use.[62]

The patent examiner, Zenas Fisk Wilber, later stated in a sworn affidavit that he was an alcoholic who was much in debt to Bell's lawyer, Marcellus Bailey, with whom he had served in the Civil War. He claimed he showed Gray's patent caveat to Bailey. Wilber also claimed (after Bell arrived in Washington

D.C. from Boston) that he showed Gray's caveat to Bell and that Bell paid him $100. Bell claimed they only discussed the patent in general terms, although in a letter to Gray, Bell admitted that he learned some of the technical details. Bell denied in a sworn affidavit that he ever gave Wilber any money.

Later developments

Continuing his experiments in Brantford, Bell brought home a working model of his telephone. On August 3, 1876, from the telegraph office in Mount Pleasant five miles (8 km) away from Brantford, Bell sent a tentative telegram indicating that he was ready. With curious onlookers packed into the office as witnesses, faint voices were heard replying. The following night, he amazed guests as well as his family when a message was received at the Bell home from Brantford, four miles (six km) distant along an improvised wire strung up along telegraph lines, fences, and laid through a tunnel. This time, guests at the household distinctly heard people in Brantford reading and singing. These experiments clearly proved that the telephone could work over long distances.[63]

Bell and his partners, Hubbard and Sanders, offered to sell the patent outright to Western Union for $100,000. The president of Western Union balked, countering that the telephone was nothing but a toy. Two years later, he told colleagues that if he could get the patent for $25 million he would consider it a bargain. By then, the Bell company no longer wanted to sell the patent.[64] Bell's investors would become millionaires while he fared well from residuals and he, at one point, had assets nearly reaching one million dollars.[65]

Bell began a series of public demonstrations and lectures in order to introduce the new invention to the scientific community as well as the general public. Only one day after his demonstration of an early telephone prototype at the 1876 Centennial Exposition in Philadelphia made the telephone the featured headline worldwide.[66] Influential visitors to the exhibition included Emperor Pedro II of Brazil, and later Bell had the opportunity to personally demonstrate the invention to William Thomson, a renowned Scottish scientist and even Queen Victoria who had requested a private audience at Osborne House, her Isle of Wight home; she called the demonstration "most extraordinary". The enthusiasm surrounding Bell's public displays laid the groundwork for universal acceptance of the revolutionary device.[67]

The Bell Telephone Company was created in 1877, and by 1886, over 150,000 people in the U.S. owned telephones. Bell company engineers made numerous other improvements to the telephone, which emerged as one of the most successful products ever. In 1879, the Bell company acquired Edison's patents for the carbon microphone from Western Union. This made the telephone practical for long distances and it was no longer necessary to shout to be heard at the receiving telephone.

On January 25, 1915, Bell made the first transcontinental telephone call. Calling from 15 Day Street in New York City, Bell was heard by Thomas Watson at 333 Grant Avenue in San Francisco. The New York Times reported:

> *On October 9, 1876, Alexander Graham Bell and Thomas A. Watson talked by telephone to each other over a two-mile wire stretched between Cambridge and Boston. It was the first wire conversation ever held. Yesterday afternoon [on January 25, 1915] the same two men talked by telephone to each other over a 3,400-mile wire between New York and San Francisco. Dr. Bell, the veteran inventor of the telephone, was in New York, and Mr. Watson, his former associate, was on the other side of the continent. They heard each other much more distinctly than they did in their first talk thirty-eight years ago.*[68]

Competitors

See also: Canadian Parliamentary Motion on Alexander Graham Bell

As is sometimes common in scientific discoveries, simultaneous developments can occur, as evidenced by a number of inventors who were at work on the telephone.[3] Over a period of 18 years, the Bell Telephone Company faced over 600 lawsuits posing legal challenges concerning the rights to the telephone, but none was successful in establishing priority over the original Bell patent[69][70] and the Bell Telephone Company never lost a case that had proceeded to a final trial stage.[69] Bell's laboratory notes and family letters were the key to establishing a long lineage to his experiments.[69] The Bell company lawyers successfully fought off myriad lawsuits generated initially around the challenges by Elisha Gray and Amos Dolbear. In personal correspondence to Bell, both Gray and Dolbear had acknowledged his prior work, which considerably weakened their later claims.[71]

On 13 January 1887, the United States Government moved to annul the patent issued to Bell on the grounds of fraud and misrepresentation. After a series of decisions and reversals, the Bell company won a decision in the Supreme Court, though a couple of the original claims from the lower court cases were left undecided.[72][73] By the time that the trial wound its way through nine years of legal battles, the U.S. prosecuting attorney had died and the two Bell patents (No. 174,465 and dated 7 March 1876 and No. 186,787 dated January 30, 1877) were no longer in effect, although the presiding judges agreed to continue the proceedings due to the case's importance as a "precedent." With a change in administration and charges of conflict of interest (on both sides) arising from the original trial, the U.S. Attorney General dropped the law suit on 30 November 1897 leaving several issues undecided on the merits.[74]

During a deposition filed for the 1887 trial, Italian inventor Antonio Meucci also claimed to have created the first working model of a telephone in Italy in 1834. In 1886, in the first of three cases in which he was involved, Meucci took the stand as a witness in the hopes of establishing his invention's priority. Meucci's evidence in this case was disputed due to a lack of material evidence for his inventions as his working models were purportedly lost at the laboratory of American District Telegraph (ADT) of New York, which later, in 1901, was incorporated as a subsidiary of Western Union.[75][76] Meucci's work, like many other inventors of the period, was based on earlier acoustic principles and despite evidence of earlier experiments, the final case involving Meucci was eventually dropped upon Meucci's death.[77] However, due to the efforts of Congressman Vito Fossella, the U.S. House of Representatives on 11 June 2002 stated that Meucci's "work in the invention of the telephone should be acknowledged", even though this did not put an end to a still contentious issue.[78][79][80] Some modern scholars do not agree with the claims that Bell's work on the telephone was influenced by Meucci's inventions.[81]

The value of the Bell patent was acknowledged throughout the world, and patent applications were made in most major countries, but when Bell had delayed the German patent application, the electrical firm of Siemens & Halske (S&H) managed to set up a rival manufacturer of Bell telephones under their own patent. The Siemens company produced near-identical copies of the Bell telephone without having to pay royalties.[82] A series of agreements in other countries eventually consolidated a global telephone operation. The strain put on Bell by his constant appearances in court, necessitated by the legal battles, eventually resulted in his resignation from the company.[83]

Family life

On July 11, 1877, a few days after the Bell Telephone Company was established, Bell married Mabel Hubbard (1857–1923) at the Hubbard estate in Cambridge. His wedding present to his bride was to turn over 4,990 of his 5,000 shares in the newly created Bell Telephone Company.[84] Shortly thereafter, the newlyweds embarked on a year-long honeymoon in Europe. During that excursion, Alec took a handmade model of his telephone with him, making it a "working holiday". The courtship had begun years earlier, however Alexander waited until he was more financially secure before marrying. Although the telephone appeared to be an "instant" success, it was not initially a profitable venture and Bell's main sources of income were from lectures until after 1897.[85] One unusual request exacted by his fiancée was that he use "Alec" rather than the family's earlier familiar name of "Aleck." From 1876, he would sign his name "Alec Bell."[86][87] They had four children: Elsie May Bell (1878–1964) who married Gilbert Grosvenor of National Geographic fame,[88][89] Marian Hubbard Bell (1880–1962) who was referred to as "Daisy",[90] and two sons who died in infancy. The Bell family home was located in Cambridge, Massachusetts until 1880 when Bell's father-in-law bought a house, and then later in 1882 the Brohead Mansion, in Washington, D.C. for the Bell family, so that Alec's family could be with him while he attended to the numerous court cases involving patent disputes.[91]

Alexander Graham Bell, his wife Mabel Gardiner Hubbard, and their daughters Elsie (left) and Marian

Bell was a British subject throughout his early life in Scotland and later in Canada until 1882, when he became a naturalized citizen of the United States. In 1915, he characterized his status as: *"I am not one of those hyphenated Americans who claim allegiance to two countries."*[92] Despite this declaration, Bell has been claimed as a "native son" by Canada, Scotland and the United States.[93] By 1885, a new summer retreat was contemplated. That summer, the Bells had a vacation on Cape Breton Island in Nova Scotia, spending time at the small village of Baddeck. Returning in 1886, Bell started building an estate on a point across from Baddeck, overlooking Bras d'Or Lake. By 1889, a large house, christened *The Lodge* was completed and two years later, a larger complex of buildings were begun that the Bells would name Beinn Bhreagh (Gaelic: *beautiful mountain*) after Alec's ancestral Scottish highlands.[94] Bell would spend his final, and some of his most productive, years in residence in both Washington, D.C., where he and his family initially resided for most of the year, and Beinn Bhreagh.[95]

Until the end of his life, Bell and his family would alternate between the two homes, but *Beinn Bhreagh* would, over the next 30 years, become more than a summer home as Bell became so absorbed in his experiments that annual stays lengthened. Both Mabel and Alec became immersed in the Baddeck community and were accepted by the villagers as "their own". The Bells were still in residence at *Beinn Bhreagh* when the Halifax Explosion occurred on 6 December 1917. Mabel and Alec mobilized the community to help victims in Halifax.[96]

Later inventions

Although Alexander Graham Bell is most often associated with the invention of the telephone, his interests were extremely varied. According to one of his biographers, Charlotte Gray, Bell's work ranged *"unfettered across the scientific landscape"* and he often went to bed voraciously reading the *Encyclopaedia Britannica*, scouring it for new areas of interest.[97] The range of Bell's inventive genius is represented only in part by the 18 patents granted in his name alone and the 12 he shared with his collaborators. These included 14 for the telephone and telegraph, four for the photophone, one for the phonograph, five for aerial vehicles, four for "hydroairplanes" and two for selenium cells. Bell's inventions spanned a wide range of interests and included a metal jacket to assist in breathing, the audiometer to detect minor hearing problems, a device to locate icebergs, investigations on how to separate salt from seawater, and work on finding alternative fuels.

Bell worked extensively in medical research and invented techniques for teaching speech to the deaf. During his Volta Laboratory period, Bell and his associates considered impressing a magnetic field on a record as a means of reproducing sound. Although the trio briefly experimented with the concept, they were unable to develop a workable prototype. They abandoned the idea, never realizing they had glimpsed a basic principle which would one day find its application in the tape recorder, the hard disc and floppy disc drive and other magnetic media.

Bell's own home used a primitive form of air conditioning, in which fans blew currents of air across great blocks of ice. He also anticipated modern concerns with fuel shortages and industrial pollution. Methane gas, he reasoned, could be produced from the waste of farms and factories. At his Canadian estate in Nova Scotia, he experimented with composting toilets and devices to capture water from the atmosphere. In a magazine interview published shortly before his death, he reflected on the possibility of using solar panels to heat houses.

Metal detector

Bell is also credited with the invention of the metal detector in 1881. The device was quickly put together in an attempt to find the bullet in the body of U.S. President James Garfield. The metal detector worked flawlessly in tests but did not find the assassin's bullet partly because the metal bed frame the President was lying on disturbed the instrument, resulting in static.[98] The president's surgeons, who were sceptical of the device, ignored Bell's requests to move the president to a bed not fitted with metal springs. Alternately, although Bell had detected a slight sound on his first test, the bullet may have lodged too deeply to be detected by the crude apparatus.[98] Bell gave a full account of his experiments in a paper read before the American Association for the Advancement of Science (AAAS) in August 1882.

Hydrofoils

Main article: Hydrofoil

The March 1906 *Scientific American* article by American hydrofoil pioneer William E. Meacham explained the basic principle of hydrofoils and hydroplanes. Bell considered the invention of the hydroplane as a very significant achievement. Based on information gained from that article he began to sketch concepts of what is now called a hydrofoil boat. Bell and assistant Frederick W. "Casey" Baldwin began hydrofoil experimentation in the summer of 1908 as a possible aid to airplane takeoff from water. Baldwin studied the work of the Italian inventor Enrico Forlanini and began testing models. This led him and Bell to the development of practical hydrofoil watercraft.

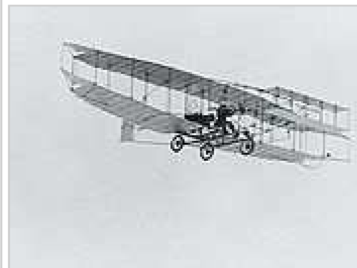
Bell HD-4 on a test run c. 1919

During his world tour of 1910–1911, Bell and Baldwin met with Forlanini in France. They had rides in the Forlanini hydrofoil boat over Lake Maggiore. Baldwin described it as being as smooth as flying. On returning to Baddeck, a number of initial concepts were built as experimental models, including the *Dhonnas Beag*, the first self-propelled Bell-Baldwin hydrofoil.[99] The experimental boats were essentially proof-of-concept prototypes that culminated in the more substantial HD-4, powered by Renault engines. A top speed of 54 miles per hour (87 km/h) was achieved, with the hydrofoil exhibiting rapid acceleration, good stability and steering along with the ability to take waves without difficulty.[100] In 1913, Dr. Bell hired Walter Pinaud, a Sydney yacht designer and builder as well as the proprietor of Pinaud's Yacht Yard in Westmount, Nova Scotia to work on the pontoons of the HD-4. Pinaud soon took over the boatyard at Bell Laboratories on Beinn Bhreagh, Bell's estate near Baddeck, Nova Scotia. Pinaud's experience in boat-building enabled him to make useful design changes to the HD-4. After the First World War, work began again on the HD-4. Bell's report to the U.S. Navy permitted him to obtain two 350 horsepower (260 kW) engines in July 1919. On 9 September 1919, the HD-4 set a world marine speed record of 70.86 miles per hour (114.04 km/h),[101] a record which stood for ten years.

Aeronautics

Main articles: Aerial Experiment Association and AEA Silver Dart

In 1891, Bell had begun experiments to develop motor-powered heavier-than-air aircraft. The AEA was first formed as Bell shared the vision to fly with his wife, who advised him to seek "young" help as Alexander was at the graceful age of 60.



AEA Silver Dart c. 1909

In 1898, Bell experimented with tetrahedral box kites and wings constructed of multiple compound tetrahedral kites covered in silk. The tetrahedral wings were named *Cygnet* I, II and III, and were flown both unmanned and manned (*Cygnet I* crashed during a flight carrying Selfridge) in the period from 1907–1912. Some of Bell's kites are on display at the Alexander Graham Bell National Historic Site.[102]

Bell was a supporter of aerospace engineering research through the Aerial Experiment Association (AEA), officially formed at Baddeck, Nova Scotia, in October 1907 at the suggestion of Mrs. Mabel Bell and with her financial support. The AEA was headed by Bell and the founding members were four young men: American Glenn H. Curtiss, a motorcycle manufacturer at the time termed the "world's fastest man" having had ridden his self-constructed motor bicycle around in the shortest time, later was awarded the Scientific American Trophy for the first official one-kilometre flight in the Western hemisphere and became a world-renowned airplane manufacturer; Lieutenant Thomas Selfridge, an official observer from the U.S. government and the only person in the army who believed aviation was the future, Frederick W. Baldwin, the first Canadian and first British subject to pilot a public flight in Hammondsport, New York; and J.A.D. McCurdy; both engineering students at University of Toronto.

The AEA's work progressed to heavier-than-air machines, applying their knowledge of kites to gliders. Moving to Hammondsport, the group then designed and built the *Red Wing*, framed in bamboo and covered in red silk and powered by a small air-cooled engine.[103] On March 12, 1908, over Keuka Lake, the biplane lifted off on the first public flight in North America.[104] The innovations that were incorporated into this design included a cockpit enclosure and tail rudder (later variations on the original design would add ailerons as a means of control). One of the AEA project's inventions, the aileron, is a standard component of aircraft today. (The aileron was also invented independently by Robert Esnault-Pelterie.) The *White Wing* and *June Bug* were to follow and by the end of 1908, over 150 flights without mishap had been accomplished. However, the AEA had depleted its initial reserves and only a $10,000 grant from Mrs. Bell allowed it to continue with experiments.[105]

Their final aircraft design, the *Silver Dart* embodied all of the advancements found in the earlier machines. On February 23, 1909, Bell was present as the *Silver Dart* flown by J.A.D. McCurdy from the frozen ice of Bras d'Or, made the first aircraft flight in Canada. Bell had worried that the flight was too dangerous and had arranged for a doctor to be on hand. With the successful flight, the AEA disbanded and the *Silver Dart* would revert to Baldwin and McCurdy who began the Canadian Aerodrome Company and would later demonstrate the aircraft to the Canadian Army.[106]

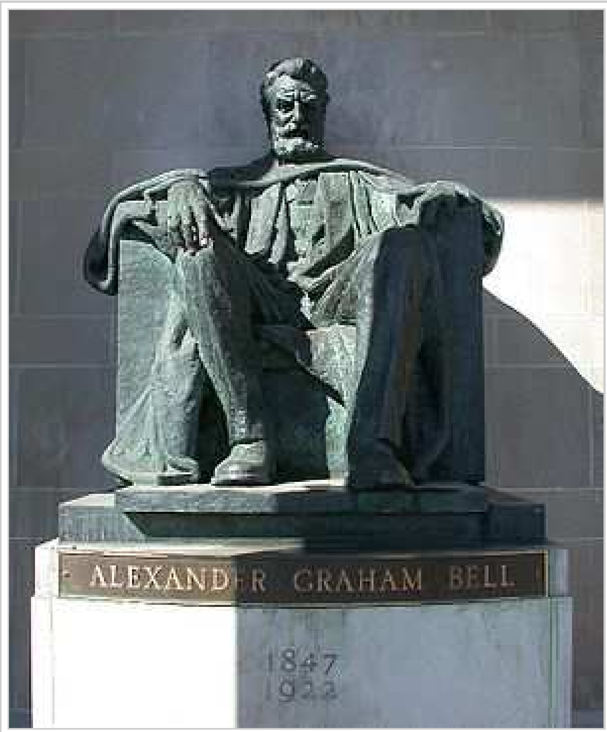
Eugenics

Along with many very prominent thinkers and scientists of the time, Bell was connected with the eugenics movement in the United States. In his lecture *Memoir upon the formation of a deaf variety of the human race* presented to the National Academy of Sciences on 13 November 1883 he noted that congenitally deaf parents were more likely to produce deaf children and tentatively suggested that couples where both parties were deaf should not marry.[107] However, it was his hobby of livestock breeding which led to his appointment to biologist David Starr Jordan's Committee on Eugenics, under the auspices of the American Breeders Association. The committee unequivocally extended the principle to man.[108] From 1912 until 1918 he was the chairman of the board of scientific advisers to the Eugenics Record Office associated with Cold Spring Harbor Laboratory in New York, and regularly attended meetings. In 1921, he was the honorary president of the Second International Congress of Eugenics held under the auspices of the American Museum of Natural History in New York. Organisations such as these advocated passing laws (with success in some states) that established the compulsory sterilization of people deemed to be, as Bell called them, a "defective variety of the human race". By the late 1930s, about half the states in the U.S. had eugenics laws, and the California laws were used as a model for eugenics laws in Nazi Germany.

Legacy and honors

Main article: Alexander Graham Bell honors and tributes

Honors and tributes flowed to Bell in increasing numbers as his most famous invention became ubiquitous and his personal fame grew. Bell received numerous honorary degrees from colleges and universities, to the point that the requests almost became burdensome.[109] During his life he also received dozens of major awards, medals and other tributes. These included statuary monuments to both him and the new form of communication his telephone created, notably the Bell Telephone Memorial erected in his honor in Brantford, Ontario's *Alexander Graham Bell Gardens* in 1917.[110]



Bell statue by A.E. Cleeve Horne, similar in style to the Lincoln Memorial, in the front portico of the

A large number of Bell's writings, personal correspondence, notebooks, papers and other documents reside at both the United States Library of Congress Manuscript Division (as the *Alexander Graham Bell Family Papers*), and at the Alexander Graham Bell Institute, Cape Breton University, Nova Scotia; major portions of which are available for online viewing.

A number of historic sites and other marks commemorate Bell in North America and Europe, including the first telephone companies of the United States and Canada. Among the major sites are:

Bell Telephone Building of Brantford, Ontario, *The Telephone City* (Courtesy: ***Brantford Heritage Inventory****, City of Brantford, Ontario, Canada*)

- Park's Canada's Alexander Graham Bell National Historic Site, which incorporates the Alexander Graham Bell Museum, in Baddeck, Nova Scotia, close to the Bell estate Beinn Bhreagh;
- The Bell Homestead, also known as *Melville House*, overlooking Brantford, Ontario and the Grand River, which was the Bell family's first home in North America;
- Canada's first telephone company building, *the Henderson Home*, of the nascent 1877 Bell Telephone Company of Canada, which was carefully relocated in 1969 to the historic *Bell Homestead*. The *Bell Homestead* and the *Bell Telephone Company Building* are both maintained by the Bell Homestead Society in Brantford, Ontario;
- The Alexander Graham Bell Memorial Park, which features a broad neoclassical monument built in 1917 by public subscription. The monument graphically depicts mankind's ability to span the globe through telecommunications;
- The Alexander Graham Bell Museum (opened in 1956), which is part of the *Alexander Graham Bell National Historic Site*, which was completed in 1978 in Baddeck, Nova Scotia. Many of the museum's artifacts were contributed by Bell's daughters;

In 1880, Bell received the Volta Prize of 50,000 francs (approximately US$10,000) for the invention of the telephone from L'Académie française, representing the French government, in Paris. Among the luminaries who judged were Victor Hugo and père Alexandre Dumas. The Volta Prize was established by Napoleon Bonaparte in 1803 to honor Alessandro Volta, and Bell received only the third such prize in its history.[111][112][113][114][115][116] Since Bell was becoming increasingly affluent, he used his prize money to create endowment funds (the 'Volta Fund') and institutions in and around the United States capital of Washington, D.C.. They included the prestigious *'Volta Laboratory Association'* (1880), also known as the *'Volta Laboratories'* and as the *'Alexander Graham Bell Laboratory'*, as well as creating the Volta Bureau (1887) as a center for studies on deafness. The Volta Laboratory became a permanently funded experimental facility devoted to scientific discovery, and the very next year invented a wax phonograph cylinder that was later used by Thomas Edison;[117] The laboratory was also the site where he and his assistant invented his *'proudest achievement'*, the photophone, the *optical telephone* which presaged fibre optical telecommunications.

In partnership with Gardiner Hubbard, Bell helped established the publication Science during the early 1880s. In 1888, Bell was one of the founding members of the National Geographic Society and became its second president (1897–1904), and also became a Regent of the Smithsonian Institution (1898–1922). The French government conferred on him the decoration of the Légion d'honneur (Legion of Honour); the Royal Society of Arts in London awarded him the Albert Medal in 1902; and the University of Würzburg, Bavaria, granted him a Ph.D. He was awarded the AIEE's Edison Medal in 1914 "For meritorious achievement in the invention of the telephone."

The *bel* (B) and the smaller *decibel* (dB) are units of measurement of sound intensity invented by Bell Labs and named after him.[118][119] Since 1976 the IEEE's Alexander Graham Bell Medal has been awarded to honor outstanding contributions in the field of telecommunications.

The 150th anniversary of Bell's birth in 1997 was marked by a special issue of commemorative £1 banknotes from the Royal Bank of Scotland. The illustrations on the reverse of the note include Bell's face in profile, his signature, and objects from Bell's life and career: users of the telephone over the ages; an audio wave signal; a diagram of a telephone receiver; geometric shapes from engineering structures;

representations of sign language and the phonetic alphabet; the geese which helped him to understand flight; and the sheep which he studied to understand genetics.[120] Additionally, the Government of Canada honoured Bell in 1997 with a $100CAD gold coin, in tribute also to the 150th anniversary of his birth,[121] and with a silver dollar coin in 2009 to honour of the 100th anniversary of flight in Canada. That first flight was made by an airplane designed under Dr. Bell's tutelage, named the Silver Dart[122] Bell's image, and also those of his many inventions have graced paper money, coinage and postal stamps in numerous countries worldwide for many dozens of years.

Bell's name is widely known and still used as part of the names of dozens of educational institutes, corporate namesakes, street and place names around the world. Alexander Graham Bell was also ranked 57th among the 100 Greatest Britons (2002) in an official BBC nationwide poll, and among the Top Ten Greatest Canadians (2004), and the 100 Greatest Americans (2005).[123][124]

Honorary Degrees

Alexander Graham Bell, who was unable to complete the university program of his youth, received numerous Honorary Degrees from academic institutions, including:

- Gallaudet College in Washington, D.C. (Ph.D) in 1880 [1]
- Harvard University in Cambridge, Massachusetts (LL.D) in 1896
- University of Würzburg in Würzburg, Bavaria (Ph.D) in 1902
- University of Edinburgh in Edinburgh, Scotland (LL.D) in April 1906 [2]
- Queen's University in Kingston, Ontario in 1909
- Dartmouth College in Hanover, New Hampshire (LL.D) on June 25, 1913 [125]

This list is incomplete; you can help by expanding it.

Death

Bell died of diabetes on August 2, 1922, at his private estate, Beinn Bhreagh, Nova Scotia, at age 75.[126] Bell had also been afflicted with pernicious anemia.[127] While tending to her husband after a long illness, Mabel whispered, "Don't leave me." By way of reply, Bell traced the sign for *no*—and then he expired.[111][128]

Upon Bell's death, during his funeral, *"every phone on the continent of North America was silenced in honor of the man who had given to mankind the means for direct communication at a distance"*.[129]

On learning of Bell's death, Canadian Prime Minister Mackenzie King cabled Mrs. Bell, saying:

> *[The Government expresses] to you our sense of the world's loss in the death of your distinguished husband. It will ever be a source of pride to our country that the great invention, with which his name is immortally associated, is a part of its history. On the behalf of the citizens of Canada, may I extend to you an expression of our combined gratitude and sympathy.*[111]

Dr. Alexander Graham Bell was buried atop Beinn Bhreagh mountain, on his estate where he had resided increasingly for the last 35 years of his life, overlooking Bras d'Or Lake.[111] He was survived by his wife and his two daughters, Elisa May and Marion.[111][130]

See also

- Alexander Graham Bell Association for the Deaf and Hard of Hearing
- Berliner, Emile
- Bourseul, Charles
- Graham Bell Island
- Innocenzo Manzetti
- Oriental Telephone Company
- Reis, Philipp

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Notes

1. ^ Bruce 1990, p. 419.
2. ^ Black 1997, p. 18. Quote: "He thought he could harness the new electronic technology by creating a machine with a transmitter and receiver that would send sounds telegraphically to help people hear."
3. ^ ***a b*** MacLeod 1999, p. 19.
4. ^ National Geographic Website
5. ^ Petrie 1975, p. 4.
6. ^ Time Line of Alexander Graham Bell
7. ^ "Alexander M. Bell Dead. Father of Prof. A.G. Bell Developed Sign Language for Mutes." *New York Times* Tuesday, August 8, 1905.
8. ^ Call me Alexander Graham Bell Note: Bell typically signed his name in full on his correspondence.
9. ^ Groundwater 2005, p. 23.
10. ^ Bruce 1990, pp. 17–19.
11. ^ ***a b*** Bruce 1990, p. 16.
12. ^ ***a b c*** Gray 2006, p. 8.
13. ^ Gray 2006, p. 9.
14. ^ Mackay 1997, p.25.
15. ^ ***a b*** Petrie 1975, p. 7.
16. ^ Mackay 1997, p. 31.
17. ^ Gray 2006, p. 11.
18. ^ Town 1988, p. 7.
19. ^ Bruce 1990, p. 37.
20. ^ ***a b c*** Groundwater 2005, p. 25.
21. ^ Petrie 1975, pp. 7–9.
22. ^ Petrie 1975, p. 9.
23. ^ ***a b*** Groundwater 2005, p. 30.
24. ^ MacKenzie 2003, p. 41.
25. ^ Groundwater 2005, p. 31.
26. ^ Micklos 2006, p. 8.
27. ^ Bruce 1990, p. 45.
28. ^ Bruce 1990, pp. 67–68. Note: The family pet was given to his brother's family.
29. ^ Bruce 1990, p. 68.
30. ^ ***a b*** Groundwater 2005, p. 33.
31. ^ Mackay 1997, p. 50.
32. ^ Petrie 1975, p. 10.
33. ^ Mackay 1997, p. 61. Note: The estate is today known as the "Bell Homestead".
34. ^ ***a b*** Wing 1980, p. 10.
35. ^ Groundwater 2005, p. 34.
36. ^ Mackay 1997, p. 62. Note: Bell would later write that he had come to Canada a "dying man".
37. ^ Groundwater 2005, p. 35. Note: Bell was thrilled at his recognition by the Six Nations Reserve and

throughout his life would launch into a Mohawk war dance when he was excited.
38. ^ Bruce 1990, p. 74.
39. ^ Town 1988, p. 12.
40. ^ *Alexander Graham Bell* 1979, p. 8. Note: In later years, Bell described the invention of the telephone and linked it to his "dreaming place".
41. ^ ***a b*** Groundwater 2005, p. 39.
42. ^ Petrina 1975, p. 14.
43. ^ Petrel 1975, p. 15.
44. ^ Town 1988, pp. 12–13.
45. ^ Petrie 1975, p. 17.
46. ^ Miller and Branson 2002, pp. 30–31, 152–153.
47. ^ Town 1988, p. 15.
48. ^ Town 1988, p. 16.
49. ^ Dunn 1990, p. 20.
50. ^ *Alexander Graham Bell* 1979, p. 8. Quote: "Brantford is justified in calling herself 'The Telephone City' because the telephone originated there. It was invented in Brantford at Tutela Heights in the summer of 1874."
51. ^ Matthews 1999, pp. 19–21.
52. ^ Matthews 1999, p. 21.
53. ^ A History of Electrical Engineering
54. ^ Town 1988, p. 17.
55. ^ Evenson 2000, pp. 18–25.
56. ^ MacLeod 1999, pp. 12–13. Note: A copy of a draft of the patent application is shown, described as "probably the most valuable patent ever."
57. ^ Bell's Lab notebook I, pp. 40–41 (image 22).
58. ^ MacLeod 1999, p. 12.
59. ^ Shulman 2008, p. 211.
60. ^ Evenson 2000, p. 99.
61. ^ Evenson 2000, p. 98.
62. ^ Evenson 2000, p. 100.
63. ^ MacLeod 1999, p. 14.
64. ^ Fenster, Julie M. "Inventing the Telephone—And Triggering All-Out Patent War." *AmericanHeritage.com, American Heritage*, 2006.
65. ^ Winfield 1987, p. 21.
66. ^ Webb 1991, p. 15.
67. ^ Ross 1995, pp. 21–22.
68. ^ "Phone to Pacific From the Atlantic". *New York Times*, January 26, 1915. Retrieved: July 21, 2007.
69. ^ ***a b c*** Groundwater 2005, p. 95.
70. ^ Black 1997, p. 19.
71. ^ Mackay 1997, p. 179.
72. ^ "U.S. Supreme Court: U S v. AMERICAN BELL TEL CO, 167 U.S. 224 (1897)
73. ^ United states V. American Bell Telephone Co., 128 U. S. 315 (1888)
74. ^ Basilio Catania 2002 "The United States Government vs. Alexander Graham Bell. An important acknowledgment for Antonio Meucci" Bulletin of Science Technology Society. 2002; 22: pp. 426–442.
75. ^ Catania, Basilio "Antonio Meucci – Questions and Answers: What did Meucci to bring his invention to the public?" *Chezbasilio.it* website. Retrieved July 8, 2009.
76. ^ "History of ADT Security." *ADT.com* website. Retrieved July 8, 2009.
77. ^ Bruce 1990, pp. 271–272.
78. ^ Resolution 269
79. ^ Congressional Record on Meucci Note: Meucci was not involved in the final trial.
80. ^ Italian Historical Society
81. ^ Antonio Meucci Note: Tomas Farley also writes that, "Nearly every scholar agrees that Bell and Watson were the first to transmit intelligible speech by electrical means. Others transmitted a sound or a click or a buzz but our boys [Bell and Watson] were the first to transmit speech one could understand."
82. ^ Mackay 1997, p. 178.
83. ^ Parker 1995, p. 23. Note: Many of the lawsuits became rancorous with Elisha Gray becoming particularly bitter over Bell's ascendancy in the telephone debate but Alec refused to launch counter actions for libel.
84. ^ Eber 1982, p. 44.

85. ^ Dunn 1990, p. 28.
86. ^ Mackay 1997, p. 120.
87. ^ "Mrs. A.G. Bell Dies. Inspired Telephone. Deaf Girl's Romance With Distinguished Inventor Was Due to Her Affliction." *New York Times*, January 4, 1923.
88. ^ "Dr. Gilbert H. Grosvenor Dies; Head of National Geographic, 90; Editor of Magazine 55 Years Introduced Photos, Increased Circulation to 4.5 Million." *New York Times*, February 5, 1966. Quote: Baddeck, Nova Scotia, February 4, 1964 (Canadian Press): Dr. Gilbert H. Grosvenor, chairman of the board and former president of the National Geographic Society and editor of the National Geographic magazine from 1899 to 1954, died on the Cape Breton Island estate once owned by his father-in-law, the inventor Alexander Graham Bell. He was 90 years old.
89. ^ "Mrs. Gilbert Grosvenor Dead; Joined in Geographic's Treks; Married Professor's Son." *New York Times*, December 27, 1964. Quote: Washington, DC, 26 December 1964. Mrs. Elsie May Bell Grosvenor, wife of Dr. Gilbert Grosvenor, chairman of the board of the National Geographic Society, died this evening at her home in Bethesda, Maryland. She was 86 years old. Death was attributed to heart disease and old age.
90. ^ "Mrs. David Fairchild, 82, Dead; Daughter of Bell, Phone Inventor." New York Times, September 25, 1962. Quote: Baddeck, Nova Scotia, September 24, 1962 (The Canadian Press) Mrs. Marian Bell Fairchild of Miami, widow of David Fairchild, noted plant explorer, and daughter of the telephone pioneer Alexander Graham Bell, died tonight at her summer home. She was 82 years old."
91. ^ Gray 2006, pp. 202–205.
92. ^ Bruce 1990, pp. 90.
93. ^ Bruce 1990, 471–472.
94. ^ Tulloch 2006, pp. 25–27. Note: Under the direction of the Boston architects, Cabot, Everett and Mead, a Nova Scotia company, Rhodes, Curry and Company, carried out the actual construction.
95. ^ MacLeod 1999, p. 22.
96. ^ Tulloch 2006, p. 42.
97. ^ Gray 2006, p. 219.
98. ^ [a] [b] Grosvenor and Wesson 1997, p. 107.
99. ^ Boileau 2004, p. 18.
100. ^ Boileau 2004, pp. 28–30.
101. ^ Boileau 2004, p. 30.
102. ^ Nova Scotia's Electric Scrapbook
103. ^ Phillips 1977, p. 95.
104. ^ "Selfridge Aerodrome Sails Steadily for 319 feet (97 m)." *Washington Post* May 13, 1908. Quote: At 25 to 30 Miles an Hour. First Public Trip of Heavier-than-air Car in America. Professor Alexander Graham Bell's New Machine, Built After Plans by Lieutenant Selfridge, Shown to Be Practicable by Flight Over Keuka Lake. Portion of Tail Gives Way, Bringing the Test to an End. Views of an Expert. Hammondsport, New York, March 12, 1908.
105. ^ Phillips 1977, p. 96.
106. ^ Phillips 1977, pp. 96–97.
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108. ^ Bruce 1990, pp. 410–417.
109. ^ Library of Congress – Alexander Graham Bell Family Papers
110. ^ Osborne, Harold S. (1943) "Biographical Memoir of Alexander Gramam Bell." *National Academy of Sciences*: Biographical Memoirs, Vol. XXIII, 1847–1922, presented to the Academy at its 1943 annual meeting.
111. ^ [a] [b] [c] [d] [e] "Obituary: Dr. Bell, Inventor of Telephone, Dies: Sudden End, Due to Anemia, Comes in Seventy-Sixth Year at His Nova Scotia Home: Notables Pay Him Tribute." *The New York Times*, August 3, 1922. Retrieved: March 3, 2009.
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118. ^ Decibel Note: The decibel is defined as one tenth of a bel.
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121. ^ Royal Canadian Mint Numismatic Coins (20th Century)
122. ^ Royal Canadian Mint website
123. ^ http://BBC News World Edition
124. ^ Beatlelinks: The Greatest Britons of All Times
125. ^ "Dartmouth graduates." *New York Times*. Retrieved: July 30, 2009.
126. ^ Gray 2006, p. 419.
127. ^ Gray 2006, p. 418.
128. ^ Bruce 1990, p. 491.
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Patents

- Complete list of Bell patents

U.S. patent images in TIFF format

- U.S. Patent 161,739 *Improvement in Transmitters and Receivers for Electric Telegraphs*, filed March 1875, issued April 1875 (multiplexing signals on a single wire)
- U.S. Patent 174,465 *Improvement in Telegraphy*, filed 14 February 1876, issued March 7, 1876 (Bell's first telephone patent)
- U.S. Patent 178,399 *Improvement in Telephonic Telegraph Receivers*, filed April 1876, issued June 1876
- U.S. Patent 181,553 *Improvement in Generating Electric Currents* (using rotating permanent magnets), filed August 1876, issued August 1876
- U.S. Patent 186,787 *Electric Telegraphy* (permanent magnet receiver), filed 15 January 1877, issued January 30, 1877
- U.S. Patent 235,199 *Apparatus for Signalling and Communicating, called Photophone*, filed August 1880, issued December 1880
- U.S. Patent 757,012 *Aerial Vehicle*, filed June 1903, issued April 1904

External links

- Biography at the *Dictionary of Canadian Biography Online*
- Alexander Graham Bell Institute
- (Italian) Timeline for Antonio Meucci
- Bell Homestead, National Historic Site
- Bell Telephone Memorial erected in honor both Bell and the Invention of the Telephone in

Brantford, Ontario's *Alexander Graham Bell Gardens*

- Biography and photos at the *Canada's Telecommunications Hall of Fame* website
- Biographical video footage at the *Canada's Telecommunications Hall of Fame* website
- Appleton's Biography edited by Stanley L. Klos
- Alexander Graham Bell National Historic Site Museum located in Baddeck, Nova Scotia containing many of Bell's experiments and models
- Alexander Graham Bell family papers Online version at the Library of Congress comprises a selection of 4,695 items (totaling about 51,500 images) containing correspondence, scientific notebooks, journals, blueprints, articles, and photographs documenting Bell's invention of the telephone and his involvement in the world's first telephone company, his family life, his interest in the education of the deaf and his aeronautical and other scientific works
- Bell's path to the invention of the telephone
- Bell's speech before the American Association for the Advancement of Science in Boston on August 27, 1880, presenting the photophone, very clear description; published as "On the Production and Reproduction of Sound by Light" in the *American Journal of Sciences*, Third Series, vol. **XX**, #118, October 1880, pp. 305–324 and as "Selenium and the Photophone" in *Nature*, September 1880
- AlexanderBell.com – Telecom pioneer
- Alexander Graham Bell Biographical information, science resources and information on 1912 Franklin Award for 'electrical transmission of articulate speech' at The Franklin Institute's Case Files online exhibit
- Alexander Graham Bell gravesite
- Alexander Graham Bell: Biography and Much More from Answers.com Excellent summary of Alexander Graham Bell's life, has many useful dates for important parts of his life
- Basilio Catania, 2003 The United States Government vs. Alexander Graham Bell. An important acknowledgment for Antonio Meucci
- Bell family tree
- *American Treasures of the Library of Congress*, Alexander Graham Bell - Lab notebook I, pp. 40–41 (image 22)
- Scientists' profile: Alexander Graham Bell

Movie biographies

- *Animated Hero Classics: Alexander Graham Bell (1995)* at the Internet Movie Database
- *The Story of Alexander Graham Bell*, 1939 film reformatted for VCR tape, Don Ameche playing Bell, (1966) ISBN 0-7939-1251-2
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- The Sound and the Silence (1992) (TV) with John Bach as Alexander Graham Bell; Canada / New Zealand / Ireland Sound and the Silence ASIN B0009K7RUW

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Alexander Graham Bell, 1847 - 1922

Printer Friendly

Alexander Graham Bell was born in Edinburgh, Scotland, on 3 March 1847. His mother, Elisa Grace Symonds, was a portrait painter and an accomplished musician. His father, Alexander Melville Bell, taught deaf-mutes to speak, and wrote textbooks on correct speech. He invented "Visible Speech," a code of symbols which indicated the positions of the throat, tongue , and lips in making sounds, and helped guide the deaf in learning to speak. Bell and his two brothers assisted their father in public demonstrations of "Visible Speech," beginning in 1862. He also enrolled in a school near Edinburgh, where he taught music and speech in exchange for instruction in other subjects at school. He became a full-time teacher after studying for a year at the University of Edinburgh.

Bell's family experienced the tragic deaths of Bell's oldest and youngest brothers to tuberculosis, and therefore hastily moved to Tutelo Heights near Brantford in Ontario, Canada, in 1870, to escape the fogs of England. Bell's father was contacted by the Board of Education in Boston, Massachusetts to teach deaf children to speak based upon his "Visible Speech" system. He turned the offer over to his son, Graham, who started a successful teaching practice that included two students, George Sanders, the son of a successful leather merchant, and Mabel Hubbard, the daughter of a successful lawyer. The contact with the two fathers proved to be pivotal, for they became his business partners.

Bell was encouraged in his research by Joseph Henry, of induction and magnetism renown, and by Sir William Thompson (Lord Kelvin). Bell showed Henry his discovery that passing an intermittent current through a helix of insulated copper wire could produce the pitch, but not the quality, of sound. Henry encouraged Bell to pursue his research and also to master the fundamentals of electricity. Sir William Thompson was later to witness Bell's demonstration of the "electric speaking telephone" at the Philadelphia Centennial Exhibition in 1876, and thought it to be 'the greatest by far of all of the marvels of the electric telegraph."

Bell's invention of the telephone was a step-by-step process, sometimes with despair that the invention could succeed. During a period of recuperation at Tutelo Heights from his strenuous workload of teaching and inventing, he contemplated the phonautagraph, a sound writer that could receive sound waves on a membrane stretched over a hollow cylinder, and then move a stylus in sympathy with the vibrations. Bell's sudden insight was that a receiver modeled closely to the human ear might produce more accurate tracings of speech vibrations. He also experimented with the harmonic multiple telegraph in which a number of telegraph signals could be sent simultaneously over the same circuitry in either or both directions. For this invention he first used a tuning fork (later substituting a tuned steel reed) with its prong placed between the poles of an electromagnet, producing a dc electric current at each vibration. By operation of a telegraph key in the circuit of each fork, the intermittent current, controlled by the vibration of that particular fork, could be sent over a telegraph line wire to a receiving end where a similar fork, tuned to the same pitch, would be actuated by an electromagnet. Only the fork tuned to that pitch would "receive" the signal. A similar system was used for remote control of substation equipment as "supervisory control" in recent years.

Bell was materially aided by Thomas A. Watson, who was adept at building electrical apparatus. On 2 June 1875, Bell, assisted by Watson, was experimenting with the multiple telegraph - Watson sending, Bell receiving. One of the tuned-reed transmitters, which was in close proximity to the pole of an electromagnet, fused its contacts. Bell heard the faint echo of the vibrating fused reed, and then realized the idea of an undulating current that could transmit sound by electrical wire. Bell was then working on a spark arrester for the multiple telegraph, and he regulated the resistance between the two wires by dipping their ends into a vessel of water, varying the resistance by adjusting the depths to which the wires were submerged. From this came the idea of producing undulating current stronger than those obtained from his magneto-electric instrument. As the diaphragm vibrated, the wire rose and fell subject to its control, and by varying the resistance, varied the magnitude of the current. With this apparatus, a test was made on 10 March 1876. Bell spoke and Watson heard the first sentence transmitted by the telephone, "Mr. Watson come here, I want you."

Bell and Watson made many successful demonstrations on the telephone, and their work paved the way for the beginning of telephone service in America. The first telephone company, the Bell Telephone Company, came into existence on 9 July 1877. Shortly after, Bell married Mabel Hubbard and sailed with his bride to England to introduce the telephone there.

Bell returned to America in 1878, and moved to Washington, D.C. He did not take an active part in the telephone business, although he was frequently called upon to testify in lawsuits brought by men claiming they had invented the telephone earlier. Several suits reached the Supreme Court of the United States. The Court upheld Bell's rights in all the cases.

Bell lived a creative life for more than 45 years after the invention of the telephone. He gave many years of service to the deaf, and produced other communication devices.

The French government awarded Bell the Volta prize of 50,000 francs in 1880 for his invention of the telephone. He used the money to help establish the Volta Laboratory for research, invention, and work for the deaf. There he and his associates also developed the method of making phonograph records on wax discs. He was awarded the IEEE (AIEE) Edison Medal in 1914 for "For meritorious achievement in the invention of the telephone."

Bell spent most of his later life at his estate on Cape Breton Island, Nova Scotia. He worked in his laboratory, or sat at his piano playing old Scottish tunes. He became a citizen of the United States in 1882. He died on 2 August 1922 in near his Nova Scotia home.

From "Alexander Graham Bell and the telephone," by Dick Reiman
in *IEEE* (int.), March 1991; and the *World Book Encyclopedia*, Vol. 2, 1972

Telephone Science Experiment #1
Alexander Bell's Famous Tuning Fork Experiment

For over a year, Alexander Bell, at the urging of his financial backers, had been working diligently to perfect his multiple-message telegraph, a system that he believed would eventually transmit an astounding 30 to 40 simultaneous messages along a single telegraph wire. The telegraph industry would gladly pay a small fortune for just such a system.

But throughout this time he was also obsessed with an elusive dream -- that of sending the human voice over a telegraph wire. He had even made several unsuccessful attempts to do this. Now, in March of 1876, having just returned to Boston after a conference with his patent attorneys in Washington, D.C., he decided to try a new approach, one he had never pursued before.

He theorized that if he could somehow vary the resistance in an electrical circuit at the frequency of sound it would cause the current to fluctuate in exact step with the sound. And if he sent that fluctuating current through one of the electromagnetic relays he was using for his telegraph system, he should be able to hear the original sound coming from the relay. If he could do that, he believed, he was very close to sending the human voice through that same circuit. He sketched out this idea in his laboratory notebook as shown in Figure 1.

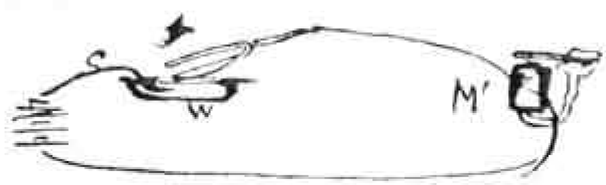


Figure 1

All he needed for the experiment was a tuning fork, a battery, a bowl filled with water and a little bit of acid (to make it electrically conductive), and a relay. The relay, Item M in Figure 1, would act as a crude earphone. With these components connected as shown, he held the relay tightly against his ear and then gave the tuning fork a sharp rap to make it vibrate. With the tuning fork still vibrating, he carefully lowered it, keeping it almost parallel with the liquid, so that just one tip barely touched the water/acid solution. To his great delight, he heard the exact pitch of the tuning fork coming from the relay pressed against his ear. He knew now that his elusive dream would soon be a reality.

You can easily perform this same experiment using the arrangement shown in Figure 2. Tuning forks can be obtained from music stores for about five dollars. A six-volt lantern battery works well. For the acid water use 5% white vinegar straight from the bottle and pour it into a 1-cup metal measuring cup. The listening device (used in place of Bell's relay) can be just about anything that can produce sound: an old telephone receiver, a headphone, a loudspeaker from an old radio, or a small replacement speaker (see Radio Shack). Connect these items as shown in Figure 2.

Figure 2

Be sure to give the tuning fork a good rap and then quickly lower it to the vinegar, keeping it as parallel as possible. Experiment to see just how far the tuning fork should enter the vinegar. Even though you can't see it, the tip of the vibrating tuning fork is being rapidly immersed and withdrawn from the vinegar. This changes the resistance between the fork and the vinegar, which in turn causes the current through the listening device to fluctuate at the same frequency of the fork. Try the experiment again, but with the fork perpendicular to the vinegar; you may not hear any sound because there is no change in resistance.

Written by Ed Evenson 2002

Invention of the telephone

From Wikipedia, the free encyclopedia

Bell speaking into prototype model of the telephone

The modern telephone is the culmination of work done by many individuals, all worthy of recognition for their contributions to the field. Alexander Graham Bell was the first to patent the telephone, an "apparatus for transmitting vocal or other sounds telegraphically", after experimenting with many primitive sound transmitters and receivers. However, the history of the invention of the telephone is a confusing collection of claims and counterclaims, made no less confusing by the many lawsuits which attempted to resolve the patent claims of several individuals.

Contents

Non-electric "telephones"

According to a letter in the Peking Gazette, a Chinese inventor created a speech transmitting device in 968, which probably transported sound through *speaking tubes*, or pipes. Speaking tubes remained common and can still be found today in a variety of locations, including ships.

The string or "lover's" telephone has also been known for centuries. Comprising two diaphragms connected by a taut string or wire, sound waves are carried as vibrations along the string or wire from one diaphragm to the other. The classic example is the tin can telephone, a children's toy made by connecting the two ends of a string to the bottoms of two metal cans, paper cups or similar items.

Make and break transmitters and electro-magnetic receivers

Innocenzo Manzetti

Innocenzo Manzetti mooted the idea of a telephone as early as 1844, and may have made one in 1864, as an enhancement to an automaton built by him in 1849.

Charles Bourseul

Main article: Charles Bourseul

In 1854 in the magazine L'Illustration (Paris) Charles Bourseul, a French telegraphist, published a plan for conveying sounds and even speech by electricity.[1] Bourseul's ideas were also published in *Didaskalia* (Frankfurt am Main) on September 28, 1854. "Suppose", he explained, “that a man speaks near a movable disc sufficiently flexible to lose none of the vibrations of the voice; that this disc alternately makes and breaks the currents from a battery: you may have at a distance another disc which will simultaneously execute the same vibrations.... It is certain that, in a more or less distant future, speech will be transmitted by electricity. I have made experiments in this direction; they are delicate and demand time and patience, but the approximations obtained promise a favourable result.”

Johann Philipp Reis

Main article: Johann Philipp Reis

In 1860 Johann Philipp Reis produced a device which could transmit musical notes, and even a lisping sentence or two. The first sentence spoken on it was "Das Pferd frisst keinen Gurkensalat" (the horse doesn't eat cucumber salad). See Reis' telephone for a detailed description. The Reis transmitter was a make-break transmitter. That is, a needle attached to a diaphragm was alternately pressed against, and released from a contact as the sound moved the diaphragm. This make-or-break signaling was able to transmit tones, and some vowels, but since it did not follow the analog shape of the sound wave (the contact was pure digital, on or off) it could not transmit consonants, or complex sounds. The Reis transmitter was very difficult to operate, since the relative position of the needle and the contact were critical to the device's operation at all. This can be called a "telephone", since it did transmit sounds over distance, but is hardly a telephone in the modern sense, as it failed to transmit a good copy of any supplied sound. Reis' invention is best known then as the "musical telephone". Prior to 1947, the Reis device was tested by the British company Standard Telephones and Cables (STC). The results also confirmed it could faintly transmit and receive speech. At the time STC was bidding for a contract with Alexander Graham Bell's American Telephone and Telegraph Company, and the results were covered up by STC's chairman Sir Frank Gill to maintain Bell's reputation. [2]

Antonio Meucci

Main article: Antonio Meucci

An early version of the telephone was invented around 1860 by Antonio Meucci who called it *teletrofono* (*telectrophone*).

The first American demonstration of Meucci's invention took place in Staten Island, New York in 1854. In 1860, a description of it was published in New York's Italian language newspaper. Meucci claimed to have invented a paired electro-magnetic transmitter and receiver, where the motion of a diaphragm modulated a signal in a coil by moving an electromagnet, although this is not mentioned in his 1871 caveat. Meucci is also credited with the early invention of inductive loading of telephone wires to increase long-distance signals. Unfortunately, serious burns, lack of English, and poor business abilities resulted in Meucci failing to develop his inventions commercially in America. Meucci demonstrated some sort of instrument in 1849 in Havana, Cuba, but the evidence is unclear if this was an electric telephone or a variant on the string telephone using wires.

(Meucci has been further credited with invention of an anti-sidetone circuit. However, examination shows that his solution to sidetone was to maintain two separate telephone circuits, and thus twice as many transmission wires. The anti-sidetone circuit later introduced by Bell Telephone instead cancelled sidetone with a feedback process.)

Western Union laboratory reportedly lost Meucci's working models, and Meucci, who at this point was living on public assistance, was unable to renew the patent after 1874;

Meucci was recognized for his pioneer work on the telephone by the United States House of Representatives in House Resolution 269 dated 11 June 2002. The resolution stated that *"if Meucci had been able to pay the $10 fee to maintain the caveat after 1874, no patent could have been issued to Bell."* However, the resolution was a symbolic, non-binding statement that had no legal effect, and was promptly followed by a motion which mooted it, passed unanimously by Canada's 37th Parliament declaring that Alexander Graham Bell was the inventor of the telephone. Additionally, many other people disagreed with the Congressional resolution, some of whom provided criticisms of both its intent and accuracy.

Further information: Canadian Parliamentary Motion on Alexander Graham Bell

Chronology of Meucci's invention

An Italian researcher in telecommunications, Basilio Catania, and the Italian Society of Electrotechnics, "Federazione Italiana di Elettrotecnica", have devoted a Museum to Antonio Meucci, constructioning a chronology of his inventing the telephone and tracing the history of the two trials involving Meucci and Alexander Graham Bell[3][4]. Both claim that Meucci was the real inventor of the telephone, but base their argument on the reconstruction rather than contemporary evidence. What follows, if not otherwise stated, is a résumé of their historic reconstruction.[5]

- In 1834 Meucci constructed a kind of acoustic telephone as a way to communicate between the stage and control room at the theatre "Teatro della Pergola" in Florence. This telephone is constructed on the model of pipe-telephones on ships and is still working.[6]

- In 1848 Meucci developed a popular method of using electric shocks to treat rheumatism. He used to give his patients two conductors linked to 60 Bunsen batteries and ending with a cork. He also kept two conductors linked to the same Bunsen batteries. He used to sit in his laboratory, while the Bunsen batteries were placed in a second room and his patients in a third room. In 1849 while providing a treatment to a patient with a 114V electrical discharge, in his laboratory Meucci heard his patient's scream through the piece of copper wire that was between them, from the conductors he was keeping near his ear. His intuition was that the "tongue" of copper wire was vibrating just like a leave of an electroscope; which means that there was an electrostatic effect. In order to continue the experiment without hurting his patient, Meucci covered the copper wire with a piece of paper. Through this device he heard inarticulated human voice. He called this device "telegrafo parlante" (litt. "talking telegraph").[7]

On the basis of this prototype, Meucci worked on more than 30 kinds of sound transmitting devices inspired by the telegraph model as did other pioneers of the telephone, such as Charles Bourseul, Philipp Reis, Innocenzo Manzetti and others. Meucci later claimed that he did not think about transmitting voice by using the principle of the telegraph "make-and-break" method, but he looked for a "continuous" solution that did not interrupt the electric current.

- In 1856 Meucci later claimed that he constructed the first electromagnetic telephone, made of an electromagnet with a nucleus in the shape of a horseshoe bat, a diaphragm of animal skin, stiffened with potassium dichromate and keeping a metal disk stuck in the middle. The instrument was hosted in a cylindrical carton box.[8] He said he constructed this as a way to connect his second-floor bedroom to his basement laboratory, and thus communicate with his wife who was an invalid.

Meucci separated the two directions of transmission in order to eliminate the so-called "local effect", adopting what we would call today a 4-wire-circuit. He constructed a simple calling system with a telegraphic manipulator which short-circuited the instrument of the calling person, producing in the instrument of the called person a succession of impulses (clicks), much more intense than those of normal conversation. As he was aware that his device required a bigger band than a telegraph, he found some means to avoid the so-called "skin effect" through superficial treatment of the conductor or by acting on the material (copper instead of iron). He successfully used an insulated copper plait, thus anticipating the litz wire used by Nikola Tesla in RF coils.

- In 1864 Meucci later claimed that he realized his "best device", using an iron diaphragm with optimized thickness and tightly clamped along its rim. The instrument was housed in a shaving-soap box, whose cover clamped the diaphragm.
- In August 1870, Meucci later claimed that he obtained transmission of articulate human voice at a mile distance by using as a conductor a copper plait insulated by cotton. He called his device "teletrofono". According to an Affidavit of lawyer Michael Lemmi drawings and notes by Antonio Meucci dated September 27 1870 show coils of wire on long distance telephone lines. The painting made by Nestore Corradi [1] in 1858 mentions the sentence "Electric current from the inductor pipe"

All this information has been published on the Scientific American Supplement No. 520, December 19, **1885** based on 1885 reconstructions for which there is no contemporary pre-1875 evidence. Meucci's 1871 caveat does not mention any of the telephone features later credited to him by his lawyer and which were published in the Scientific American Supplement.[9] See Meucci#The caveat for the text of his caveat.

Cromwell Varley

Around 1870 Mr. C. F. Varley, F.R.S., a well-known English electrician, patented a number of variations on the audio telegraph based on Reis' work. He never claimed or produced a device capable of transmitting speech, only pure tones.

Poul la Cour

Around 1874 Poul la Cour, a Danish inventor, experimented with audio telegraphs on a telegraph line between Copenhagen and Fredericia in Jutland. His experiment used a vibrating tuning-fork to interrupt the line current, which, after traversing the line passed through an electromagnet that acted upon the tines of another tuning-fork, making it resonate at the same pitch of the transmitting fork. Moreover, the hums were also recorded on paper by turning the electromagnetic receiver into a relay, which actuated a Morse code printer by means of a local battery. Again, la Cour made no claims of transmitting voice, only pure tones.

Electro-magnetic transmitters and receivers

Elisha Gray

Main article: Elisha Gray, See also: Elisha Gray and Alexander Bell telephone controversy

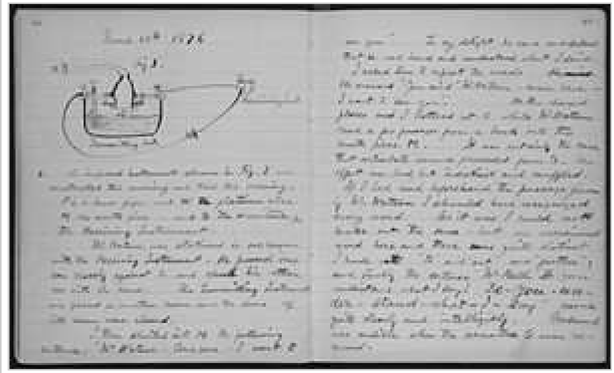
Elisha Gray, of Chicago also devised a tone telegraph of this kind about the same time as La Cour. In Gray's tone telegraph, several vibrating steel reeds tuned to different frequencies interrupted the current, which at the other end of the line passed through electromagnets and vibrated matching tuned steel reeds near the electromagnet poles. Gray's 'harmonic telegraph,' with vibrating reeds, was used by the Western Union Telegraph Company. Since more than one set of vibration frequencies — that is to say, more than one musical tone — can be sent over the same wire simultaneously, the harmonic telegraph can be utilised as a 'multiplex' or many-ply telegraph, conveying several messages through the same wire at the same time; and these can either be read by the operator by the sound, or a permanent record can be made by the marks drawn on a ribbon of travelling paper by a Morse recorder. On 27 July 1875, Gray was granted U.S. patent 166,096 for "Electric Telegraph for Transmitting Musical Tones" (the harmonic telegraph).

On 14 February 1876, Gray filed a patent caveat for a telephone on the very same day in 1876 as did Bell's lawyer. The water transmitter described in Gray's caveat was strikingly similar to the experimental telephone transmitter tested by Bell on March 10, 1876, a fact which raised questions about whether Bell (who knew of Gray) was inspired by Gray's design or vice versa. Although Bell did not use Gray's water transmitter in later telephones, evidence suggests that Bell's lawyers may have obtained an unfair advantage over Gray.[10][11]

Alexander Graham Bell

Main article: Alexander Graham Bell

Alexander Graham Bell of Scotland is commonly credited as the inventor of the first practical telephone. The classic story of his crying out "Watson, come here! I want to see you!" is a well known part of American history[12]. But Alexander Graham Bell was also an astute and articulate business man with influential and wealthy friends.



Bell's March 10, 1876 laboratory notebook entry describing his first successful experiment with the telephone.

As Professor of Vocal Physiology at Boston University, Bell was engaged in training teachers in the art of instructing deaf mutes how to speak, and experimented with the Leon Scott phonautograph in recording the vibrations of speech. This apparatus consists essentially of a thin membrane vibrated by the voice and carrying a light stylus, which traces an undulatory line on a plate of smoked glass. The line is a graphic representation of the vibrations of the membrane and the waves of sound in the air.[13]

This background prepared Bell for work with spoken sound waves and electricity. He began his experiments in 1873-1874 with a harmonic telegraph, following the examples of Bourseul, Reis, Meucci, and Gray. Bell's designs employed various on-off-on-off make-break current-interrupters driven by vibrating steel reeds which sent interrupted current to a distant receiver electro-magnet that caused a second steel reed or tuning fork to vibrate.[14]

During a June 2, 1875 experiment by Bell and his assistant Watson, a receiver reed failed to respond to the intermittent current supplied by an electric battery. Bell told Watson, who was at the other end of the line, to pluck the reed, thinking it had stuck to the pole of the magnet. Mr. Watson complied, and to his astonishment Bell heard a reed at his end of the line vibrate and emit the same timbre of a plucked reed, although there was no interrupted on-off-on-off current from a transmitter to make it vibrate.[15] A few more experiments soon showed that his receiver reed had been set in vibration by the magneto-electric currents induced in the line by the motion of the distant receiver reed in the neighbourhood of its magnet. The battery current was not causing the vibration but was needed only to supply the magnetic field in which the reeds vibrated. Moreover, when Bell heard the rich overtones of the plucked reed, it occurred to him that since the circuit was never broken, all the complex vibrations of speech might be converted into undulating (alternating) currents, which in turn would reproduce the complex timbre, amplitude, and frequencies of speech at a distance.

After Bell and Watson discovered on June 2, 1875 that movements of the reed alone in a magnetic field could reproduce the frequencies and timbre of spoken sound waves, Bell reasoned by analogy with the mechanical phonautograph that a skin diaphragm would reproduce sounds like the human ear when connected to a steel or iron reed or hinged armature. On July 1, 1875, he instructed Watson to build a receiver consisting of a stretched diaphragm or drum of goldbeater's skin with an armature of magnetized iron attached to its middle, and free to vibrate in front of the pole of an electromagnet in circuit with the line. A second membrane-device was built for use as a transmitter.[16] This was the "gallows" phone. A few days later they were tried together, one at each end of the line, which ran from a room in the inventor's house in Boston to the cellar underneath. Bell, in the work room, held one instrument in his hands, while Watson in the cellar listened at the other. Bell spoke into his instrument, “Do you understand what I say?” and Mr. Watson answered “Yes”. However, the voice sounds were not distinct and the armature tended to stick to the electromagnet pole and tear the membrane.

Because of illness and other commitments, Bell made little or no telephone improvements or experimentats for eight months until after his U.S. patent 174,465 was published.[16] On March 10, 1876, Bell tested Gray's water transmitter design only after Bell's patent was granted and only as a proof of concept scientific experiment[17] to prove to his own satisfaction that intelligible "articulate speech" (Bell's words) could be electrically transmitted.[18] After March 1876, Bell focused on improving the electromagnetic telephone and never used Gray's liquid transmitter in public demonstrations or commercial use.[19]

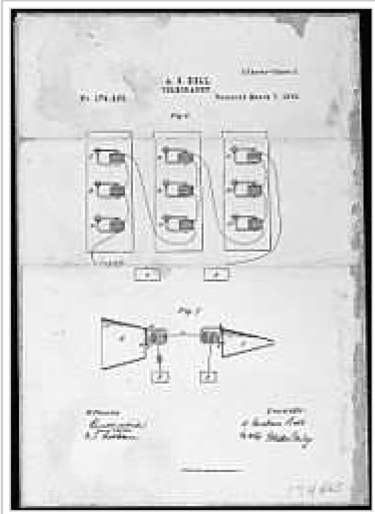
Variable resistance transmitters

Elisha Gray

Gray's harmonic telegraph apparatus followed in the track of Reis and Bourseul — that is to say, the interruption of the current by a vibrating contact. But Gray recognized the lack of fidelity of the make-break transmitter, and reasoned by analogy with the lovers telegraph, that if the current could be made to more closely model the movements of the diaphragm, rather than simply opening and closing the circuit, greater fidelity might be achieved. Gray filed a patent caveat with the US patent office on February 14, 1876 for a liquid microphone. The device used a metal needle or rod that was placed — just barely — into a liquid conductor, such as a water/acid mixture. In response to the diaphragm's vibrations, the needle dipped more or less into the liquid, varying the electrical resistance and thus the current passing through the device and on to the receiver. Gray did not convert his caveat into a patent until after the caveat had expired and hence left the field open to Bell.

Bell's success

The first successful bi-directional transmission of clear speech by Bell and Watson was made on March 10, 1876 when Bell spoke into his device, “Mr. Watson, come here, I want to see you.” and Watson answered. Bell used Gray's liquid transmitter design[21] in his famous March 10, 1876 experiment, but Bell did not use a liquid transmitter again, because it was not practical for commercial products.



Alexander Graham Bell's telephone patent[20] drawing, 7 March 1876.

The first long distance telephone call was made on 10 August 1876 by Bell from the family homestead in Brantford, Ontario, to his assistant located in Paris, Ontario, some 10 miles (16 km) distant.

A finished instrument was then made, having a transmitter formed of a double electromagnet, in front of which a membrane, stretched on a ring, carried an oblong piece of soft iron cemented to its middle. A mouthpiece before the diaphragm directed the sounds upon it, and as it vibrated with them, the soft iron “armature” induced corresponding currents in the coils of the electromagnet. These currents after traversing the line were passed through the receiver, which consisted of a tubular electromagnet, having one end partially closed by a thin circular disc of soft iron fixed at one point to the end of the tube. This receiver bore a resemblance to a cylindrical metal box with thick sides, having a thin iron lid fastened to its mouth by a single screw. When the undulatory current passed through the coil of this magnet, the disc, or armature-lid, was put into vibration and sounds were emitted from it.

This primitive telephone was rapidly improved, the double electromagnet being replaced by a single bar magnet having a small coil or bobbin of fine wire surrounding one pole, in front of which a thin disc of ferrotype was fixed in a circular mouthpiece, and served as a combined membrane and armature. On speaking into the mouthpiece, the iron diaphragm vibrated with the voice in the magnetic field of the pole, and thereby caused undulatory currents in the coil, which, after traveling through the wire to the distant receiver, were received in an identical apparatus. This form was patented January 30, 1877. The sounds were weak and could only be heard when the ear was close to the earphone/mouthpiece, but they were distinct.

Public demonstrations

Earliest public demonstration of Bell's telephone

In June 1876, Bell exhibited a telephone prototype at the Centennial Exhibition in Philadelphia, where it attracted the attention of Brazilian emperor Pedro II and scientist Sir William Thomson. In August 1876 at a meeting of the British Association for the Advancement of Science, Thomson revealed the telephone to the European public. In describing his visit to the Philadelphia Exhibition, Thomson said, 'I heard [through the telephone] passages taken at random from the New York newspapers: "s.s. Cox has arrived" (I failed to make out the s.s. Cox); "The City of New York", "Senator Morton", "The Senate has resolved to print a thousand extra copies", "The Americans in London have resolved to celebrate the coming Fourth of July!" All this my own ears heard spoken to me with unmistakable distinctness by the then circular disc armature of just such another little electro-magnet as this I hold in my hand.'

Later public demonstrations

The later telephone design was publicly exhibited on May 4 1877 at a lecture given by Professor Bell in the Boston Music Hall. According to a report: Going to the small telephone box with its slender wire attachments, Mr. Bell coolly asked, as though addressing some one in an adjoining room, “Mr. Watson, are you ready!” Mr. Watson, five miles away in Somerville, promptly answered in the affirmative, and soon was heard a voice singing “America”. [...] Going to another instrument, connected by wire with Providence, forty-three miles distant, Mr. Bell listened a moment, and said, “Signor Brignolli, who is assisting at a concert in Providence Music Hall, will now sing for us.” In a moment the cadence of the tenor's voice rose and fell, the sound being faint, sometimes lost, and then again audible. Later, a cornet solo played in Somerville was very distinctly heard. Still later, a three-part song came over the wire from Somerville, and Mr. Bell told his audience “I will switch off the song from one part of the room to another, so that all can hear.” At a subsequent lecture in Salem, Massachusetts, communication was established with Boston, eighteen miles distant, and Mr. Watson at the latter place sang “Auld Lang Syne”, “The Star-Spangled Banner”, and “Hail Columbia”, while the audience at Salem joined in the chorus.

Summary of Bell's achievements

Bell did for the telephone what Henry Ford did for the automobile. Although not the first to experiment with telephonic devices, Bell and the companies founded in his name were the first to develop commercially practical telephones around which a successful business could be built and grow. Bell adopted carbon transmitters similar to Edison's transmitters and adapted telephone exchanges and switching plug boards developed for telegraphy. Watson and other Bell engineers invented numerous other improvements to telephony. Bell succeeded where others failed to assemble a commercially viable telephone **system**. It can be argued that Bell invented the telephone industry.

Carbon microphone - Thomas Edison

Thomas Alva Edison took the next step in improving the telephone with his invention in 1878 of the carbon grain transmitter that provided a strong voice signal on the transmitting circuit that made long-distance calls practical. Edison discovered that carbon grains, squeezed between two metal plates, had a resistance that was related to the pressure. Thus, the grains could vary their resistance as the plates moved in response to sound waves, and reproduce sound with good fidelity, without the weak signals associated with electro-magnetic transmitters.

The carbon microphone was further improved by Emile Berliner, Francis Blake, David E. Hughes, Henry Hunnings, and Anthony White. The carbon transmitter remained standard in telephony until the 1980s, and is still being produced.

Improvements to the early telephone

Additional inventions such as the call bell, central telephone exchange, common battery, ring tone, amplification, trunk lines, wireless phones, etc. were made by various engineers who made the telephone the useful and widespread apparatus it is now.

Telephone exchange - Tivadar Puskás

Tivadar Puskás was working on his idea for a telegraph exchange when Alexander Graham Bell received the first patent for the telephone. This caused Puskás to take a fresh look at his own work and he refocused on perfecting a design for a telephone exchange. Puskás got in touch with the American inventor Thomas Edison who liked the design. According to Edison, "Tivadar Puskas was the first person to suggest the idea of a telephone exchange". Puskás's idea finally became a reality in 1877 in Boston. [22][23][24][25][26] It was then that the Hungarian word "hallom" "I hear you" was used for the first time in a telephone conversation when, on hearing the voice of the person at the other end of the line, Puskás shouted "hallom". This cannot be confirmed by any original documents, however it has passed into Hungarian modern folklore. Hallom was shortened to Hello, an older greeting that can be traced back to the Old English verb hǽlan.

Controversy

See also: Canadian Parliamentary Motion on Alexander Graham Bell

Bell has been widely recognized as the "inventor" of the telephone outside of Italy, where Meucci was championed as its inventor. In the United States, there are numerous reflections of Bell as a North American icon for inventing the telephone, and the matter was for a long time non-controversial. In June 2002, however, the United States House of Representatives passed a symbolic bill recognizing the contributions of Antonio Meucci *"in the invention of the telephone"* (not *"for the invention of the telephone"*), throwing the matter into some controversy. Ten days later the Canadian parliament countered with a symbolic motion conferring official recognition for the invention of the telephone to Bell.

Champions of Meucci, of Manzetti, and of Gray have each offered fairly precise tales of a contrivance whereby Bell actively stole the invention of the telephone from their specific inventor. In the 2002 congressional resolution, it was inaccurately noted that Bell worked in a laboratory in which Meucci's materials had been stored, and claimed that Bell must thus have had access to those materials. Manzetti claimed that Bell visited him and examined his device in 1865. And it is alleged that Bell bribed a patent examiner, Zenas Wilber, not only into processing his application before Gray's, but allowing a look at his rival's designs before final submission.

One of the valuable claims in Bell's 1876 patent US 174,465 was claim 4, a method of producing variable electrical current in a circuit by varying the resistance in the circuit. That feature was not shown in any of Bell's patent drawings, but was shown in Elisha Gray's drawings in his caveat filed the same day 14 February 1876. A description of the variable resistance feature, consisting of 7 sentences, was inserted into Bell's application. That it was inserted is not disputed. But when it was inserted is a controversial issue. Bell testified that he wrote the sentences containing the variable resistance feature before 18 January 1876 "almost at the last moment" before sending his draft application to his lawyers. A book by Evenson[27] argues that the 7 sentences and claim 4 were inserted, without Bell's knowledge, just before Bell's application was hand carried to the Patent Office by one of Bell's lawyers on 14 February 1876.

Contrary to the popular story, Gray's caveat was taken to the US Patent Office a few hours before Bell's application. Gray's caveat was taken to the Patent Office in the morning of 14 February 1876 shortly after the Patent Office opened and remained near the bottom of the in-basket until that afternoon. Bell's application was filed shortly before noon on 14 February by Bell's lawyer who requested that the filing fee be entered immediately onto the cash receipts blotter and Bell's application was taken to the Examiner immediately. Late in the afternoon, Gray's caveat was entered on the cash blotter and was not taken to the Examiner until the following day. The fact that Bell's filing fee was recorded earlier than Gray's led to the myth that Bell had arrived at the Patent Office earlier.[28] Bell was in Boston on 14 February and did not know this happened until later. Gray later abandoned his caveat and that opened the door to Bell being granted US patent 174,465 for the telephone on 7 March 1876.

Further information: Elisha Gray and Alexander Bell telephone controversy

Patents

- US patent 161739 *Transmitter and Receiver for Electric Telegraphs* (tuned steel reeds) by Alexander Graham Bell (April 6, 1875)
- US patent 174465 *Telegraphy* (Bell's first telephone patent) by Alexander Graham Bell (March 7, 1876)
- US patent 178399 *Telephonic Telegraphic Receiver* (vibrating reed) by Alexander Graham Bell (June 6, 1876)
- US patent 181553 *Generating Electric Currents* (magneto) by Alexander Graham Bell (August 29, 1876)
- US patent 186787 *Electric Telegraphy* (permanent magnet receiver) by Alexander Graham Bell (January 15, 1877)
- US patent 201488 *Speaking Telephone* (receiver designs) by Alexander Graham Bell (March 19, 1878)
- US patent 213090 *Electric Speaking Telephone* (frictional transmitter) by Alexander Graham Bell (March 11, 1879)
- US patent 220791 *Telephone Circuit* (twisted pairs of wire) by Alexander Graham Bell (October 21, 1879)
- US patent 228507 *Electric Telephone Transmitter* (hollow ball transmitter) by Alexander Graham Bell (June 8, 1880)
- US patent 230168 *Circuit for Telephone* by Alexander Graham Bell (July 20, 1880)
- US patent 238833 *Electric Call-Bell* by Alexander Graham Bell (March 15, 1881)
- US patent 241184 *Telephonic Receiver* (local battery circuit with coil) by Alexander Graham Bell (May 10, 1881)
- US patent 244426 *Telephone Circuit* (cable of twisted pairs) by Alexander Graham Bell (July 19, 1881)
- US patent 252576 *Multiple Switch Board for Telephone Exchanges* by Leroy Firman (Western Electric) (January 17, 1882)

- US patent 474230 *Speaking Telegraph* (graphite transmitter) by Thomas Edison
- US patent 203016 *Speaking Telephone* (carbon button transmitter) by Thomas Edison
- US patent 222390 *Carbon Telephone* (carbon granules transmitter) by Thomas Edison
- US patent 485311 *Telephone* (solid back carbon transmitter) by Anthony C. White (Bell engineer)
- US patent 597062 *Calling Device for Telephone Exchange* (dial) by A. E. Keith (11 January 1898)
- US patent 3449750 *Duplex Radio Communication and Signalling Appartus* by G. H. Sweigert
- US patent 3663762 *Cellular Mobile Communication System* by Amos Edward Joel (Bell Labs)
- US patent 3906166 *Radio Telephone System* (DynaTAC cell phone) by Martin Cooper et al. (Motorola)

See also

- Timeline of the telephone
- History of the telephone

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2. ^ BBC NEWS | Science/Nature | Bell 'did not invent telephone'
3. ^ http://www.esanet.it/chez_basilio/meucci.htm
4. ^ http://www.aei.it/ita/museo/mam_hpg1.htm
5. ^ Basilio Catania's reconstruction, in English
6. ^ Picture of the acustic telephone, page maintained by the Italian Society of Electrotechnics
7. ^ Meucci's original drawings. Page maintained by the Italian Society of Electrotechnics
8. ^ Meucci's original drawings. Page maintained by the Italian Society of Electrotechnics
9. ^ Text of Meucci's Caveat, pages 16-18
10. ^ Elisha Gray and Alexander Bell Controversy
11. ^ Inventor's Digest, July/August 1998, p. 26-28
12. ^ American Treasures of the Library of Congress ... Bell - Lab notebook
13. ^ Robert Bruce (1990), pages 102-103, 110-113, 120-121
14. ^ Robert Bruce (1990), pages 104-109
15. ^ Robert Bruce (1990), pages 146-148
16. ^ [a] [b] Robert Bruce (1990), page 149
17. ^ Evenson, page 99.
18. ^ Evenson, page 98.
19. ^ Evenson, page 100.
20. ^ US patent 174465 Alexander Graham Bell: „Improvement in Telegraphy“ filed on February 14, 1876, granted on March 7, 1876.
21. ^ Shulman, pages 36-37. Bell's lab notes dated March 9, 1876 show a drawing of a person speaking face down into a liquid transmitter very similar to the liquid transmitter depicted as Fig. 3 in Gray's caveat.
22. ^ http://www.hungarian-history.hu/mszh/epuskas.htm
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- Telephone Patents
- HRes 269, text of 17 October 2001
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External links

- Alexander Bell's Experiments - the tuning fork and liquid transmitter.

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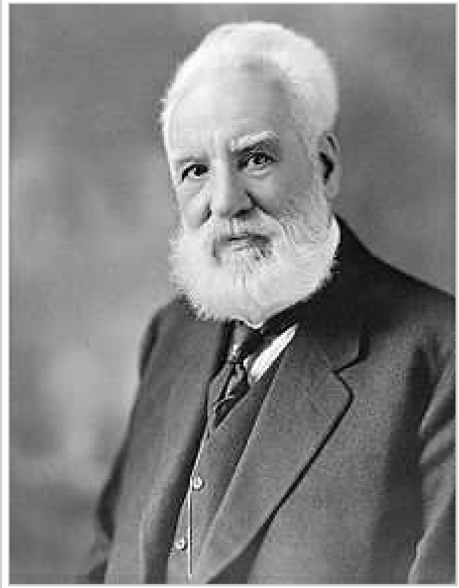
Categories: Telecommunications history | Telephony | Telecommunications | Technology in society | Discovery and invention controversies

Canadian Parliamentary Motion on Alexander Graham Bell

From Wikipedia, the free encyclopedia

The **Canadian Parliamentary Motion on Alexander Graham Bell**, in the first session of Canada's 37th Parliament was unanimously passed by all four parties of its federal government on June 21, 2002, to affirm that Alexander Graham Bell, who had lived in both Brantford, Ontario and Baddeck, Nova Scotia for extended periods of time, was the inventor of the telephone.[1][2][3]


Alexander Graham Bell c. 1914-1919

The motion was a response to the United States' 107th Congress' earlier resolution (HRes 269) of June 11, 2002, which recognized the contributions of competitor Antonio Meucci and has been misinterpreted as establishing priority for the invention of the telephone to Meucci who would later be associated with the Globe Telephone Company.[2][4]

That symbolic resolution, however, stopped short of stating that Meucci had invented the telephone, or that Alexander Graham Bell did not do so. The congressional resolution also did not annul or modify any of Bell's patents for the telephone.

The intricately worded HRes 269 resolution of the 107th Congress has often been erroneously reported[5] by various news media and incorrectly cited by Meucci advocates as proof that he was the true inventor of the telephone.


Antonio Meucci c. 1880

Contents

Full text of the parliamentary motion on Bell

As directly quoted in Hansard, the official Canadian parliamentary record:[1]

Hon. Sheila Copps (Minister of Canadian Heritage, Lib.): `Mr. Speaker, I would like to ask the House for unanimous consent on the following motion, which has been discussed with all parties, regarding Alexander Graham Bell. I move [that]:`

> *This House affirms that Alexander Graham Bell of Brantford, Ontario and Baddeck, Nova Scotia is the inventor of the telephone.*

The Speaker: *Does the hon. Minister of Canadian Heritage have the unanimous consent of the House to propose this motion?*

Some hon. members: *Agreed.*

The Speaker: *Is it the pleasure of the House to adopt the motion?*

Some hon. members: *Agreed.*

(Motion agreed to)

[continuing....]

Hon. Sheila Copps: *Mr. Speaker, might I suggest that we forward a copy of this to the congress in the United States so they get their facts straight?*

Full text of the earlier congressional resolution HRes 269 (Version EH) of the 107th U.S. Congress

As directly quoted in HRes 269 (Ver. EH), and recorded by the US GPO (table and paragraph numbering added for referencing purposes): [6]

Para. #	Verbiage
Intro.	**H. Res. 269** In the House of Representatives, U.S., June 11, 2002.
¶ 1	Whereas Antonio Meucci, the great Italian inventor, had a career that was both extraordinary and tragic;
¶ 2	Whereas, upon immigrating to New York, Meucci continued to work with ceaseless vigor on a project he had begun in Havana, Cuba, an invention he later called the ‘‘teletrofono’’, involving electronic communications;
¶ 3	Whereas Meucci set up a rudimentary communications link in his Staten Island home that connected the basement with the first floor, and later, when his wife began to suffer from crippling arthritis, he created a permanent link between his lab and his wife’s second floor bedroom;
¶ 4	Whereas, having exhausted most of his life’s savings in pursuing his work, Meucci was unable to commercialize his invention, though he demonstrated his invention in 1860 and had a description of it published in New York’s Italian language newspaper;
¶ 5	Whereas Meucci never learned English well enough to navigate the complex American business community;
	Whereas Meucci was unable to raise sufficient funds to pay his way through the patent

¶ 6	application process, and thus had to settle for a caveat, a one year renewable notice of an impending patent, which was first filed on December 28, 1871;
¶ 7	Whereas Meucci later learned that the Western Union affiliate laboratory reportedly lost his working models, and Meucci, who at this point was living on public assistance, was unable to renew the caveat after 1874;
¶ 8	Whereas in March 1876, Alexander Graham Bell, who conducted experiments in the same laboratory where Meucci's materials had been stored, was granted a patent and was thereafter credited with inventing the telephone;
¶ 9	Whereas on January 13, 1887, the Government of the United States moved to annul the patent issued to Bell on the grounds of fraud and misrepresentation, a case that the Supreme Court found viable and remanded for trial;
¶ 10	Whereas Meucci died in October 1889, the Bell patent expired in January 1893, and the case was discontinued as moot without ever reaching the underlying issue of the true inventor of the telephone entitled to the patent; and
¶ 11	Whereas if Meucci had been able to pay the $10 fee to maintain the caveat after 1874, no patent could have been issued to Bell: Now, therefore, be it
¶ 12	Resolved, That it is the sense of the House of Representatives that the life and achievements of Antonio Meucci should be recognized, and his work in the invention of the telephone should be acknowledged.
Attest.	Attest: Clerk

Critical views of both the Bell Parliamentary Motion and Resolution HRes 269

In 2003, the distinguished Italian telecommunications inventor and Meucci book author Professor Basilio Catania, interviewed on the parliamentary Bell motion and the congressional Meucci resolution, first commented on Bell's record as an inventor and scientist:

> *"I am not the kind of man who can make statements without proofs. I did not do it with Meucci and I do not see why I should do it with Bell... ...I can, however, state that the theoretical description of the electrical transmission of speech in Bell's first patent is nearly perfect and appears to me as the first clear treatise ever written."*[7]

Professor Catania later went on to note the straightforwardness of the follow-up parliamentary motion compared to the seaminess of the initial congressional resolution:

> *"The Canadian reaction to an unfortunate passage in Resolution No. 269 of the US House of Representatives is quite understandable. In my opinion the insinuation against the morality and scientific stature of Alexander Graham Bell, in the above resolution, was both unnecessary and unproven, though there had been suspicions that Bell might have fished something from Meucci's ideas. Personally, I would have refrained from stating anything that is not fully proven. I do, however, appreciate that, in the Canadian motion pro Bell, nothing [derogatory] is said against Antonio Meucci... "*[7]

However, intellectual property law author R.B. Rockman was more critical in his view of HRes 269.[4]

After first reviewing the essential details of *American Bell Telephone Company v. Globe Telephone Company, Antonio Meucci, et al.* (31 Fed 728 (SDNY, 1887)), where he noted major inconsistencies in Meucci's various testimonies, the paucity of direct evidence that both the Globe and Meucci brought forward in support of their defences and the court's definitive rejection of those defences in favour of Bell, Rockman then compares the *'Bell v. Globe and Meucci'* court decision (of July 19, 1887) with *HRes 269*:

> *"I conclude that the comments of Mr. Grosvenor* [who wrote a memo highly critical of HRes 269 by comparing it with Bell v. Globe] *are more likely correct in comparison to the statements* [within the preamble of HRes 269] by the United States House of Representatives."[4]

Rockman then proceeded to dissect and parse the U.S. Government's 1887 legal challenge to Bell's telephone patent, which had been brought by United States Attorney General Augustus H. Garland, a major stock shareholder of the Pan-Electric Company which was the instigator of the suit. Pan-Electric sought to overturn Bell's patent in order to compete against the American Bell Telephone Co.[4][8][9]

It was this very court challenge that is referenced in *HRes 269's* preamble, in paragraph No. 9, which inferred an immoral and possibly criminal intent by Bell ("...the Government of the United States moved to annul the patent issued to Bell on the grounds of fraud and misrepresentation"), to which Rockland wrote:

> "The United States House of Representatives in its resolution of June 11, 2002 states merely that the government of the United States filed the lawsuit, and that the Supreme Court found the complaint viable and remanded the case for trial. The House of Representatives resolution, in my opinion, leaves out many of the salient details [of the Garland-initiated suit]*, and presents a disjointed and incorrect view of the invention of the telephone."*[4]

The same paragraph No. 9 of the Meucci resolution also did not mention that the U.S. Attorney General, plus another cabinet member and two senators had been given or owned millions of dollars of stock in Pan-Electric, as revealed by Joseph Pulitzer in the New York World, a fact which many viewed as a strong incentive for them to try to overturn Bell's patent.[10]

President Grover Cleveland subsequently ordered the Attorney General not to 'pursue the matter' after the court case stalled out. [10] One of several biographies on the controversial Attorney General Augustus Garland's involvement in the *'Government case'* noted:

> *"He did, however, suffer scandal involving the patent for the telephone. The Attorney General's office was intervening in a lawsuit attempting to break Bell's monopoly of telephone technology, but it had come out that Garland owned stock in one of the companies that stood to benefit. This congressional investigation received public attention for nearly a year, and caused his work as attorney general to suffer."*[9]

The *'Government case'* became one of the greatest scandals in Grover Cleveland's presidency, and was ended when Cleveland ordered Garland to discontinue the trial. [10]

Other factual errors were also found within the preamble to the resolution, among them were:

- Paragraph No. 2 of the resolution referred to Meucci's invention involving "electronic communications", however Meucci's patent caveat described a 'lover's telegraph' which transmitted sound vibrations mechanically across a taut wire, a conclusion that was also noted in Rockman's review (*"The court further held that the caveat of Meucci did not describe any elements of an electric speaking telephone….."*, and *"The court held that Meucci's device consisted of a mechanical telephone consisting of a mouthpiece and an earpiece connected by a wire, and that beyond this the invention of Meucci was only imagination."*) [10][4]

- Paragraphs Nos. 7 & 8 implied that Bell had access to Meucci's works prior to patenting the telephone (*"….Meucci later learned that the Western Union affiliate laboratory reportedly lost his working models"*, followed by: *"Alexander Graham Bell, who conducted experiments in the same laboratory where Meucci's materials had been stored was granted a patent…. with inventing the telephone"*). [10] The same inference in the resolution was also described by Rockman. [4] Research by Professor Catania himself showed that Meucci's samples were reportedly lost at a laboratory of American District Telegraph (ADT) of New York, however ADT would not become a subsidiary of Western Union until 1901.[11][12] Grosvenor also noted that with Bell living and working in the Boston and Brantford areas, and with Meucci living and working in the Staten Island, New York area, there was no overlap where Bell would have had access to Meucci's works prior to Bell's patent application. Grosvenor further pointed out that in 1878, two years after Bell received his patent, the American Bell Telephone Comp., not Bell, was awarded a Western Electric laboratory as part of a patent infringement settlement with the Western Union Telegraph Company. Alexander Graham Bell never worked in that laboratory, and the timing of the transfer made it irrelevant in any event to Bell's patent application of February 1876. [10] Additionally, the American Bell Telephone Company and Western Union were both competitors to each other and did not share facilities both prior to, and subsequent to the patent lawsuit settlement.

- Paragraph No. 11 stated that *"…if Meucci had been able to pay the $10 fee to maintain [his] caveat after 1874, no patent could have been issued to Bell"*. However writer and publisher Edwin S. Grosvenor noted in a memo that Bell had succeeded in building a telephone based on a sound knowledge and understanding of its principles, whereas Meucci had been found by the court not to have understood the basics of the electric telephone's operation, with that court case having been conducted some time after Bell was awarded his patent. Since Meucci's caveat didn't describe any of the principles of electric telephony, it would therefore have been irrelevant to Bell's application even had the caveat been renewed. [10]

In total Grosvenor listed 10 errors in detail found within the congressional Meucci resolution, and was highly critical of both its intent and accuracy. [10] He also asked two salient questions in Section "C" of the same report: *"1) Should Congress overrule the US courts and its own committee, which looked at evidence extensively, and without reviewing any evidence in the matter?"*, and *"2) Should [the U.S.] Congress pass resolutions on historical facts without checking with legitimate historians or their own library?"* The same document also noted that HRes 269 contradicted the findings of its own Congressional committee's investigation, which had, in 1886, produced a report of 1,278 printed pages. [10]

Grosvenor concluded that: *" The historical "facts" stated in HR 269 were obtained from highly biased sources, and [were] based on shoddy, cursory research."*[10]

See also

- Invention of the telephone

- Elisha Gray
- Elisha Gray and Alexander Bell telephone controversy
- Antonio Meucci
- Augustus H. Garland -Attorney General

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Notes

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7. ^ *a b* Cusmano, Domenic. "Interview with Basilio Catania." *Accenti.ca*, July 16, 2003, Retrieved: April 30, 2009.
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9. ^ *a b* "Augustus Hill Garland (1874-1877)", *Old Statehouse Museum website*. Retrieved: May 1, 2009. Note: According to this biography: "He did, however, suffer scandal involving the patent for the telephone. The Attorney General's office was intervening in a lawsuit attempting to break Bell's monopoly of telephone technology, but it had come out that Garland owned stock in one of the companies that stood to benefit. This congressional investigation received public attention for nearly a year, and caused his work as attorney general to suffer."
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External links

- Antonio Meucci Centre

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Categories: Telecommunications history | Telephony | Telecommunications | Discovery and invention controversies

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Alexander Graham Bell's Path to the Telephone

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Introduction

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To organize and depict, in abbreviated form, Alexander Graham Bell's invention of the telephone, we [1] have created a series of flowchart "maps" that include every sketch we have been able to locate from Bell's experimental notebooks, patents, depositions in court and correspondence. As the dates on the map indicate, time advances as on the maps from top to bottom. Multiple boxes spreading from right to left at the same time indicate that Bell was pursuing several lines of research at that point.

When we say that Bell followed a path to the telephone, it makes his innovation process sound more linear and goal-directed than it really was, though Bell tried very hard to be scientific in his approach [2] and therefore was more linear than his competitors Edison and Gray. We refer to this flowchart as a *map* because the term *flowchart* implies more logical structure than does *map*, which may reflect the wanderings of an inventor.

This series of maps is arranged hierarchically. The top level depicts the major experiments along Bell's path to a patent and to a device that successfully transmitted speech. When you click on one of the sketches in boxes on this top level, you will move to a lower-level map, depicting a series of experiments that were subsumed under that higher-level box. Some of these lower level maps will be combined with text which describes the depicted experiments and/or sketches. These maps were originally developed using a program called **TopDown** on the **Macintosh**; exporting them to the World Wide Web has caused us to make format changes that we think will result in improvements over the longer term, but in the short term, may make them more difficult to use. We welcome feedback as you attempt to explore Bell's path. What follows is a narrative that will help you to understand the structure of the top-level map, and will also provide references for further study.

When Bell started the early experiments depicted in the top level of the map, he wasn't thinking about a telephone. Indeed, as the parallelogram-shaped box on the upper right-hand part of our map suggests, he was thinking about the cutting-edge technology of his day: the multiple telegraph. Throughout the maps, this shape will indicate an inference about Bell's goals at a particular stage. When the goal is explicitly stated, we use a box with a wedge pointing toward the goal. At the time, everyone knew that the inventor who could create a device that would send multiple messages over the same wire would reap fame and fortune. A duplex that could send two messages simultaneously was available by the early 1870s, but Bell, Edison, and Gray were all in pursuit of a device that could send four, six, eight, or more messages.

Bell's first idea for a multiple telegraph stemmed from his observations of Helmholtz's apparatus for producing vowel sounds electromechanically. The oval to the right of the "Mental Model for a Multiple Telegraph" box suggests the Helmholtz influence; a sub-map under this oval suggests how Bell found out about Helmholtz. Bell wanted to use Helmholtz's scientific discoveries as the basis for a working device. Here we appear to have a clear-cut case of an inventor borrowing his ideas from others. If Bell had simply taken Helmholtz's apparatus and tweaked it a bit to create a multiple telegraph, there would be no need for a cognitive map--one could trace an invention path that required virtually no mental processing. Bell, however, did more than modify the Helmholtz apparatus, he transformed it. Indeed, he misunderstood it in a creative way. Helmholtz's device used a series of tuning forks and resonance chambers to simulate vowel sounds. A single tuning fork continually interrupted the circuit, which kept all the other forks in constant vibration. Bell could not read Helmholtz in the original German; instead, this apparatus was described to him by Alexander Ellis, and Bell derived much of his understanding from complex diagrams. Therefore, according to Robert Bruce,**[3]** he made an important error. He assumed the lower interrupting fork was transmitting vowel sounds which were reproduced by the other forks.**[4]** Bell assumed that if vowels could be transmitted over wires, so could other sounds, including musical tones and consonants.

Therefore, this mapping method allows us to represent how an inventor transforms knowledge from outside sources and contacts. An inventor's or user's mental representation of a device is not always the same as--or even similar to--the way the designer intended it to be represented. In the case of invention, two kinds of representation are particularly crucial.

Mental Models and Mechanical Representations

In terms of our cognitive framework,**[5]** the Helmholtz interrupting fork and resonator served as mental models for Bell's harmonic multiple telegraph. Mental models are dynamic visual representations of devices, objects, or forces that an inventor or scientist can "run" in his or her "mind's eye." There is a growing literature on mental models in cognitive psychology; the term is not always used in the same way by different authors **[6]**. Our meaning and use are best illustrated by examples.

Consider the interrupting fork and resonator. For Bell, these devices served as mental pictures of how a multiple telegraph might be achieved. The box below the goal statement on the upper right contains Bell's first attempt to build a multiple telegraph transmitter and receiver. The transmitter closely resembles Helmholtz's interrupting fork; it made or broke contact with a dish of Mercury, which alternately completed and interrupted the circuit. Similarly, the receiving end resembles Helmholtz's upper resonator; the electromagnets attracted the tuning fork every time the circuit was completed, causing the fork to vibrate. (see lower level maps subsumed under the "Mental Model for a Multiple Telegraph" box).

We have put boxes around the transmitter and receiver to indicate what we call "slots",**[7]** or areas an inventor can concentrate on. For example, if one divides Bell's multiple telegraph into transmitter and receiver slots, one can then imagine putting different devices in place of the Helmholtz fork and resonator.

Bell intended to set up a series of tuning forks which made or broke contact with mercury cups, and match them with tuning forks on the other end of the circuit that would vibrate at the same frequency. Four, six, eight or more tuning forks could send separate tones over the same wire to the same number of matching tuning forks, each of which would respond only to the vibrations sent by its "twin" on the transmitting end.

In his subsequent experiments, he began with devices that looked like Helmholtz's, but gradually developed alternatives that accomplished the same goals. These alternate devices are what we call mechanical representations; they can be inserted into slots like different values into a variable or function. Experiments with different mechanical representations often suggest alterations in the mental model, as we shall see below.

Below the "Mental Model for a Multiple Telegraph" box is a conclusion, marked by a box with a wavy line on the bottom. This indicates what Bell learned from the line of experiments associated with the box: he now had a clear idea how to transmit musical tones, though he had not mastered the complexities of the circuits involved in turning this idea into a successful multiple telegraph. Indeed, in response to his difficulties with circuits and connections, Bell made an important decision about his cognitive style: "It became evident to me, that with my own rude workmanship, and with the limited time and means at my disposal, I could not hope to construct any better models. I therefore from this time (November, 1873) devoted less time to practical experiment than to the theoretical development of the details of the invention."**[8]**

To show how Bell evolved a new mechanical representation, let us explore one of the sub-maps associated with the box labeled "Mental Model for a Multiple Telegraph." Figure 3* shows a lower-level, more detailed map of how Bell developed his tuned reed relay, a mechanical representation he used repeatedly as a kind of "transceiver" He began with two tuning fork arrangements that were attempts to reproduce Helmholtz's apparatus and effects as closely as possible. Then he switched to a steel plate, vibrating over twin electromagnets, an idea he got from reading J. Baille"s *The Wonders of Electricity*.**[9]** Finally, he left one end of the plate free to vibrate. The result is displayed in the box labeled "Universal Transceiver."

Here we think Bell alters his mental model to accommodate his insight that the same device can be used as both transmitter and receiver. In effect, he merges his transmitter and receiver slots into kind of a "transceiver" slot.

The simplicity of this approach is appealing--and unique to Bell. Edison, for example, recognized immediately that one had to perfect a distinct transmitter. Gray also had a series of separate transmitters and receivers, and only used a "transceiver" in one of his later attempts to get around Bell's successful patent that included a speaking telegraph. **[10]** Bell's experiments with reed relays and similar devices in complex telegraph circuits continued throughout this period. Indeed, the line that branches back to a circuit with two of these reed relays suggests how this line of research played a critical role in Bell's first telephone--but we will say more about that later (in the June 2nd Experiment section).

Inventors need not be limited to a single mental model; indeed, they can consider several alternatives at one time. Bell was no exception. The "Alternate Mental Model for a Multiple Telegraph" box shows that, in addition to imagining a multiple harmonic telegraph in which the same device served as both transmitter and receiver, Bell also thought about, and experimented with, transmitters and receivers that could handle multiple tones. In this particular sketch,[11] a cylinder of bar magnets is rotated rapidly in front of a magnet and induces a current. This intermittent, make-or-break current, is transmitted to a coil of wire in the center of which a nail vibrates, making a crackling sound: "The sound issuing from the helix is a kind of crackling noise, and cannot be called a musical note although its pitch is quite apparent."[12]. The pitch of the sound coming from the vibrating nail can be altered by rotating the cylinder more rapidly or more slowly. Hence, multiple operators could send distinct tones over the same wire simply by rotating their cylinders at different rates, and the same kind of receiver could be used to translate these different rotation-rates into distinct messages. This scheme obviated the need for separately tuned forks on either end.[13]

Vibratory Analyzer Slot

How would a telegraph operator be able to distinguish different tones reliably? Remember that the operator might have to distinguish eight or more separate messages sent either to separately tuned forks or to a single universal receiver. Both Bell and his competitor, Elisha Gray, confronted this problem after they had established that the transmission of distinct tones was possible. The box labeled "Vibratory Analyzer Slot" shows Bell's solution, which he was able to patent.[14] The "P" inside a circle next to the box indicates that the sketch is part of a successful patent and flags patents in our mapping methodology.

The new slot is shown to the right of one of Bell's tuned reed relays. As the steel reed vibrates, it makes contact with a lever, the other end of which dips in and out of two cups of mercury, alternately making and breaking a circuit. (See Figure 4*) Therefore, the harmonic vibrations of the reed were translated into on-off impulses suitable for telegraphy. This lever and twin cups resembled Morse's original telegraph portrule, illustrating the way in which mechanical representations can readily be borrowed from another source.[15]

The Morse device provided Bell with a mechanical representation that he used in his March 6 application. But in his patent, Bell made it clear that it was the principle he was after, not just a specific mechanical representation: "Many forms of circuit breakers for the purpose may be employed such as membranes &c., all that is required being that the circuit breaker shall be capable of vibratory or oscillatory movement, and that its normal rate of movement, when in oscillation or vibration, shall be slower than that of the receiver by which it is actuated."[16] Indeed, Bell later patented an improvement in this vibratory circuit-breaker.[17]

So, by the spring of 1875, Bell had a mental model for a complete system of multiple telegraphy and had succeeded in patenting parts of it. A significant part of this mental model was the idea that the goal in multiple telegraphy was to transmit what Bell called an "undulatory current" as opposed to the intermittent or make-or-break current used in single telegraphy. To trace this important aspect of Bell's mental model, we will have to go to the upper left-hand box of the **Master Map**.

The Ear Phonautograph

Bell lacked the electrical knowledge and expertise of other multiple telegraph inventors like Edison and Gray. But he did posses a unique area of expertise. He was a teacher of the deaf, and therefore understood the importance of speech in communication. His father, Alexander Melville, had invented a "Visible Speech" alphabet that would help the deaf learn to speak. Bell was similarly interested in devices that would help the deaf "see" speech, as is indicated by the goal box above "The Ear Phonautograph" (see the top left-hand corner of the **Master Map**).

Bell's interest in teaching the deaf kindled his interest in devices used to visualize sound; these devices are represented on sub-maps beneath the ear phonautograph box. At MIT, he experimented with Koenig's manometric flame and a version Scott's phonautograph that had been improved by Charles Cross' pupil, Charles Morey. Bell planned to use the devices to give a deaf child feedback. Bell would make templates of speech sounds and then instruct the child to speak into one of the devices and reproduce the template pattern. Since Bell could not physically record the manometric flame patterns using photography and since the patterns were difficult to discern, he concentrated on the phonautograph.

Controlled tests of the two devices revealed differences in curves produced in response to the same sound. Bell concluded that the phonautograph device needed extensive modification so that the tracings would match the flame shapes of the manometric capsule. Considering the phonautograph's geometry--with its thin, light membrane and the relatively heavy wooden lever and style moved by the membrane--Bell was struck by the resemblance between the device and the structure of the human ear. The ear analogy suggested the sorts of modifications he might undertake to successfully replicate the flame shapes in the tracings of this device. The modifications aimed to make the analogy between technology and nature more literal. Bell sought to duplicate "the shape of the membrane of the human ear, the shapes of the bones attached to it, the mode of connection between the two, etc."**[18]**

Bell built an ear phonautograph in 1874 following a suggestion from Clarence Blake (a more detailed picture of this device can be found by clicking on the top level phonautograph box and going to a lower level). It consisted of the bones of an actual human ear, mounted on a wooden frame. When one spoke into it, the bones vibrated; a bristle brush descending from the bones traced the shape of the sound waves on a piece of smoked glass, which could be rolled back and forth underneath..

The box with the wavy line below the phonautograph shows the conclusion Bell drew from this experiment--that sound could be translated into visible waves. From this phonautograph, Bell gained a tactual, "hands-on" understanding of how speech is translated into sinusoidal or undulating waves. From his multiple telegraph experiments, Bell gained a similar understanding of how the vibrations of a reed could be translated intoelect ric current, and reproduced as sound.

The Harp Apparatus

Bell's background in telegraphy and in the visible reproduction of sound come together in the box labeled "Harp Apparatus", which represents a new mental model of how undulating sound waves might be translated into electric currents of the same form. Bell sketched, but never built, this device in the summer of 1874. To understand its function, it is better to refer to its precursor, stored in a sub-map (found by clicking on the top level box). This device consists of two permanent horseshoe magnets with two of Bell's steel reeds on each. Bell hoped such a device would serve as a transceiver for two distinct signals, corresponding to each of the reeds.

Why had Bell decided to substitute a permanent magnet for the electromagnets he had previously preferred in his multiple telegraph experiments? In his own words, Bell realized that:

> when a permanent magnet is moved towards the pole of an electromagnet, a current of electricity appeared in the coil of the electro-magnet; and that when the permanent magnet was moved from the electro-magnet, a current of opposite kind was induced in the coils. I had no doubt, therefore, that a permanent magnet, like the reed of one of my receiving instruments, vibrating with the frequency of a musical sound in front of the pole of an electro magnet, should induce in the coils of the latter alternately positive and negative impulses corresponding in frequency to the vibration of the reed, and that these reversed impulses would come at equal distances apart.**[19]**

In other words, Bell postulates that if a magnet is moving away from a coil half of the time and moving towards the coil the other half then the induced current should imitate the vibrating magnet because the flux will be increasing half of the time (magnet moving towards coil) and decreasing half of the time (moving away). If the flux is increasing and decreasing periodically (at discrete intervals in time) then so will the induced current in the coil.

To accomplish this goal, Bell put two steel reeds, A and B on a horseshoe-shaped permanent magnet M. A" and B" represent the same reeds on a duplicate transceiver. When A is plucked, A" will sound, and vice-versa. When A vibrated toward the coil under it, the current became increasingly positive (or negative, depending on which pole of the magnet A was and how the underlying coil was wound); when A vibrated away from the coil, a current of the opposite kind was induced. The signal, therefore, was sent across as a sinusoidal wave, exactly the same form of wave traced by the phonautograph on smoked glass or reflected into a rotating mirror by the manometric flame .

Bell referred to this as an "undulating current", and it became the focus of his successful telephone patent two years later. Bell knew, from Helmholtz, that this wave would "express in a graphical manner the vibratory movement of the air while the reeds were producing their musical tones."**[20]** Furthermore, the vibrations of the individual reeds on the permanent magnet could be summed into a single undulating curve. Therefore, the device could send A and B as distinct tones and also the sum of A and B. (For a picture of this device, explore the levels below the Harp Apparatus box on the top level box).

Bell realized that if one could combine the sounds from two reeds to make a more complex wave, one could theoretically reproduce any sound by a combination of reeds. This insight is derived from the Helmholtz apparatus, in which multiple tuning forks were used to reproduce vowel sounds.

The result, in Bell's case, was a new mental model for the transmission of musical tones, vowel sounds, or even speech. This model is represented by the harp apparatus, a device Bell sketched, but never built, in the summer of 1874. (For a better picture of this device, explore the levels below its top level box). It essentially involves placing a large number of steel reeds on the poles of a horseshoe-shaped electromagnet long enough to accommodate the reeds. Like the strings of a piano, these reeds would theoretically reproduce any musical tone; like Helmholtz's tuning forks, they could theoretically reproduce vowel sounds as well. For example, when one spoke a vowel into the transmitting harp, a combination of reeds representing the fundamental tone and its overtones would vibrate and this exact combination would be transmitted to the other side, reproducing the vowel sound. This principle had been clearly established by the Helmholtz device which was Bell's original mental model; in this case, however, the single interrupting fork and series of separate resonators were replaced by a series of reeds combining to induce a current in a single electromagnet.

Bell knew he could never build such a device, owing in part to the multiplicity of reeds that would be required, but it served as a new mental model, showing him how the undulating waves traced by the phonautograph could be turned into an undulating electric current and reproduced as sound.

This undulating current was Bell's greatest innovation. Telegraphy involved make or break connections well suited to dots and dashes, but poorly suited to speech.**[21]** Bell called the current produced by these "intermittent", because it was on or off; when several messages containing dots and dashes were combined, Bell thought the result would be a continuous "on" current, which could not transmit a message. But the result of combining undulating currents would be a sinusoidal curve that would be different for every combination of sounds, therefore allowing one to discriminate among different messages.

Bell believed that a steel reed vibrating over a magnet could never induce an undulating current of sufficient force to transmit over a distance. Therefore, he continued to focus primarily on developing a multiple telegraph, encouraged by his primary backer and future father-in-law Gardiner Hubbard, who urged him constantly to perfect such a device and abandon the pursuit of a speaking telegraph.**[22]**

The continuation of these efforts is suggested by the "alternate mental model for a multiple telegraph" box. Bell turns to these experiments with rotating magnets just after developing his horseshoe magnet transceiver. The rotating magnets allowed him to induce a current far more powerful than anything he could achieve with a reed vibrating over a permanent magnet.

The June 2nd Experiment

The lines from the Harp and the multiple telegraph come together on the map in a box labeled "Experiment in which one reed relay induces a powerful current in others", which shows two reed relays connected in a circuit. This kind of circuit emerges from Bell's earliest mental model for a multiple telegraph, based on substituting the reeds for Helmholtz's tuning forks. But the harp mental model primes Bell to recognize the significance of a serendipitous discovery he and Watson made on June 2, 1875. Bell had set up three multiple telegraph stations, A, B and C, each with three tuned-reed relays. He wanted to be able to pluck the first reed in A and have the corresponding reeds in B & C vibrate. (For a diagram, explore the levels below the "Experiment in which one reed relay induces a powerful current in others" box). Naturally, these reeds were very difficult to tune and required constant adjustment--shortening or lengthening.

When Bell depressed the telegraph key corresponding to one of the reeds at A, the corresponding reed at B vibrated well, but Watson, who was in another room with C, said it was stuck. To release it, Watson plucked it; Bell noticed that this caused the corresponding reed at B to vibrate powerfully. Bell then listened to each of the reeds at B in succession, placing his ear right against them, and heard both the pitch and the overtones of the tuned reed. "These experiments at once removed the doubt that had been in my mind since the summer of 1874, that magneto-electric currents generated by the vibration of an armature in front of an electro-magnet would be too feeble to produce audible effects that could be practically utilized for the purposes of multiple telegraphy and of speech-transmission."**[23]**

Here we arrive at one of those moments of creative insight that are often referred to as "mysterious"**[24]**, and, in this case, as heavily dependent on serendipity. Consider Watson's dramatic description:

> That undulatory had passed through the connecting wire to the distant receiver which, fortunately, was a mechanism that could transform the current back into an extremely faint echo of the sound of the vibrating spring that had generated it, but what was still more fortunate, the right man had that mechanism at his ear during that fleeting moment, and instantly recognized the transcendent importance of that faint sound thus electrically transmitted. The shout I heard and his excited rush into my room were the result of that recognition. The speaking telephone was born at that

> moment...All the experimenting that followed that discovery, up to the time the telephone was put into practical use, was largely a matter of working out the details.[25]

Here we have a classic account of the Eureka moment. There is no doubt that this was a very important experiment, but its significance is somewhat exaggerated by Watson: extensive work remained to be done afterwards, and the current insight was grounded in earlier work. Although his early experiments combining two transmitters and receivers in an attempt to build a multiple telegraph were not successful, Bell noticed a particular phenomenon that prepared him to appreciate the serendipitous discovery of June 2nd. When Bell tried to use two of his steel reed relays as transmitters and pressed his ear against one of the receiving reeds, he heard "two musical tones, corresponding in pitch to the two transmitters employed, but different in pitch from the sound produced when the reed of the receiver at [the] ear was plucked with the finger."[26] Bell had, of course, hoped to hear only a single tone corresponding to the pitch of one of the sending reeds; the extra tone was a kind of interference effect that another inventor might have dismissed as noise or error to be removed. Bell knew that this effect depended on dampening the vibrations of the reed, in this case by pressing his ear against it.[27]

So, by June 2nd Bell knew that a single one of his reed relays could receive complex sounds. He also knew that a reed could generate sufficient current to transmit a tone over a distance. What he learned from the serendipitous error involving the stuck reed was that a single reed, when dampened or stuck, could also induce a current sufficient to transmit complex sounds over a distance--at this point, no greater than from one room to another, but the potential for longer transmission was clearly there. The multiple reeds of the harp were not necessary.

Cognitive psychologists have recently begun to study the effect of various kinds of error on scientific reasoning.[28] Typically, the concern in such studies is with how people can be taught to recognize and remove sources of error. But one of the characteristics of genius is recognizing when an apparent "error" is in fact a phenomenon of great significance. Serendipity lies in the beholder. The little mold on one of Alexander Fleming's petri dishes is an oft-cited example.[29] Similarly, Bell confronts an error--a single reed stubbornly produces multiple tones when plucked--and realizes that this apparent problem is in fact an opportunity.

Bell immediately asked Watson to build a working telephone in which a reed relay was attached to a diaphragm or membrane with a speaking cavity over it. As one spoke into the cavity, the membrane would vibrate; these vibrations would be translated into an electrical current by the dampened reed, which would send them to a similar device on the other end. Unfortunately, this device did not produce intelligible speech, though Bell and Watson heard a kind of mumbling that suggested they were on the right track (see the box labeled "Gallows Telephone").

Sound and Electricity as Sinusoidal Waves

Bythe 20th of January,1876, in a patent application, Bell states his mental model of how mechanical motion is translated into electrical current:

> Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibrations upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body---that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration--that is, with the loudness of the sound; and the polarity of the current

> corresponds to the direction of the vibrating body--that is, to the condensations and rarefactions of air produced by the vibration.[30]

The "body" he uses to illustrate these vibrations is his standard reed relay mechanical representation. Even though the Gallows telephone does not work, he knows he has discovered the theoretical principle behind a telegraph or telephone. The above passage from his patent application describes a one-to-one correspondence between characteristics of sound and electricity as well as the belief that sound and electricity will form the same sinusoidal curve when transmitted.

The Ear Mental Model

On February 21, 1876, Bell made a statement and a sketch of the mental model that represented the synthesis of the phonautograph and his multiple telegraph experiments.[31] Bell draws an ear with two different mechanical representations next to the bones. On the left is an electromagnet, suggesting that the bones will serve a function similar to the armature on his familiar reed-relay mechanical representation. On the right an iron cylinder is attached to the bones and this vibrates in the center of a magnetized helix with an iron core. Again, Bell had conducted experiments with such an arrangement, verifying that it could produce an undulatory current; he would later develop this mechanical representation into a telephone receiver. Beside the sketch, Bell wrote, "Make transmitting instrument after the model of the human ear. Make armature after the shape of the ossicles. Follow out the analogy of nature."[32]

What Bell first does in this remarkable statement is outline two goals. Cognitive scientists have done extensive work on goals, especially the differentiation between goals and sub-goals.[33] The statement "Make armature after the shape of the ossicles" is a sub-goal under "Make transmitting instrument after the model of the human ear" because the former suggests what needs to be done in a particular slot in order to accomplish the latter. (Note that we use a wedge-shaped box to denote stated, as opposed to inferred, goals).

The statement that he was "following the analogy of nature" illustrates another component of our framework. Inventors and scientists often employ heuristics, or "rules of thumb", to reach their goals. [34] Bell's strategy of "following the analogy of nature" is one such strategy: when in doubt, try to copy nature. Note that heuristics depend heavily on mental models; in order for Bell to copy nature, he has to have both a clear understanding of the ear and a set of mechanical representations that he can employ.

Bell's Gallows telephone followed this mental model--it is a kind of electromechanical ear. If so, why does Bell state his mental model a year later? Actually, it is rare for an inventor or scientist to state their underlying assumptions explicitly.[35] Bell is a theoretical inventor; therefore, he pays careful attention to developing and articulating a mental model. He might have had the rough outlines of this mental model long before the February 22nd date on which he wrote it in his notebook, and merely noted it as both a reminder to himself and in preparation for future patent litigation.[36] Or this entry might have represented a moment in which he synthesized earlier insights into a conscious statement .

By now, the reader may be somewhat bewildered by the variety of uses to which we have put the term mental model. We used it to describe Bell's understanding of the Helmholtz apparatus for reproducing vowel sounds, Bell's own harp apparatus, his understanding of how sound and electricity could be visualized in terms of sinusoidal waves, and finally, this sketch of the bones of the ear next to two different mechanical representations.

Mental model is a 'scruffy" term, which means it cannot (to the dismay of philosophers) be defined precisely. But the term draws our attention to the way Bell imagines devices and how they work. Some of his mental models seem very close to practical devices; others, like the harp and the ear, are flights of the imagination that could never be built. But they allow him to carry out thought experiments, to visualize and manipulate the relationships between sound, electricity and magnetism. Given his limited electromechanical skills, mental modeling is especially important to Bell.

A Slot Diagram Based on a Patent Drawing

Below the mental model on our main map is a slot diagram based on Bell's patent signed on January 20, 1876 and submitted on February 14th . The oval in it connected to this slot diagram reflects the fact that Gardiner Hubbard actually submitted the patent for his son-in-law. Bell was waiting for a possible British patent when Hubbard decided it was time and they could afford to wait no longer. As it turned out, Hubbard's timing was very tight--a few hours later, Elisha Gray submitted a caveat for a speaking telegraph.**[38]**

The oval, in this case, reflects an important change of heart that we need to explain more fully. Hubbard had gone from being suspicious of Bell's telephonic researches to becoming a backer. Indeed, it was Hubbard who built the corporation that bears Bell's name and made the inventor a millionaire. This oval will eventually include a sub-map that sketches Hubbard's path from telegraph to telephone backer, and records the early details of the agreements that lead to the Bell corporation. The map can serve as a reminder of areas that need work.

Generally speaking, we find that patent drawings make the best basis for slot diagrams, although--given the limited number of patents filed by Bell--we often have to use his notebook sketches. Patent applications provide the best sketches and most articulate description of the goals and sub-goals reached by inventors.

In Bell's case, the "Ear and Membrane" slot indicates that Bell could use a number of different devices to realize the same function as the anatomical parts. The "Ossicles Slot" has the same meaning; the patent diagram shows one of his steel reed armatures serving the function of the bones, but the ear diagram in his notebook makes it clear he considered alternate mechanical representations. Bell's ear mental model suggests nothing about how he is going to accomplish long-distance transmission, so we have introduced a "Line" slot. Note that this slot overlaps with the Ossicles slot; this is deliberate, to indicate the obvious--that improving the relationship between the armature and the induction coil is one of the keys to long-distance transmission. Slots are not necessarily mutually exclusive. We have also noted slots for "power source", to indicate that he could remove the battery or increase its strength, and a "motion into current" slot, to indicate that he could experiment with different ways of translating the motion of the armature into an undulating electric current. Finally, there is a "receiver" slot, to denote the fact that Bell will try a variety of substitutions to improve reception, including devices which do not look exactly like the transmitter. Again, whatever he learns about armatures in the Ossicles slot could be applied to the receiver.

In Bell's case, we could possibly have determined his slots simply from looking at his ear diagrams. But we do not determine slots solely on an a priori basis; instead, we also look closely at the experiments an inventor does,to see what areas he is concentrating on. In other words, we could have divided the ear up very differently, but we have tried to stick hard to Bell's divisions. Slots, then, become an important tool for mapping the invention process.

Bell's patent was eventually granted, and became the focus of endless litigation, but that lies beyond our story. Part of the frustration experienced by other inventors like Edison and Gray comes from the fact that when Bell filed, he had no working telephone. But he did have a mental model, as our slot diagram illustrates. In his subsequent experiments, Bell opened certain of these slots and tried to insert or develop different mechanical representations to improve performance.

The First Transmission of Speech

When Bell obtained his patent, he still did not have a working device. The line of experiments that led to the first successful transmission of speech is depicted in the two boxes below the "Slots in Bell's Ear Mental Model" box (by below, in this case, we mean lower on the same page in Mosaic, connected by arrows). To see a detailed rendition of the actual experiments, one needs to click on these two boxes. The upper box describes experiments with devices that look much like the ear mental model.

The box that is lower and to the right is connected by a minus and a plus sign with devices next to each. This is a short-hand way of indicating that to get from one box to the other, Bell removes an electromagnet and substitutes a dish of water. The box called 'spark arrester" above it is connected by an arrow, to indicate that Bell had previous experience using water as a medium of resistance in a device that prevented sparks in a telegraph rely. The liquid experiments led to the famous "Watson--come here--I want you" result obtained on March 10th. Text describing these experiments in detail can be obtained by clicking on the detailed representations of the experiments themselves.

The upper level map needs to be continued to Bell's second patent, obtained in January of 1877. This second patent includes devices that look much like those in his first patent; he abandoned the liquid transmitter variations, which is why they are depicted off to the side. The story of why he did this is told elsewhere,**[38]** and will be incorporated in future versions of the map.

Endnotes

1. "We" refers to a team of faculty and students that included my colleague W. Bernard Carlson and several recent graduates of the University of Virginia, including Tamar Lieberman, Matthew M. Mehalik, Christy Nilsen and Charles Twardy.Back

2. D.A. Hounshell makes the case that Bell deliberately sought to establish strong links to the scientific community of the day, whereas Elisha Gray did not. Bell's careful attention to science and scientists was one of the reasons for his success. See "Bell and Gray: Contrasts in Style, Politics, and Etiquette", *IEEE Proceedings* 64 (1976) :1305-14; and "Two Paths to the Telephone", *Scientific American* 244 (January 1981) : 156-63.Back

3. R. Bruce (1973). *Alexander Graham Bell and the Conquest of Solitude.* Boston: Little, Brown & Co., p. 51. Bruce cites a source from 1879-- much later than the actual event. This is not a reliable source because a later reconstruction has great potential for distorting the original events. We have not been able to find more reliable sources with earlier dates to describe this event. In an account from 1877 Bell indicates that he understood Helmholtz by describing that the Helmholtz apparatus "produce[s] vowel sounds artificially." (George B. Prescott. (1972) *Bell's Electric Speaking Telephone: Its Invention, Construction, Application, Modification and History*. New York: Arno

Press. pp.66-67) So, we must be careful in interpreting this bit of information, since it does not come to us directly from primary sources written at the time of the event.

What is clear is that Bell saw his early multiple telegraph experiments as similar to Helmholtz's experiments with vowel sounds--"My knowledge of Helmholtz's apparatus for the artificial production of vowel sounds incited me to experiments of a similar character..." (*The Bell Telephone: The Deposition of Alexander Graham Bell in the Suit Brought by the United States to Annul the Bell Patents*. (1908) Boston: American Bell Telephone Company. p. 12)--whereas, in fact, Bell's and Helmholtz's experiments were quite different.Back

4. See R. Bruce (1973). *Alexander Graham Bell and the Conquest of Solitude.* Boston: Little, Brown & Co., pp. 50-51.Back

5. R. D. Tweney (1989) makes a distinction between framework and theory:

> Truth claims in a theory are based on the familiar strategies of scientific practice, while truth claims in a framework rely on interpretive procedures more akin to the methods of historical scholarship,. A theory is an attempt to construct a model of the world which meets certain criteria of testability; it makes predictions, is potentially disconfirmable, and has interesting consequences. A framework is an attempt to re-construct a model of the world which meets criteria other than testability as such. An adequate framework is one that is consistent with the details of the process, is interestingly related to our theories of the world, and reduces the apparent complexity of the real world process in a way which permits anchoring the framework to the data. In effect, an adequate framework must allow us to see order amid chaos ("A Framework for the Cognitive Psychology of Science," in B. Gholson, W.R. Shadish, R.A. Niemeyer & A.C. Houts (Eds.) *Psychology of Science*. Cambridge: Cambridge University Press, p. 344).

Our framework and maps allow us to perceive order among the chaos of the inventor's sketches, artifacts, caveats and notes, Our framework might eventually evolve into a more formal, theoretical model, but at the very least, it provides us with a rigorous basis for comparing inventors.Back

6. For good reviews, see D. Gentner & A.L. Stevens, Mental Models. (Hillsdale, N.J.: Lawrence Erlbaum Associates, 1983), 99-129 and W.B. Rouse & N.M. Morris, "On Looking Into the Black Box: Prospects and Limits in the Search for Mental Models," *Psychological Bulletin*, Vol. 100 (1986) : 349-363.Back

7. This term is borrowed from R.J. Weber & D.N. Perkins (1989) "How to Invent Artifacts and Ideas," *New Ideas in Psychology*, 7:49-72.Back

8. A.G. Bell, *The Multiple Telegraph* Boston: Franklin Press, Rand, Avery & Co., 1876, p. 8. Klahr and Dunbar, in an experimental simulation of scientific reasoning, found that college students adopted either a theoretical or experimental style; Bell obviously leaned more toward the former, which in Klahr and Dunbar's artificial task was more effective. See D. Klahr and K. Dunbar, "Dual Space Search During Scientific Reasoning," *Cognitive Science*, 1988, Vol. 12, 1-48.Back

9. J. Baille. *The Wonders of Electricity*. New York: Charles Scribner, 1872), pp. 140-143.Back

10. Bell's sucessful patent was number 174,465. Gray's rejected patent application was filed on 29 October 1877.Back

11. The sketches of transmitter and receiver here are not juxtaposed in this way in the original documents; we have done so to illustrate Bell's alternate mental model. For the rotating magnet, see Bell, *The Multiple Telegraph*, p. 14. Bell eventually patented the general principle of using rotating magnets to induce a continuous current in a closed circuit; see A. G. Bell, "Generating Electric Currents," *U.S. Patent No. 181,553*, (filed August 12, 1876, granted August 29, 1876). For the nail in a helix, see letter from A.G. Bell to Gardiner Hubbard on November 27, 1874. *Bell Family Papers*, Library of Congress, Box 80.Back

12. Bell to Hubbard, op cit.Back

13. For more details on Bell's multiple telegraph experiments, see M.E. Gorman, M. Mehalik, W.B. Carlson & M. Oblon, "Alexander Graham Bell, Elisha Gray and the Speaking Telegraph: A Cognitive Comparison", *History of Technology*, Vol. 15, 1993. For example, in the case of the nail in a helix, Bell was re-discovering a principle used by Philip Reis in the first device labeled a telephone. Bell claims he made the discovery independently, without knowing Reis' work. Those wishing to receive preprints of this paper can write to the senior author of this chapter.Back

14. Bell filed an application for this patent on March 6, 1875. The patent "Improvement in Transmitters and Receivers for Electric Telegraphs" was granted on April 6, 1876 as Patent No. 161,739. The patent shows the circuit-breaker as part of an autograph or facsimile telegraph. Bell attached this mechanical representation to the autograph telegraph, in part, to avoid an interference with Gray; as he said in a letter to his mother and father, March 5th, 1875:

    > My lawyers were at first doubtful whether the examiners would declare an interference between me and Gray as Gray's apparatus had been there for so long a time.
    >
    > They feared I had but a poor chance--and my spirits at once fell to zero. They said it would be difficult to convince them I had not copied. When however they saw the "Autograph Telegraph" developed from the multiple telegraph --they at once said that was a good proof of independent invention as Gray had no such idea.Back

15. Brooke Hindle, Emulation and Invention, New York: W. W. Norton & Co., 198= 1.Back

16. A. G. Bell, "Improvement in Transmitters and Receivers for Electric Telegraphs," op cit.Back

17. A. G. Bell, "Telephonic Telegraph Receiver," Patent No. 178,399, filed April 8, 1876, granted June 6, 1876.Back

18. *The Bell Telephone* (1908), 23-29.Back

19. A.G. Bell, "Telephonic Telegraph Receiver," 21.Back

20. *The Bell Telephone* (1908), 34. Bell is reporting his understanding at a later date, during patent testimony (date 4 April 1892). Bell claims to have arrived at this understanding in the summer of 1874.Back

21. Bell felt that the the first "telephone", developed by Philip Reis, in Germany, worked on this make-or-break principle; as a result, it could reproduce the pitch of a vowel, but not the complex overtones represented by the multiple resonators in the Helmholtz apparatus. see *The Telephone Appeals*. Boston: Alfred Mudge & Son Law Printers, 1887. pp. 104-110.Back

22. Gardiner Hubbard eventually decided to support his son-in-law's telephonic researches, and ended-up being the principle founder of the Bell Telephone Corporation. It was Hubbard who made Bell a millionaire (see Bruce, 1973).Back

23. *The Bell Telephone* (1908), p. 59Back

24. See D. N. Perkins, *The Mind's Best Work* Cambridge: Harvard UP, 1981; and M. Boden, *The Creative Mind: Myths & Mechanisms*. New York: Basic Books, 1990, for a summary of the literature on creativity and insight that includes arguments about how these "mysterious" processes can be unpacked and studied.Back

25. T.A. Watson (1913) "The Birth and Babyhood of the Telephone" Address delivered to the *3rd Annual Convention of the Telephone Pioneers of America at Chicago*. Reprinted by the American Telephone and Telegraph Co., pp 10-11.Back

26. A.G. Bell, *The Bell Telephone*, p. 16.Back

27. Bruce, op cit, p. 147.Back

28. See chapters 4-6 of M.E. Gormans *Simulating Science: Heuristics and Mental Models in Technoscientific Thinking*. Bloomington: Indiana University Press, 1992, for a description of this research.Back

29. G. MacFarlane (1984). *Alexander Fleming: The Man and the Myth*. Cambridge, MA: Harvard U. Press.Back

30. A. G. Bell, "Improvement in Telegraphy," Patent No. 174,465, witnessed 20 Jan 1876, submitted 14 Feb 1876, granted 7 March 1876. Reproduced in *The Bell Telephone: The Deposition of Alexander Graham Bell in the Suit Brought by the United States to Annul the Bell Patents*. Boston: American Bell Telephone Company, 1908, p. 455-56.Back

31. *Experiments Made by Alexander Graham Bell*, vol. I, p. 13.Back

32. Ibid. Exptl Notebook vol. 1, p. 13.Back

33. See, for example, R. Wilensky, *Planning and Understanding: A Computational Approach to Human Reasoning*. Reading, MA: Addison-Wesly, 1983.Back

34. There is a long literature on scientific heuristics in cognitive psychology; see, for example, D. Kulkarni & H.A. Simon, "The Processes of Scientific Discovery: The Strategies of Experimentation", *Cognitive Science*. Vol.12 (1989) 139-175; and M.E. Gorman & W.B. Carlson , "Can Experiments Be Used to Study Science?" *Social Epistemology* 3(1989) :89-106.Back

35. Edison describes his mental model based on Reiss in patent testimony: "My sketches were rough ideas of how to carry out that whch was necessary in my mind, to turn the Reiss transmitter into an articulating transmitter. They were notes for future use in experimentation." (from Edison testimony, "The interferences on Telephones between Thomas A. Edison, A. E. Dolbear, Elisha Gray, A.G. Bell, J.W. McDonough, G.B. Richmond, W.L. Voelkers, J.H. Irwin, and Francis Blake, Jr.," deposition taken November 8, 1880, p. 9 paragraph 26).Back

36. Indeed, Bell's notebook was started in response to Gardiner Hubbard's reminder that he ought to write everything down.Back

37. See Bruce, op cit, pp. 165-168.Back

38. See M.E. Gorman, M. Mehalik, W.B. Carlson & M. Oblon, "Alexander Graham Bell, Elisha Gray and the Speaking Telegraph: A Cognitive Comparison", *History of Technology*, Vol. 15, 1993, 1-56.Back

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Bell did not invent telephone, US rules

Scot accused of finding fame by stealing Italian's ideas

Rory Carroll in Rome
The Guardian, Monday 17 June 2002 11.14 BST

Italy hailed the redress of a historic injustice yesterday after the US Congress recognised an impoverished Florentine immigrant as the inventor of the telephone rather than Alexander Graham Bell.
Historians and Italian-Americans won their battle to persuade Washington to recognise a little-known mechanical genius, Antonio Meucci, as a father of modern communications, 113 years after his death.

The vote by the House of Representatives prompted joyous claims in Meucci's homeland that finally Bell had been outed as a perfidious Scot who found fortune and fame by stealing another man's work.

Calling the Italian's career extraordinary and tragic, the resolution said his "teletrofono", demonstrated in New York in 1860, made him the inventor of the telephone in the place of Bell, who had access to Meucci's materials and who took out a patent 16 years later.

"It is the sense of the House of Representatives that the life and achievements of Antonio Meucci should be recognised, and his work in the invention of the telephone should be acknowledged," the resolution stated.

Bell's immortalisation in books and films has rankled with generations of Italians who know Meucci's story. Born in 1808, he studied design and mechanical engineering at the Academy of Fine Arts in Florence, and as a stage technician at the city's Teatro della Pergola developed a primitive system to help colleagues communicate.

In the 1830s he moved to Cuba and, while working on methods to treat illnesses with electric shocks, found that sounds could travel by electrical impulses through copper wire. Sensing potential, he moved to Staten Island, near New York City, in 1850 to develop the technology.

When Meucci's wife, Ester, became paralysed he rigged a system to link her bedroom with his neighbouring workshop and in 1860 held a public demonstration which was reported in New York's Italian-language press.

In between giving shelter to political exiles, Meucci struggled to find financial backing, failed to master English and was severely burned in an accident aboard a steamship.

Forced to make new prototype telephones after Ester sold his machines for $6 to a secondhand shop, his models became more sophisticated. An inductor formed around an iron core in the shape of a cylinder was a technique so sophisticated that it was used decades later for long-distance connections.

Meucci could not afford the $250 needed for a definitive patent for his "talking telegraph" so in 1871 filed a one-year renewable notice of an impending patent. Three years later he could not even afford the $10 to renew it.

He sent a model and technical details to the Western Union telegraph company but failed to win a meeting with executives. When he asked for his materials to be returned, in 1874, he was told they had been lost. Two years later Bell, who shared a laboratory with Meucci, filed a patent for a telephone, became a celebrity and made a lucrative deal with Western Union.

Meucci sued and was nearing victory - the supreme court agreed to hear the case and fraud charges were initiated against Bell - when the Florentine died in 1889. The legal action died with him.

Yesterday the newspaper La Repubblica welcomed the vote to recognise the Tuscan inventor as a belated comeuppance for Bell, a "cunning Scotsman" and "usurper" whose per- fidy built a communications empire.

FEIRAS DE CIÊNCIAS
Faça experiências de Física de baixo custo

Telefone simples de Bell usando um diapasão

Alexander Bell, em 1876, teorizou que se fosse possível variar a resistência elétrica de um circuito elétrico na mesma freqüência do de um certo som, poderia fazer a corrente elétrica flutuar junto com o som. E fizesse relés elétromagnéticos de telégrafos oscilarem, poderíamos ouvir o som original. Se isso fosse possível, poderíamos "transmitir"a voz humana atrevés desse circuito.
Materiais necessários
* Diapasão
* Bateria
* Bacia com água
* Um pouco de ácido (pode usar vinagre branco)
* Relé (agirá como um fone-de-ouvido) ou um alto-falante pequeno

Com estes componentes conectados como mostrados na figura, mantenha o relé firmemente próximo a sua orelha, bata o diapasão em alguma superfçie adequada (escolha isso a sua volta) e, com cuidado, apróxime ele da água, mantendo-o quase paralelo, de modo que apenas uma ponta mal toque a solução de água + ácido. Você irá ouvir no "fone" o som emitido pelo diapasão.
Imagine a felicidade de Bell ao fazer esta experiência!
Você pode comprar diapasões em lojas de música (custam barato).
Ao invés do relé, pode-se usar algum pequeno alto-falante velho (como na figura).
Mesmo que não possamos ver, a ponta do diapoasão vibrando irá entrar e sair rapidamente da solução.Isto muda a resistência elétrica entre o diapasão e o vinagre, que faz, por sua vez, com que a corrente elétrica através do circuito flutue na mesma freqüência do diapasão.
Mude a posição do diapasão. Analise o que acontece.

Material escrito pela The Antique Telephone Collectors Association (ATCA)

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O Canal da Física Na Internet
Prof. Alberto Ricardo Präss

- **Bell's Variable Resistance Microphones :**

- **Return**

- Bell from the beginning knew that he was going to need an external power source to drive his telephone system long distances**.**

- So one of the first experiments after receiving his patent was designing a variable resistance microphone**.**
  He used several variations and a whole range of resistive materials and tested their suitability for microphone work.

- This was not his strong suit. Tedious experiments were hard for him to-do.

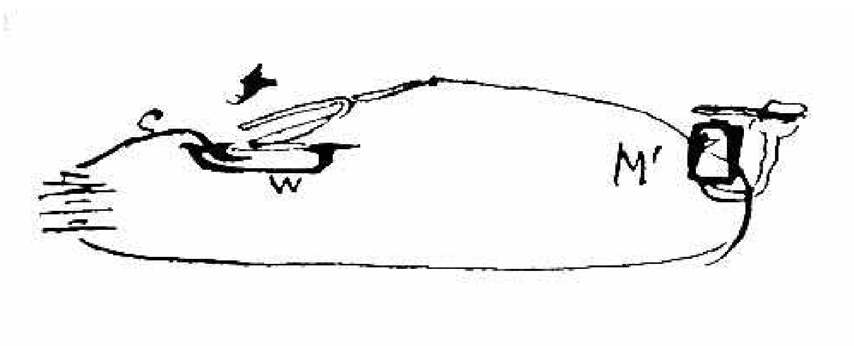
- In the end others (Edison) solved Bells technical problems using a carbon button resistive element.

- In the beginning however Bells started with an acid cup and a tuning fork arrangement as the sound generating device.

- Its depth in the acid cup determined the current flowing thru the transmitter. So as the prong of the fork varies up and down the resistance varies and therefore the current from the battery which then passes through the receiver varies.

- The receiver which is on the right of the drawing is one of Bells reed receivers tuned to the frequency of the tuning fork

From Bell's sketch book of his an experiment with an acid cup transmitter.



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Tuning Fork Transmitter	Resonate Reed Receiver

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A evolução da rede multimídia

Richard Wise

Introdução

Você está em casa e escuta o sermão no hall, ou houve a melodia da música de um sucesso de baile.
"O maravilhoso telefone", canção popular de 1877

Transportado por fios subterrâneos ou pelo ar, spectrum é spectrum.

Na década de 90 o desenvolvimento de multimídia entrou em nova fase. Enquanto a primeira geração de multimídia na década de 80 desenvolveu-se acessando texto, som e imagens de CD ROM em computadores particulares desconectados, a segunda geração na década de 90, era para estabeleceu-se com computadores conectados à infra-estrutura de comunicação existente. Nesse processo, o desenvolvimento das novas tecnologias de multimídia veio a ser conectado com a infra-estrutura tecnológica e institucional estabelecida pela indústria de telecomunicações em curso desde o século anterior. Esta infra-estrutura é baseada em transmissões tecnológicas com e sem fio, sendo que na comparação entre essas duas diferentes mídias de transmissão é importante focar mais em suas similaridades do que em suas diferenças. Nesse contexto, toda a energia luminosa viaja em ondas e, conforme James Clerk Maxwell descobriu em 1860, as ondas de rádio e luz são radiações eletromagnéticas viajando a velocidade da luz e somente diferindo nas freqüências as quais elas vibram. Corrente elétrica não é o mesmo que radiação eletromagnética. Os elétrons que a constituem movem-se muito mais lento que a luz. Todavia, informação pode ser propagada num fio por uma corrente elétrica à velocidade da luz, da mesma maneira como as ondas de rádio podem irradiar. Quando isso é realizado a distinção entre transmissões com fio e sem fio torna-se menos clara.

Este capítulo examinará a evolução da rede tecnológica começando com o telégrafo elétrico e os primórdios da telefonia direta, até o desenvolvimento de redes a cabo e via satélite e a Internet. Ao fazer isso, também abordará a importância da compressão, *switching* e da fibra óptica no desenvolvimento das infra-estruturas da rede. Surpreendentemente o capítulo termina com um retorno à radiodifusão sem fio, salientando o fato que o significado das transmissões necessariamente não muda as oportunidades oferecidas pelo *spectrum* .

A era pré-digital

Transmissão por meio de fiação

O telégrafo elétrico

A idéia de usar eletricidade na comunicação em longa distância remonta dc século 18, mas experimentos anteriores de Lamond na França (1787) e Ronalds na Inglaterra (1816) foram dificultados pelos caprichos naturais da eletricidade estática e pelo fato de terem sido adversamente afetados pela umidade. Em 180C Alessandro Volta inventou a primeira bateria capaz de produzir uma corrente contínua de baixa voltagem elétrica, o *Voltaic Pile* , e, em 1820 na Dinamarca, Hans Christian Oersted, descobriu que a passagem de corrente elétrica através de um fio próximo a uma agulha magnética podia movê-la. Essas descobertas juntas tornaram possível o telégrafo elétrico. Willian Cooke and Charles Wheatstone patentearam o primeiro telégrafo em 1837 que:

> *era um elegante instrumento contendo cinco agulhas verticais girando em torno de machados horizontais combinados com uma ponta fina de diamante marcado no mostrador com as letras do alfabeto. Cada uma das agulhas podia ser movida para direita ou para esquerda, inclinando a chave apropriada em frente ao instrumento, e por meio de fios os quais conectava o instrumento a outro, no final da linha, as agulhas correspondentes do receptor seriam derivadas na mesma direção.*

O telégrafo de Cooke and Wheastone foi implantado na estrada de ferro Great Western Railway, em 1839, onde foi usado como meio de monitoramento e controle do material que circulava nas estradas de ferro e, por volta de 1852, mais de 4.000 milhas de telégrafo tinham sido instaladas pela companhia ferroviária Britânica. Havia pouco uso pelo público em geral ou mesmo organizações comerciais até a metade do século 19, quando o público tornou-se ciente da importância do telégrafo, a partir da publicidade dada ao papel que representou na captura de um notório assassino na Inglaterra em 1845. Depois disso c telégrafo veio a ter acréscimo de seu uso nos negócios e pelo público em geral.

A mais antiga rede de telégrafo precisou de muitos operadores e o sistema, particularmente perto de centros urbanos, encontrou crescente dificuldade para vencer o enorme amento no tráfego. Entretanto, no decurso da segunda metade do século 19, esses problemas foram amenizados com a introdução de algumas inovações, como telégrafo impresso (o qual imprimia a mensagem transmitida na máquina receptora) e o multiplicador, que enviava várias mensagens no mesmc fio, simultaneamente.

Nos Estados Unidos, Samuel Morse e Alfred Vail desenvolveram um sistema baseado em eletroímãs. Em um receptador Morse, um eletroímã energizado por um pulso de corrente atraía uma blindagem de ferro mole na qual gravava os pontos e traços do código Morse em uma faixa de papel, para mais tarde ser interpretado pelo operador.

Já no final do século 19 o sistema de telégrafo foi expandido numa escala global com a introdução de cabos submarinos através do Canal Inglês em l850 e no Atlântico em 1860. Por volta de 1900 todas as maiores cidades do mundc estavam conectadas por telégrafo, e a infra-estrutura básica sobre a qual a rede multimídia global do final do século 20 seria baseada já estava pronta. Nc entanto, telegrafia (literalmente "escrita à distância") logo foi ofuscada pela telefonia (fala à distância), que proveria às populações das nações industrializadas com uma forma a mais rica e a mais acessível de comunicação.

Telefonia

O moderno telefone surgiu das investigações de Alexander Graham Bell, em 1870, sobre como os humanos produziam e recebiam os sons. Bell, um médicc escocês que mais tarde se tornou cidadão americano, especializou-se nc tratamento de pacientes com dificuldades auditivas e, casualmente definiu os princípios básicos da telefonia a partir de suas tentativas de reproduzir artificialmente a fala humana. A inspiração de Bell para saber como isso podia ser realizado veio do cientista alemão Von Helmholtz, que tinha simulado os sons da fala usando corrente elétrica para vibrar um diapasão. Inicialmente, Bell começou a realizar experiências de transmissão elétrica de som à distância. Enquanto o telégrafo trabalhava num princípio digital (mensagens eram transmitidas na forma de discretos pulsos de eletricidade), o telefone de Bell trabalhava num princípio analógico. O bocal do telefone (o transmissor) convertia sons em uma corrente elétrica flutuante que era a representação analógica da onda que carrega o som, enquanto o fone de ouvido (o receptor) convertia de volta a corrente em som.

Em 1880 Bell começou vender sua nova invenção nos Estados Unidos, como uma mídia de massa, uma fonte de informação e entretenimento transmitido de uma central para assinantes. Esta concepção de telefonia, como um meio transmissor de música, entretenimento e informação, tinha um grande apelo. Por exemplo, em 1881 na Exposição Internacional de Eletricidade de Paris havia um grande público interessado nas demonstrações telefônicas em que os visitantes foram convidados a escutar musica acústica, lírica e perfomances teatrais através de fones de ouvido. No mesmo período, a *Téâtrophone Company of Paris* tornava o entretenimento telefônico acessível para as camadas menos favorecidas da população através de máquinas que operavam com moedas.

Em 1890 as companhias telefônicas na América do Norte e Europa ofereciam a seus clientes serviços musicais e entretenimento, assim como coberturas de eventos esportivos, discursos políticos e serviços religiosos. Em 1896 a Companhia Telefônica Universal ofertou aos assinantes mais abastados de Londres um acesso a várias peças teatrais londrinas por l0 libras ao ano, mais 5 libras pela tarifa de instalação. Em 1891, o sistema *Théâtrophone* foi instalado em salas no Savoy Hotel, em Londres, e no mesmo período o *Wisconsin Telephone Company* , nos Estados Unidos, transmitia música para os assinantes diariamente ao final da tarde e, aos domingos à tarde.

No início do século 20 houve exemplos do que nós hoje chamamos de teleconferência. Em 1912 um grupo de executivos do meio jornalístico, em Nova Iorque , tomou parte de uma ligação telefônica múltipla na qual *"Taft falou de Boston, o premier canadense Borden falou de Hot Springs Virginia, um poema de Kipling foi recitado do Teatro Daly e uma vocalista apresentou uma canção sulista de um outro teatro de Nova Iorque"* . Em Ontario, Canadá, em 1990 o telefone foi até usado para transmitir os procedimentos legais de um julgamento de assassinato, quando transmissores telefônicos foram instalados no tribunal. Os transmissores foram conectados a vinte receptores e alugados para interessados por vinte e cinco centavos a hora. Entretanto, com a chegada do rádio depois da Primeira Guerra Mundial, esmoreceu como um meio de comunicação e entretenimento. Bell e o seu apoiador financeiro notaram que o sucesso do telefone comercial não seria estabelecido em *"música melancólica lançada do cyberspace do século 19 mas em sua capacidade de facilitar a comunicação pessoa"* . Em 1878 os telefones Bell tiveram um impulso de divulgação quando houve um desastre de trem na cidade de Tarriffville, em Connecticut, quando um farmacêutico pôde usar um dos poucos telefones da cidade para mobilizar médicos da cidade vizinha para o local do acidente. O desastre deu a Companhia Telefônica Bell ampla divulgação, que gerou um crescimento significativo no número de assinantes. A princípio Bell instalou um sistema de ligações locais, para depois começar a construir linhas conectando cidades, espalhando-se rapidamente, sendo que em 1904 já cobria todo o Estados Unidos. A subsidiaria implantada por Bell para agenciar esse negócio a longa distância foi a *American Telephone and Telegraph Company* (AT&T). Esta, posteriormente, tornou-se a gerenciadora e as companhias Bell, tornaram-se subsidiárias.

Ao mesmo tempo em que o telefone tornou-se um meio de comunicação pessoal, seu declínio como um instrumento de entretenimento e notícias foi ocasionado principalmente pela crescente popularidade do cinema, rádio e gramofone. Uma notória exceção para o declínio do telefone como meio de entretenimento foi o serviço de informação telefone base Húngaro *Telefon Hirmond* , fundado em 1893. Descrito por Marvin como "o único exemplo de programa contínuo e sistemático do século dezenove que verdadeiramente antecipa o sistema de radiodifusão do século vinte", *Telefon Hirmondo* continuou operando após a Primeira Guerra Mundial.

Cable

Embora em 1920 o telefone tivesse sido substituído pelo rádio como o instrumento através do qual o entretenimento entrava nos lares, fios ainda representavam um papel significativo na transmissão de tais programações devido a problemas técnicos de distribuição. Os problemas técnicos enfrentados nas comunicações via rádio à longa distância, em 1920, advinham do fato de que as transmissões à rádio estão sujeitas a interferência atmosférica, particularmente do vapor de água. Isto demonstrou ser um problema, particularmente nos Estados Unidos, devido a seu tamanho geográfico (transmissões seguras de rádio a longa distância só tornaram-se possível em 1940 quando se descobriu que interferência podia ser reduzida se a freqüência de transmissão fosse aumentada). A solução foi encontrada na transmissão elétrica. Nos EUA uma das primeiras estações de rádio, a WEAF em Nova Iorque , foi implantada pela AT&T que, obviamente, fez uso de suas linhas telefônicas para radiodifusão à distância e para conectar suas estações em outras cidades, estabelecendo, assim, a primeira rede de rádio.

As redes de rádio à cabo vieram a ser instaladas na Europa durante o ano de 1920. Na Europa e reino Unido, as primeiras radio difusoras atendiam apenas as maiores cidades, deixando uma grande parte da população sem um sinal satisfatório. Muitos comerciantes aproveitaram a oportunidade para erguer antenas altas e captar o fraco sinal da programação de áreas urbanas ou de países estrangeiros. Eles, então, retransmitiam para assinantes por sistema à cabo. O primeiro sistema de retransmissão foi implantado na Holanda no começo de 1920 e o primeiro a ser instalado na Inglaterra foi em 1925. Por volta de 1935 havia 343 sistemas à cabos na Inglaterra (embora alcançasse somente 3,1 de portadores de licença de radio). O país com maior número de conexões à cabo era a Holanda - em 1939 - com 50 por cento de famílias conectadas.

Como a tecnologia do rádio receptor cresceu e a rede de transmissão da BBC se expandiu, as programações à cabo diminuíram no Reino Unido em 1930 e, um número de sistema de retransmissão saiu do mercado. Houve um gerenciamento das emissoras para sobreviver na década de 40, em função das restrições no alcance das transmissões durante o período de guerra, que tinham o intuito de prevenir bombardeiros inimigos que captassem seus sinais.

Com o restabelecimento da transmissão televisiva depois da guerra, as cabos operadoras na Inglaterra e Europa receberam novos estímulos, quando elas retomaram a mesma posição que tinham no início do rádio, através de suprimento de sinais para lares com fraca recepção da programação da televisão. Nos Estados Unidos também, disso, a televisão a cabo desenvolveu-se como solução ad hoc para o problema de má recepção do sinal, tanto em áreas distantes dos principais centro populacional como em grandes cidades, onde o reflexo de múltiplos sinais e barreiras físicas dos edifícios dificultavam a recepção. Companhias privadas providenciariam um serviço a cabo para as comunidades com má recepção, enviando para baixo um fio de uma antena em uma área onde o sinal era forte. Esse sistema ficou conhecido como Community Antena Television (CATV). Um dos primeiros sistemas CATV foi implantado em Lansford, Pensilvânia, em 1950 por uma rádio local e televisão varejista que ergueu no alto de uma montanha uma antena conectada por cabo coaxial para cada assinante, uma prática conhecida como "importação de sinal à distância". Por volta de 1952, setenta companhias de importação de sinal à distância estavam operando nos Estrados Unidos.

No princípio as companhias usaram pares torcidos de fios De cobre de telefone permitindo de 2 a 4 canais de televisão, mas como o sistema a cabo veio a ser permanente esse foram trocados por cabos coaxiais, os quais reduziam a interferência externa por ter um condutor de fio ao redor de outro. Cabos coaxial foram capazes de carregar sinais elétricos de freqüência mais alta que os pares abertos de fios de telefone, então as companhias de cabos podiam prover muito mais canais do que estava acessível no ar. As companhias a cabo começavam agora a aumentar as transmissões, tendo canais de programação com outras companhias, de fora da área local. Inicialmente isso foi feito através das antenas principais das companhias de cabo locais, mas cada vez mais, a partir do final década de 60 e início da década de 70, sinais de programação a distância foram transmitidos usando emissões de microondas.

Transmissão sem fio

O início do rádio

Transmissões sem fio evoluíram dos avanços científicos no final do século dezenove. Particularmente, as descrições teóricas das ondas de rádio de James Clarck Maxwell (1864) e a detecção dela no final de 1880 por Hertz, possibilitaram a primeira demonstração de transmissão de rádio feita por Marconi em Salisbury Plain , na Inglaterra, a uma distância de 1.75 milhas (É interessante frisar que, muito antes da era digital, Marconi usou tecnologia digital em forma de pulsos "on-off " do código Morse). O progresso foi rápido, logo depois. Em 1899 Marconi obteve a primeira transmissão entre França e Inglaterra (atravessando o Canal). A primeira transmissão transatlântica realizou-se em 12 de dezembro de 1901, de Cornwall, Inglaterra para Saint John´s, Newfoundland. Em 1902 o Canadense Reginald Fessenden realizou a primeira transmissão de rádio analógica enviando voz e música a uma distância de 25 milhas . Fessenden fez isso através da técnica de modulação de amplitude, ou magnitude, propagando ondas de rádio com o som das ondas gerado pela fala ou música. O transmissor de rádio gerava a propagação de ondas com características constantes, como amplitude e freqüência. O sinal contendo a informação desejada era então usado para modular o propagador. Essa nova onda, chamada de onda modulada, continha a informação do sinal.

Durante a primeira década do século vinte outras técnicas foram desenvolvidas para melhorar a recepção e a transmissão dos sinais de rádio. A mais significante dessas técnicas foi o diodo, ou válvula, produzido por sir Ambrose Fleming em 1905, a qual permitiu detectar ondas de rádio de alta freqüência, e a *audion* , ou triode inventada por Lee De Forest em 1907, a qual amplificava ondas de rádio. No início da década de 20, a transmissão regular de rádio, com música, entretenimento e notícias, estava acontecendo na Europa e América por companhias públicas e comerciais.

Em 1930 o americano, Edwin H. Armstrong, engenheiro de rádio, desenvolveu a técnica de modular a freqüência da onda propagadora (FM) muito mais que sua amplitude (AM), método usado desde Fessenden. Freqüência de rádio modulada provou ser menos propensa à interferência de fontes elétricas naturais ou artificiais, devido a sua constante amplitude. Isso se tornou ideal para as transmissões de televisão e rádio de alta fidelidade. FM foi transmitida em freqüência e potência mais alta que AM rádio (30-300 MHz contra os 0.3-3 MHz) conferindo-lhe uma faixa mais larga que a AM. Esta onda de freqüência muito alta (VHF) capacidade de banda suficiente para propagar dois ou mais canais para produzir, por exemplo, som *stereophonic* e *quadraphonic* . Quando a televisão se tornou um veículo de massa após a Segunda Guerra Mundial ela também foi transmitida em VHF a partir do *spectrum* radiofônico, embora por volta de 1960 a maioria das transmissões de televisão começou a mudar para ultra - alta freqüência (UHF – 300 MHz para 3,000 MHz).

Em 1960 mesmo as mais altas freqüências do *spectrum* de radiofônico começaram ser exploradas muito mais com o propósito de retransmitir chamadas telefônicas que programação.Companhias americanas como Sprint e MCI começaram a explorar transmissões com freqüência super alta de microondas (3,000 para 30.000 MHz), no sentido de conter o monopólio das transmissões das chamadas telefônicas a longa distância da AT&T. Este desenvolvimento tecnológico grande repercussão institucional e política, já que resultou no maior desafio para o monopólio da AT&T em telefonia a longa distância e a conseqüente quebra da AT&T em 1980. (veja capítulo 5)

O telefone celular

Esse padrão de transmissão híbrida com e sem fio tem sido um destaque na história das telecomunicações. Isso é bem ilustrado pelo desenvolvimento do rádio celular como um meio de estabelecer a telefonia móvel individual. Rádio-telefone não era novo, porém, antes de 1980 era grande e caro, sendo que havia um número limitado de operarações simultâneas por área. Desenvolvido em 1970 pelo laboratório Bell, da AT&T, para ser utilizado em automóveis, o telefone celular foi vendido com grande sucesso para o público durante a década de 1980. O sistema dividia uma área em grupos de células e, cada célula cobria um raio de 8 a 12 milhas , com seu próprio rádio transmissor de cerca de 120 canais de rádio de duas vias. Para eliminar as interferências celulares, células vizinhas não podiam usar a mesma freqüência de rádio, mas a freqüência usada em cada grupo podia ser repetida em grupos adjacentes. Quando o usuário se desloca, o sinal é trocado automaticamente para a célula vizinha.

Interatividade

Deixando a televisão de lado, o potencial multimídia dos cabos encontra-se no fato de que os cabos coaxiais usados pelas companhias a cabo tem 416.000 vezes mais capacidade do que os pares de fios telefônicos. Isso significa que eles podem entregar não somente pontos de canal de televisão, mas também formas de caminho duplo de comunicação.

Com essa combinação de microondas e cabo coaxial algumas operadoras americanas a cabo, por volta de 1970, eram capazes de oferecer a seus assinantes de 50 a 100 canais de televisão com capacidade em dois sentidos completamente ativos, permitindo ao usuário um grau de controle sobre o que lhe é apresentado na tela.

Algumas experiências em interatividade à cabo foram conduzidas a partir da década de 70, com variados graus de sucesso. O primeiro, em 1977, foi o *Qube* , sistema o qual capacitou os usuários responder interativamente, pressionando botões que retornavam os sinais aos computadores a cabo na outra extremidade, para serem analisadas e mostrados. A interatividade oferecida pela *Qube* para seus assinantes incluía as possibilidades de competição com outros telespectadores em shows de enigma, e voto para a mais popular personalidade dos melodramas, bem como compras. Ainda que o sistema tenha tido grande repercussão, ele não provou ser rentável e foi descontinuado em 1984. Durante os anos 80, a forma mais importante de interatividade era o *pay-per-view* , onde os telespectadores podiam escolher um programa por uma taxa extra.

Na Inglaterra o cabo nunca veio a ser tão difundido quanto nos Estados Unidos, porque a transmissão terrestre geralmente era melhor. Na década de 50, cerca de um milhão de lares ingleses estavam conectados, no sentido de obter melhor recepção, mas como os transmissores se tornaram mais potentes, o número de casas conectadas caiu. Durante a década de 1970 o número de assinantes a cabo parou de crescer e começou a cair. A indústria perdeu 140.000 assinantes em 5 anos, e teve início um *lobby* por maior liberdade na distribuição adicional da programação, particularmente filmes, com o objetivo de manter os clientes já existentes e atrair outros novos. Até essa época, um forte *lobby* , da década de 1930, (particularmente pela BBC), restringia às operadoras a cabo simples retransmissão da programação dos canais existentes.

Satélite

Surpreendentemente, o desenvolvimento tecnológico que mais contribui para o rápido crescimento na televisão a cabo, particularmente nos Estados Unidos foi a comunicação via satélite. Em 1970, somente 11% dos lares americanos estavam com conexão a cabo nos Estados Unidos. Em 1975, ano do primeiro satélite, houve um crescimento para 12 por cento e, na década de 1990, com a distribuição, por satélite, de canais dedicados a filmes e esportes, mais de 63% dos lares americanos estavam conectados a cabo. Cabo, nos Estados Unidos, se tornou um negócio multimilionário, e seu sucesso inspirou outras iniciativas ao redor do mundo, particularmente na Europa.

Originalmente, o satélite foi concebido no sentido de tornar a distribuição de microondas mais acessível. O primeiro satélite de comunicação, desenvolvido pela iniciativa priva da Telstar, foi lançado em 1962. A *Communications Satellite Corporation* (COMSAT) foi incorporada em 01 de fevereiro de 1963 a uma companhia americana privada para criar, em conjunto com as administrações de telecomunicações de outros países, um sistema comercial de satélite de telecomunicações. Em meio de 1964 a *International Telecomunication Satellite Consortium* (INTELSAT) foi formada por 110 países para gerenciar a comunicação internacional via satélite. Em 1965 a INTELSAT lançou o Intelsat I, mais conhecido como *Early Bird* – pássaro matutino – o primeiro satélite de comunicação comercial geosicronizado do mundo (que foi precedido, em 1963, pelo satélite Syncom II, também geosicronizado, porém experimental). Um satélite com órbita geosincrônica a uma distância de 22.500 milhas da terra leva vinte e quatro horas para completar uma órbita. Já que, isso é o mesmo tempo que a terra leva para dar uma volta em seu eixo, ele surge " flutuando " sobre a mesma localização e pode ser usado para transmitir sinais de comunicação, conseqüentemente para a mesma área de cobertura (*footprint*).

A primeira conexão significativa entre satélite e cabo ocorreu em 1975, nos Estados Unidos. A *Home Box Office* (HBO), um canal de televisão pago, usou o satélite para transmitir a luta de boxe entre os campeões, pesos pesados, Mohammed Ali e Joe Frazier, de Manila nas Filipinas para os assinantes a cabo nos Estados Unidos. HBO, originalmente, tinha sido implantada para fornecer filmes de longa metragem para a rede a cabo usando as conexões das microondas na terra, mas depois do sucesso da transmissão de Ali-Frazier ficou claro que satélite supria com muito mais eficiência e custo-benfício a distribuição. HBO começou vender seus serviços de filme para companhias a cabo nos Estados Unidos e logo foi seguida por outras companhias incluindo o serviço de noticias vinte e quatro horas da CNN e o *Superchannel* da Geórgia, ambos pertencentes à *Turner Broadcasting System of Atlanta* . A disponibilidade desses canais extras de televisão tornou a rede a cabo muito atrativa para o público e resultou em grande expansão n a década de 80 com a maioria das principais cidades dos US concedendo franquia para as companhias a cabo. Em 1975, o ano da transmissão de Ali-Frazier, 12% dos lares nos Estados Unidos possuíam TV a cabo; cinco anos mais tarde, em 1980, esse número tinha aumentado mais de 20%. Por volta de 1985, 43% dos lares dos US estava conectado a cabo, e em meados da década de 1990, tinha crescido mais de 63%.

Satélite de programação direta (DBS)

No final da década de 1970 algumas pessoas compraram suas próprias antenas parabólicas com a finalidade de receber gratuitamente os programas que eram transmitidos para as cabos operadoras. A resposta dos provedores de programa de satélite foi dificultar seus sinais, pois desse modo somente as companhias a cabo com decodificador próprio poderiam recebê-los. Oportunamente, na metade da década de 1980, os programadores de satélite permitiram às companhias independentes, vender decodificadores para os proprietários de antenas parabólicas. Ter que pagar por um serviço, inicialmente levou a uma queda de vendas de antenas nos Estados Unidos e o predomínio a cabo significou que o DBS não teve um grande impacto, sendo que por volta de 1988, menos de 4% das residências americanas possuíam antenas. DBS, na Inglaterra, começou em 1989 com o estabelecimento da *SKY Television* seguida pela *British Satellite Broadcasting* (BSB) em 1990 (entre 1982 a 1989 a Sky operou com um satélite de baixa potência para o sistema a cabo). As duas companhia fundiram-se em 1990 para formar a BSkyB (*British Sky Broadcasting* – embora, na verdade, a Sky assumiu a BSB). Nesse início, a BSkyB lutou para obter lucro. Entretanto essa situação mudou dramaticamente quando a companhia venceu o contrato para mostrar ao vivo, em 1992, o futebol da primeira liga inglesa. Na Inglaterra, as antenas parabólicas foram muito mais absorvidas que em qualquer outro país do mundo A programação de futebol da Sky reavivou a agonizante indústria a cabo (ao passo que as companhias à cabo habilitadas contribuíram para baixarem as tarifas telefônicas da *British Telecom* , depois de 1991, que também contribui para o crescimento de assinantes a cabo).

Computadores e Comunicação

O processo de tornar existente a rede de telecomunicações dentro de portadores potentes de multimídia, começou na década de 60 quando a primeira troca para telefone digital foi implantada usando *Pulse Code Modulation* (PCM). PCM converteu os sinais analógicos de voz em sinais digitais, digitalizando a forma da onda. Nesse estágio a aplicação da tecnologia dos computadores para o sistema de telefone foi visto como um simples meio de aumentar a capacidade de trabalho dos circuitos. No final da década de 1990 a digitalização conduziria a convergência do telefone, cabo e indústrias de programação, como transmissores de multimídia para o mercado de massa.

O modem

O passo decisivo no processo de convergência digital foi a invenção do modem por Ward Christensen em 1977. Isso tornou possível a conexão de computadores entre si por meio de linha telefônica. Na verdade, bancos de dados comerciais on-line tinham aparecido nos finais dos anos de 1960, mas usavam linhas exclusivas para fornecer informações para clientes em terminais distantes. O mercado de banco de dados, na realidade, somente decolou depois da invenção de Christensen.

O modem (da contração de MODulator, DEModulator) converte os sinais digitais do computador em sinais análogos da linha telefônica. Esses são então, transmitidos pela linha telefônica para um outro modem o qual converte de volta as ondas de som em uma corrente de bit (*bit-stream*) que o computador pode ler. O modem reduziu dramaticamente o custo da conexão dos computadores às linhas telefônicas e, em 1979, somente dois anos depois da sua invenção, já havia 33 milhões de transações de dados, por ano, somente entre os computadores ingleses. Em 1983 isso já tinha dobrado para 74 milhões de transações. Durante a década de 1980 várias companhias implantaram serviços de banco de dados que utilizavam *modens* para entregar informações para assinantes comerciais, particularmente em serviços financeiros, advocacia e bibliotecas. O uso do serviço de banco de dados veio a ser uma fonte significativa de renda para as companhias telefônicas.

O modem tornou possível para os computadores a conexão via infra-estrutura da rede mais difundida do mundo, o sistema de telefonia. Entretanto o sistema de telefone a fio de cobre, e o mais novo, mas menos comum rede de cabos, não teve capacidade suficiente na largura da banda (*bandwidth*), para entregar as mais sofisticadas multimídias interativas disponíveis, por exemplo, em CD-ROM. O sistema de dados *on-line* desenvolvido durante a década de 1980, só podia transmitir texto ou dados numéricos ou, em alguns casos, simples linhas gráficas.

As vantagens da digitalização

O começo da transmissão digital mostrou que as limitações do fio de cobre, e certamente todo meio de transmissão podiam ser vencidas pela computação. As principais técnicas usadas para melhorar o volume de informações que pode ser transmitido por um certo meio são primeiramente, compressão digital, que converte grande quantia de informação digital para uma quantia menor de transmissão, e segundamente, o *packet-switching* (*swithtching* "empacotado") que tem tornado possível o fenômeno da Internet.

Bandwidth

Bandwidth ("largura da banda") é o termo usado na teoria da comunicação para definir a capacidade de um canal de comunicação em carregar informações medidas em Hertz ou ciclos por segundo. A voz no telefone requer uma *bandwidth* de 3-4 kHz (milhares de ciclos por segundo), entretanto imagens de televisão requerem 6-8MHz (milhões de ciclos por segundo). A mais extensa *bandwidth* de um canal de comunicação, o maior alcance de freqüência e, portanto informação, pode ser enviado num tempo determinado. Somente a transmissão de voz em telefone de qualidade normal requer uma *bandwidth* de 64.000 bits por secundo (64 kilo bits por segundo). Enviar som e imagens em movimento requer a maior de todas as *bandwidth* com uma quantia dependendo do tamanho da tela e da taxa do frame do vídeo. Uma imagem de vídeo de três cores com 1.024 *pixel* por 768 *pixel* correndo trinta *frames* por segundo requer uma *bandwidth* de 566Mbits/s (milhões de bits por segundo).

Compressão

As técnicas de compressão funcionam reduzindo o número de bits que têm que ser transmitido para transportar uma quantia de informação dada. Preferível a aumentar a *bandwidth* média de transmissão, a compressão usa a força disponível do transmissor e receptor final para reduzir o número de bits a serem transmitidos. O princípio da compressão pode ser melhor compreendido considerando o caso do vídeo digital. Transmitir uma imagem em televisão digital requer uma taxa de dados de 217 megabites por segundo. Entretanto, não se torna necessário repetir isso por todo o frame, já que, de frame para frame grandes partes da cena não trocam. Por transmitir somente aquelas porções de imagens que trocam, a quantia de bits que tem que ser transmitida pode ser, consideravelmente, reduzida.

Vários padrões de compressão têm sido adotados, os mais importantes para compressão existente para a compressão de vídeo moção (*motion video*), são aqueles estabelecidos pela *Moving Pictures Expert Group* (MPEG). A compressão MPEG-1 pode reduzir entre 50 e 200- fold a quantidade de dados que precisa ser transmitida para sustentar uma imagem de vídeo de 320 *pixels* por 240 *pixels* com um som de qualidade de CD a 30 *frames* por segundo. A redução dependerá de quanta mudança há de frame para frame.

O rápido desenvolvimento de técnicas de *switching* e compressão de *softwares* , em laboratórios de pesquisa de companhias telefônicas resultou na metade da década de 90 na possibilidade de transmitir vídeos de qualidade VHS - vídeo de baixa qualidade em fios duplos torcidos de cobre. Como Gilder explica:

> *Gráficos e vídeos podem impor imensa enchente de bits no sistema, mas a tecnologia de compressão poderia reduzir a enchente por um escoamento controlável, com pequena ou nenhuma perda na qualidade da imagem.*

Tanto quanto o aperfeiçoamento na qualidade das imagens, quanto a capacidade extra dada às transmissões a fio pela digitalização tornou possível para as companhias a cabo oferecer a seus assinantes um alto nível de interatividade. Por exemplo, em 1993 a companhia de cabo Videotron, com franquias em Londres e sul da Inglaterra, introduziu um sistema que permitia aos telespectadores escolher diferentes câmeras em jogos de futebol tanto assim como assistir aos replays.

Switching

O uso mais antigo do processo digital na comunicação, como temos visto, foi no telefone central com a introdução do *switching* eletrônico. A rede de telefone é uma rede *switched* : isto é, o caminho ou circuito, necessário para conectar um telefone a outro é criado e mantido somente durante cada chamada individual de telefone. Nos primeiros tempos, os sistemas *switching* de telefone eram realizados por operadores humanos que usavam *plugs switchboard* para fazer o caminho da uma linha para outra.

No início do século vinte centrais telefônicas automática começaram a substituir os operadores manuais. (A primeira central automática de telefone público da Inglaterra abriu em Epson, Surrey em 1912). Essas centrais automatizadas usavam transmissões automecânicas e *switches* que eram controlados por dígitos discados, um sistema inventado em 1889 por Almon B. Strowger, um empreiteiro em Kansas City. O Switching eletrônico mecânico reduziu a necessidade de operadores, mas não era flexível e precisava de considerável manutenção. Entretanto centrais Strowger ainda operavam em 1990. Uma das últimas, a central Strowger, empresa privada de Catford, Inglaterra, somente fechou em 1995.

Entretanto com a introdução dos *switches* eletrônicos, na década de 1960, foi possível computadorizar os *switches* eliminando de maneira efetiva a distinção entre comunicação eletrônica e computação já que ambos desviam os bits de informações em torno sob o controle de programas armazenados. Com esse desenvolvimento veio a concepção de "rede inteligente" na qual a rede de telecomunicações podia 'processar, determinar o caminho e armazenar informações usando *switches* digitais e conexões de transmissão, computadores e banco de dados'.

A vantagem inicial dessas tecnologias para o sistema de telefonia foi que a tornaram mais eficiente, possibilitando detectar e eliminar os erros de transmissão. A digitalização também evitou que o sistema se tornasse congestionado redistribuindo mensagens para fora dos circuitos sobrecarregados. Somente mais tarde foi percebido que *switches* digitais controlados por programas permitiam serviços extras para serem oferecidos para usuários de telefone, incluindo centrais virtuais, serviços de atendimento, despertador, chamadas reprogramadas e cartão telefônico.

Mas definitivamente a digitalização do sistema telefônico aumentou a possibilidade das companhias telefônicas e a cabo superar as limitações da *bandwith* e da infra-estrutura de cobre existente para entregar serviços multimídias a seus assinantes. Como Gilder explana:

> *Se tudo mais falhasse, switches eletrônicos potentes compensariam quase qualquer limitação de largura da banda. Switching compensariam a banda nos terminais aliviando a rede, da necessidade de transmitir todos os sinais para todos os destinos. Ao invés disso, o switch central receberia todos os sinais e então os encaminharia para os endereços apropriados.*

O mais vasto método usado de *switching* digital para a transmissão integrada de voz, dados e imagens em forma digital através de rede telefônica é a *Integrated Services Digital Network* - ISDN (Rede Integrada de Serviços Digitais). Uma linha ISDN pode carregar dois canais de 64-kilobits-por-segundo para um cliente usando dois pares de fios de cobre torcidos. A *International Telecommunications Union* estabeleceu padrões para ISDN já no ano de 1984.

As tecnologias seguintes - tais como high bit rate digital subscriber line, HDSL (linha digital de alta taxa de bit assinada) - melhorou consideravelmente o ISDN entregando trinta canais (2 Mbit/s) por duas ou três linhas de cobre para os assinantes. *Asynchronous Transfer Mode* (ATM) tecnológico é uma outra tecnologia de *switching* em desenvolvimento pelas companhias de telecomunicações, e é alegado que pode promover o crescimento da disponibilidade máxima de taxa de bit para além de 6 Mbit/s. ATM permite qualidade de vídeo VHS para os lares através de linhas telefônicas de cobre. Nos US vários testes usando ATM foram executados, como o notável Time-Warner Cable/Silicon Graphis Full Network (FSN). Em 1994 um estudo piloto envolveu 4.000 lares em Orlando, Florida postos em rede usando as últimas tecnologias de transmissão, *switching* e compressão. O sistema tinha um tronco de fibra ótica para as imediações de até 500 casas e os serviços entravam nas casas por cabo coaxial. Em 1995 houve um teste ATM em East Anglia , Inglaterra conduzido pela British Telecon (BT), Apple e Oracle no qual as famílias eram habilitadas aptas a selecionar vídeos e outros serviços por transmissão para dentro de suas casas, através de linhas telefônicas de cobre.

Packet switching

A chave da tecnologia *switching* para o desenvolvimento de uma infra-estrutura digital universal tem sido o *packet switching* (*switching* “empacotado”). No capítulo 1 nós descrevemos como os cientistas tentando assegurar a sobrevivência do sistema de comunicação militar no evento em que a guerra nuclear fez uso do *packet switching* . Em uma rede empacotada, mensagens são divididas em pacotes uniformes com um cabeçalho dando (a) o destino para qual ele é endereçado, (b) a mensagem da onde ele pertence e (c) sua posição na mensagem. Os vários hóspedes da rede de computadores lêem e encaminham os pacotes diferentes e, toda a mensagem é então, reunida quando alcança seu destino final.

Os primeiros testes de *packet switching* foram executados na Inglaterra em 1968 pelo *National Physical Laboratory* (Laboratório Nacional de Física). O *packet switching* formou a base da Rede de Agências de Programas de Pesquisas

Avançadas - *Advanced Research Programs Agency Network* (ARPANET) - financiada pelo Pentágono, que foi implantada em 1969. Era ARPANET que veio a ser o alicerce da Internet.

A Internet

O significado do *packet switching* para a Internet é, conforme Howard Rheingold chama atenção, desdobrável em duas partes:

> *Primeiro, criam-se quarteirões de edifícios (building block) para o sistema de comunicação sem controle central porque você não precisa de um controlador central quando cada pacote e a rede inteira de rotas sabe como espalhar informação.Segundo, como as informações do mundo vêm digitalizadas, aqueles pacotes podem carregar tudo o que os humanos podem perceber e a máquinas podem processar – voz, som de alta-fidelidade, textos, gráficos coloridos de alta resolução, programas de computador, dados e vídeos com movimento.*

Falando mais precisamente, "Internet" é qualquer rede de redes e, muitas organizações acadêmicas, comerciais e militares já tiveram seus computadores conectados dentro de uma rede local (LANs) há alguns anos. O processo pelo qual a Internet – com a letra maiúscula I – começou a existir, é que uma dessas LANs foi progressivamente capaz de falar uns aos outros através do uso de *packet switching* e padrões comuns para a troca de informação digital, conhecidos como protocolos.

Conforme vimos anteriormente as origens da Internet encontra-se com a ARPANET. A espinha dorsal da ARPANET era baseada em computadores PDP 8 e PDP11 situados em universidades americanas que foram ligados por linhas de telefone permanentes abertas. Originalmente usados para facilitar as comunicações entre militares e pesquisadores acadêmicos trabalhando em contratos militares, ARPANET em 1983, generosamente, como resultado de redução militar atravessou uma enorme reorganização. O principal resultado foi que isso a dividiu em seção militar e seção civil. A Internet cresceu na seção civil da ARPANET. Da ARPANET veio o IP - *Internet Protocol* designado para deixar qualquer computador em comunicação com qualquer outro via sistema telefônico. Nos US, sob a proteção da *National Spience Foundation Network* (NSFNET), o IP foi adotado por organizações governamentais e acadêmicas com o objetivo de trocar informações entre seus principais computadores e também como método de comunicação escolar usando o correio eletrônico. Eventualmente, sites de educação e pesquisa, que não tinham feito parte da ARPANET original, adotaram o IP como fizeram, mais tarde, quase todas as outras LANs no mundo.

O interesse comercial na Internet começou em 1989 quando a companhia americana, CompuServe, primeiro preocupou-se em prover um serviço de banco de dados e começou a oferecer acesso a Internet a seus assinantes ansiosos para usar e-mail. CompusServe foi seguida pela América Online e Delphi, em 1993, que ofereceram acesso a banco de dados, correio eletrônico, assim como, serviços de bate papo on-line. Esses serviços provedores também permitiam a seus assinantes receber e enviar softwares e arquivos de computador usando protocolo de transferência de arquivo (ftp) assim como interagir com computadores mais distantes. (telnet)

Internet browsers

Um dos problemas em se obter aceitação da Internet pelo público em geral foi a dificuldade de usar o software associado. De muitas maneiras isso se comparou às dificuldades enfrentadas pelos mais antigos computadores pessoais antes da evolução e aceitação da Interface do Usuário Gráfico (Graphical User Interface - GUI) na década de 80.O desenvolvimento que mais superou esse problema e começou a estabelecer a Internet como um meio de massa foi o *World Wide Web* (Ampla Teia Mundial) - WWW ou W3. A *World Wide Web* foi desenvolvida por Tim Berners-Lee um físico da CERN (*The European Laboratory for Particle Physics* - Laboratório Europeu da Partícula Física) como um meio de facilitar o trabalho em grupo e trocar informações com seus colegas. Em 1991 Berners-Lee dispôs seu programa WWW livremente na Internet.

A WWW é baseada na concepção de hipertexto. Hipertexto trabalha com o princípio de criar ligações entre dados digitais que então, ao clicar em uma palavra na tela do computador com um mouse trará à tela uma definição, uma imagem, um texto de artigo ou um som. Na WWW a informação é inserida em documentos na rede usando um formato hipertexto chamado *Hypertext Markup Language* (HTML) em que o browser interpreta como texto, estilo ou cor ou como um link para outro endereço ou algum lugar a mais na Internet. O WWW usa um protocolo chamado *Hypertext Transmission Protocol* (http) o qual permite a qualquer computador "falar" com outro computador indiferente do seu sistema de operação.

O *World Wide Web* funciona no modelo servidor-cliente onde um provedor de informação passa a um servidor que segura a informação tornando-a disponível para um cliente em qualquer outro lugar pela Internet. A flexibilidade do sistema permite ao indivíduo usar programas " *helper* " (de ajuda) para exibir animação, vídeo ou tocar música.

Programas para clientes que permitem ao usuário "navegar" são conhecidos como *browsers* e se parecem e trabalham muito semelhantemente ao aplicativo Apple´s HyperCard (veja capítulo 3). O primeiro *browser* bem sucedido foi Mosaic, desenvolvido por Mar Andreeson e Eric Bine do *National Centre for Supercomputing Applications* (Centro Nacional de Aplicações de Supercomputador), NCSA nos EUA. Andreeson deixou a NCSA para implantar uma nova companhia, Netscape, com o objetivo de desenvolver suas idéias. Em 1994, o primeiro produto da Netscape, o *browser* Navigator, foi distribuído livremente pela Netscape, pela Internet, para organizações não lucrativas e educacionais, logo superou o Mosaic em popularidade. Organizações comerciais tiveram que pagar e isto deu a Microsoft a chance de obter uma competitividade aguçada quando eles lançaram seu browser Internet Explorer, baseado no Mosaic, gratuitamente em 1996. A Netscape teve que responder diminuindo o preço comercial do Navigator. Em 1997 a Netscape deu um passo a mais e lançou o código de fonte para Communicator. O código de fonte é o texto do programa produzido pelos programadores em uma linguagem como C++. Costumeiramente o código de fonte é patenteado sem acesso para os usuários. Deixando o código fonte livremente disponível, a Netscape dizia para os usuários que não havia características escondidas no software que poderiam secretamente armazenar informações de seus PCs e isso também deu aos escritores de softwares a oportunidade de desenvolver o próximo programa.

No fim da década de 90 um número das então chamadas tecnologias "convergentes" tinham sido desenvolvidas para facilitar a transmissão de canais de televisão na Internet. Exemplos dos produtos convergentes incluem Microsoft´s WebTV, a híbrida TV-PC, com intenção de prover acesso a Internet pelo sistema a cabo. Outro exemplo dessa tendência foi a Apple´s iMac lançada em 1998. Ela é baseada no sistema operacional da Macintosh e combina as funções da WebTV - como um aparelho de acesso a Internet com um CD ou DVD player.

Transmissão digital sem fio

Uma das outras características da digitalização e *packet switching* é que eles podem ser aplicados facilmente tanto para transmissão sem fio quanto com fio. Pela metade da década de 90 tecnologias de rádio digital tornaram isso possível ao transmitir a mesma gama de freqüências através do ar tanto quanto por cabo coaxial. Uma vantagem importante da transmissão digital em qualquer meio, como temos visto, é que ela pode levar vantagem nas técnicas de compressão por prover muito mais canais a uma freqüência dada. Para transmissões via satélite isso também significa mais custo-benefício do caro transponder time. A transmissão de televisão digital também tem algumas outras vantagens. Ela torna possível a alta definição nos formatos *widescreen* , tanto quanto, permite baixar o código para ser salvo pelo receptor para fornecer interatividade, por exemplo, para jogos. A transmissão digital também promete transformar a mais antiga forma de transmissão: o som do rádio. Em 1996 a Bosch da Alemanha e a Deutsche Telekom, as operadoras de telecomunicação, demonstraram um sistema DAB-TV que era um rádio/televisão híbrida, e em 1996 a BBC lançou um serviço digital Áudio Broadcasting (DAB) com som de qualidade de CD.

Televisão via satélite digital

Pelos anos 90 transmissão direta análoga via satélite estava tecnicamente e financeiramente estabelecida, mas já estava se tornando óbvio que isso era uma fase passageira e que o estímulo real viria com a introdução da transmissão digital. O primeiro sistema digital DBS, o satélite geosincronizado Hughes DirectTV, foi lançado em 1994 oferecendo 150 canais digitais em toda a América do Norte. Isso se tornou rapidamente um dos maiores sucessos de consumo entre produtos eletrônicos de todos os tempos: em seus primeiros sete meses de venda de antena parabólica de dezoito polegadas e caixa set-top, as vendas foram maiores que aquelas obtidas no primeiro ano da VCRs nas vendas em CD players e televisão wide-screen juntas.

O mercado nos Estados Unidos da América é extremamente competitivo e a DirecTV logo foi associada aos satélites EchoStar e PrimeStar também com sistema de antena parabólica direct-to-home (DTH). Na Europa vários serviços de satélites digitais começaram em 1990 incluindo DStv na Itália, CanalSatellite Numérique na França e DF1 na Alemanha. No Reino Unido a BSkyB anunciou que estaria lançando um satélite digital DBS geosincronizado com 200 canais no final de 1998.

Deixando a televisão de lado e num desenvolvimento que simboliza a independência da forma do meio em relação ao conteúdo, transmissões sem fio rapidamente se tornaram o meio fundamental de comunicação entre pessoas. Esse processo começou com o rádio celular, mas ganhou um impulso adicional quando o satélite digital foi visto por oferecer oportunidades para tráfego de voz e dados. Organizações que têm instalado novos sistemas de comunicação de satélite digital incluem Inmarsat. Esse projeto fundado por 1.200 companhias e oitenta países membros lançou vários satélites geosincronizados para prover telefonia às regiões mais remotas do mundo. No entanto, um inconveniente do satélite geosincronizado é que sua órbita é muito alta para uma telefonia e transmissão de dados eficazes. A distância que o sinal tem que viajar significa que há sempre um ligeiro atraso na recepção e o equipamento terminal tem sido incômodo e caro. Para superar esses problemas, vários sistemas de satélite digital foram desenvolvidos na década de 1990 usando um número maior de satélites menores de baixa órbita, chamados de "constelações". Em 1990 a Microsoft e a companhia de telefonia móvel McCaw Cellular, formaram um grupo a Teledesic, para lançar um sistema que consistia em 840 pequenos satélites operando em baixa órbita terrestre em 2001. Em 1994 a Motorola começou a trabalhar em um sistema de satélite chamado Iridium que em 1998 tinha colocado 66 satélites espaçados igualmente a 420 milhas da terra. Como eles orbitavam em baixa altitude esse sistema usa menos força para transmitir e receber sinais, permitindo aparelhos de tamanhos menores para o usuário.

Televisão Terrestre Digital

(DTT) Digital Terrestrial Television

Transmissores DTT operam em freqüência muito mais baixa que DST – 0.6 gigahertz bem oposto dos 11 gigahertz do satélite – e têm que transmitir numa estreita faixa de freqüência. Isso significa que o satélite digital pode transmitir centenas de canais, mas a transmissão digital terrestre será capaz de transmitir somente algumas dúzias. Apesar dessas desvantagens o *Broadcasting Act* do governo Britânico de 1996 plantou a base para a introdução e licença de serviços de televisão digital terrestre.

Isso não quer dizer que DTT não tenha vantagens. É mais barato que a DST, tanto para transmitir quanto para receber.Terrestre é também mais adequado para transporte ou recepção móvel do que o satélite ou o cabo e, desde que, transmissores digital terrestre usem menos força que transmissores PAL eles poderiam conduzir para integração com serviços de rádio celular.

Crescimento da banda larga por transmissão

Fibra ótica

Desde os finais de 1960 a industria das telecomunicações é capaz de fazer uso da fibra ótica. Cabo de fibra ótica é um desenvolvimento radical na tecnologia de comunicação porque ele transmite fótons (por ex. luz) onde cabos ou fios de telefones transmitem elétrons (ex. eletricidade). Nós temos visto o quanto a tecnologia digital tem aumentado a capacidade de alcance e a eficiência das infra-estruturas de transmissões a cabo e sem cabo existentes. A tecnologia ótica promete uma ainda maior expansão na banda larga da rede de telecomunicações. Cabos de fibra ótica são fios tão finos quanto fios de cabelo, de vidro, altamente transparente através do qual pulsos de luz de um LASER (*Light Amplification by Stimulated Emission of Radiation* - amplificação da luz por emissão de radiação estimulada) são transmitidos. O laser faz uso do fato que, átomos que batem com luz na freqüência certa, são estimulados a liberar um excesso de energia em forma de fótons ou partículas de luz. O sinal eletrônico é digitalmente cifrado e então convertido em pulsos de luz laser por um emissor em que são, então, conduzidos pela fibra para um detector ótico o qual os converte de volta para a forma eletrônica.

A idéia de usar fibra, como um sistema de transmissão, foi sugerida em 1966 por Charles K. Kao, um engenheiro chinês que trabalhava no *Standard Telecommunicatinos Laboratories* (Laboratórios de Telecomunicação Padrão), na Inglaterra, que propôs a possibilidade de converter uma conversa telefônica em pulsos de luz infravermelha que poderiam ser transmitidos através de um fio de vidro puro e então, convertidos novamente em fala. O principal problema técnico era que o vidro precisava ser perfeitamente transparente. Entretanto, dentro de onze anos esse problema tinha sido superado e a primeira conexão de fibra ótica estava operando entre Hitchin e Stevenage em Hertfordshire na Inglaterra.

Recentes tentativas de comunicação ótica foram frustradas devido à necessidade de usar amplificadores eletrônicos ao longo do caminho. Esses amplificadores convertiam os fótons em elétrons impulsionava-os e então os convertia novamente para fótons. Isso constituía um retardo. Esse problema foi solucionado pela equipe da Universidade de Southampton, Inglaterra, com o desenvolvimento de todos os amplificadores óticos. Essa equipe descobriu que introduzindo o elemento érbio em uma fibra de comprimento curto, ela funcionaria como um amplificador. Nos anos 90 todas as conexões óticas usando amplificadores de fibra ótica dopados com érbio estavam implantadas entre Chipre e Israel (261 km) e entre Nápoles e Pomezia, na costa oeste da Itália. Um outro importante melhoramento técnico para a tecnologia de transmissão "fotônica" foi o desenvolvimento do soliton: uma forma de moldar pulsos de luz para evitar dispersão e distorção a longa distância. O mais significativo sobre fibra ótica no que diz respeito à comunicação, é que a luz tem freqüência muito mais alta que a eletricidade e pode carregar maior volume de informação. Na verdade, operando em freqüência muito alta de luz infravermelha os cabos de fibra ótica têm uma ilimitada badwidth e podem realmente carregar muito mais sinais do que pode ser transmitido através do ar em todo o spectrum do rádio. George Gilder chama esse potencial do cabo de fibra ótica de "fibresphere":

> *Considere todas as freqüências de rádio correntemente usadas no ar pelo rádio, televisão, microondas, e satélites de comunicação e multiplique por dois mil. A bandwidth de uma fibra pode carregar mais que duas mil vezes tantas informações quanto todas essas freqüências de rádio e microondas que formam o "ar". Um fio fibra pode suportar, duas vezes mais, o tráfego da rede de telefone durante a hora do pico do dia das mães nos Estados Unidos da América (momento mais congestionado para o sistema de telefonia).*

Pela década de 1990, a taxa de dados de 1.000 Gigabits por segundo, tinha sido alcançada pela fibra ótica e, 82 companhias telefônicas e de cabo no mundo industrialmente desenvolvido levaram vantagem com a tecnologia ótica elevando sua capacidade de sustentar a rede. Pelo meio da década de 1990 a maioria dos países economicamente avançados estavam conectados por cabo ótico submarino e a principal via de tronco de fibra em cada país já está instalada. A interrupção tem ocorrido entre esses troncos e o "local loop" (laço local) em residências e negócios que ainda estão opressivamente conectados por telefone com fios de cobre e, menos, mas que vem aumentando rapidamente em extensão, por linhas coaxiais de companhias de cabo.

Entretanto, a fibra ótica tem algumas desvantagens. Uma delas é que vidro, diferente do cobre, não pode transmitir eletricidade e então pode ser posto fora de ação em queda de força – telefones convencionais continuam funcionando durante a queda de força. Um outro problema é que o custo de conversão de sinais entre domínio elétrico e ótico tende a impossibilitar a comunicação ótica para todos com exceção dos usuários grandes e fortes. O sistema British Telecom´s TPON (*Telecommunication over Passive Optical Networks* – telecomunicação por rede ótica passiva) tem procurado superar isso começando com uma única fibra na troca, a qual é então, progressivamente separada espalhando-se na rede e multiplicando o número de terminações servidas pela mudança da fibra original. Em geral, de qualquer forma, ambos custo e uma falta de percepção do interesse do consumidor têm dificultado a expansão da fibra ótica para as residências.

Conclusão

Nesse capítulo, vimos como a tecnologia de telecomunicações tem experimentado imenso aproveitamento e grande melhoria em sua capacidade e extensão desde a invenção do telégrafo na primeira metade do século dezenove. Por todo esse processo fica a lição de que o conteúdo dos meio não tem necessariamente relação com a tecnologia dos meio empregados para transmiti-lo. No final do século dezenove famílias desfrutaram de entretenimento levado a seus lares através de fios. Famílias no final do século vinte também receberam entretenimento através de fios. Quando o rádio foi inventado em 1896 ele era visto como a pretensão futura da comunicação pessoal. 83 Pela década de 1990, com o desenvolvimento da comunicação móvel digital, a futura comunicação pessoal era novamente conectada a tecnologias sem fio. Ainda no período interveniente *wireless* (sem fio) foi o principal meio para a transmissão de notícias e entretenimento e fios foram usados para a comunicação pessoal.

A convergência de computador digital e o sistema de telecomunicações representam continuidade e troca. A convergência digital pode ser vista, ou como o último estágio num contínuo processo de crescimento tecnológico ou como um novo estágio qualitativo na história da comunicação humana. Tecnologia digital representa uma mudança radical não somente em eficiência e organização da rede de comunicação, mas também, potencialmente em seu papel cultural. Com a tecnologia digital a fidelidade técnica e o alcance da representação dos meios que pode ser transportado para dentro dos lares, decididamente excedem a qualquer coisa que pudesse ter sido imaginada por gerações anteriores de consumidores dos meios de massa. Dada a potência das novas tecnologias de comunicação digital é tentador ver a recente mudança dramática no cenário da mídia como conseqüência desses avanços em tecnologia digital. Contudo no próximo capítulo examinaremos uma proposição de que tem sido muito mais “político” que “força tecnológica” o instrumento de motivação dessas mudanças.

The evolution of networking multimedia IN Wise, Richard. Multimedia: a critical introduction. London: Routledge, 2000. Revisado por Cristina Bocian e Louise Kanefuku

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Volta à página inicial

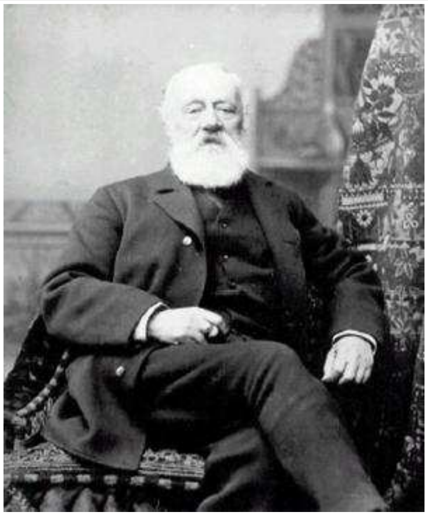
Antonio Meucci

Heroes-villains

The True Inventor of the Telephone?

American children are taught without question that Alexander Graham Bell, a Scottish immigrant invented the Telephone.

However as they progress in school it is often learned that this invention was hotly contested between two rival inventors: the eventual winner Bell, and another man named Elisha Gray. Both men filed for patents on a telephone device on the same day, but while Gray filed a patent caveat (an intention to file a real patent), Bell filed for a full patent. In the end Bell won the case even though his device resembled Gray's more than his own design**.**



Antonio Meucci

Interestingly, this is only part of the story as there is an even older claimant, an Italian that was already developing a speaking telegraph when Alexander Graham Bell was still an infant. His name was **Antonio Meucci** and his brilliance and ingenuity has gone unrecognized for far too long.

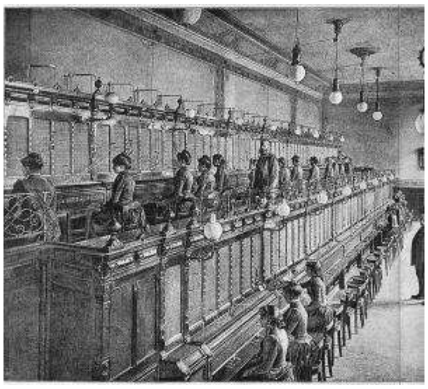
Antonio Santi Giuseppe Meucci, born in Florence in 1808 was a highly inquisitive man and lived a life of constant experimentation. He studied mechanics, drawing, chemistry and physics for six years at the Florence Academy of Fine Arts. Meucci's gift for invention was evident at an early age as he created an improved chemical propellant for fireworks when he was eighteen. While working at Florence's Pergole Theatre, Meucci met his future wife, a seamstress named Ester Mochi and they soon married. Due to his involvement in the Italian reunification movement, Meucci was constantly under surveillance by the Grand Duchy of Tuscany's police forces and so immigrated to Havana, Cuba in 1835 to work as the Superintendent of Mechanics at the Tacon Theatre.

While living in Havana Meucci started experimenting with electricity including electroplating experiments and even a crude form of Electro-shock therapy he used to treat patients with headaches. It was during one of these experiments with electricity that he came up with a device that would change the world: his speaking telegraph, or as he called it the **Teletrofono**.

It all started when Meucci heard a patient's voice coming through an electrically charged copper wire he was using for one of his treatments. This discovery immediately piqued his interests and he started experimenting with voice communication over wire in 1849. By 1850, he decided to move to New York to better exploit his new discoveries - and to escape the watchful eyes of the Spanish Governor of Cuba. Being both a supporter of liberty and a confirmed Freemason made Meucci a dangerous person in the eyes of the Pro-Spanish Government of Cuba and so left for the United States even though he could hardly speak English.

Here it was born : Antonio Meucci Inventor of the Telephone

Meucci arrived in Staten Island, New York at the same time that the hero of Italian reunification movement, **Giuseppe Garibaldi** also landed in the city. The two became fast friends, both sharing ideas on liberty and a desperate need for cash. Even though he arrived fairly wealthy, Meucci gave much away to Italian refugees and in support of Garibaldi. Meucci quickly got to work finding a way to make an honest living for himself and the growing Italian immigrant community and came up with America's first smokeless candle at his New York Paraffin Candle Company. It did not make him rich, but it allowed for Meucci's continued experimentation with his Teletrofono, that is until much of this money and property was lost after being swindled by false creditors.



Old Telehone Exchange from 1892

A tragic case of rheumatoid arthritis crippled his wife Ester, but necessitated the creation of a working prototype of his invention in order to communicate with her within his home. Just when it seemed that Meucci was about to become a household name, even more tragedy struck as a Staten Island ferry explosion would leave him hospitalized and further impoverished. After recovering, he would discover that Ester had sold off his prototypes in order to keep away from complete bankruptcy. Meucci was devastated, but still persevered and in 1871 he borrowed twenty dollars in order ensure a patent caveat since he could no longer afford to register an official US patent. Even though Meucci beat both Gray and Bell by nearly five years, it was his inability to afford a full-fledged patent as well as his poor English that allowed his ideas to be at the least, neglected and at the worst, stolen.

In an attempt to make his invention known and to produce patents in the US and Europe, Meucci found three financial backers and founded the Teletrofono Company in 1871. Unfortunately for Meucci, the group split a year later without success short of renewing his patent caveat. Once again short of funds but undaunted, Meucci approached an affiliate of the Western Union Telegraph Company in order to test his designs on their lines. After two years, all Antonio Meucci had to show for this effort were delays, excuses and the eventual disappearance of his materials. Meucci was now left without the funds ($20) to renew his caveat for 1874, his materials were most likely stolen, and he never even got to test his design. When Alexander Graham Bell finally filed his patent in 1876, Meucci's patent caveat was two years expired, making his battle for recognition even more difficult.

In the years after receiving the patent, Bell was subject to numerous lawsuits by claimants to the invention of the telephone, including Antonio Meucci and later the US Government. After years of delays, The United States Government vs. The American Bell Telephone Co. and Alexander Graham Bell was started in 1886 but further complicated by countersuits brought against Meucci by the wealthy Bell. However through his descriptions (given by an interpreter), over 24 affidavits (including one from the man who bought his models from his wife), a copy of his original caveat and models he was able to construct, Meucci gave a very strong argument. However it has been reported that the judge in the case was a shareholder in Bell's company and delayed the outcome of the case year after year until Meucci's death in 1889. The Government kept up the case, still upholding that Meucci was the true inventor of the telephone until 1897 when it was finally closed without a decision. The case was later appealed to the Supreme Court by the Globe Telephone Company to uphold Meucci's claim but was dismissed in 1892.

Until recently, Antonio Meucci has been neglected by nearly all, mere footnotes in the fields of Science and Italian history. His house on Staten Island is more known for Garibaldi than Meucci and his contributions have mostly gone unnoticed. Hopefully that is starting to change as in **2002 the US Congress passed Resolution 269, finally recognizing Antonio Meucci as the true inventor of the Telephone.** The genius of Meucci should be rightfully acknowledged not only as a telecommunications pioneer, but also as a great Italian who deeply cared for his countrymen and supported a unified and free Italy.

By Justin Demetri

For More Information on Antonio Meucci:

- Garibaldi-Meucci Museum
- Basilio Catania's Meucci FAQ:
- Italian Historical Society of America:

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6-20-02

News Flash: U.S. House of Representatives Says Alexander Graham Bell Did Not Invent the Telephone

By HNN Staff

"Bell, Alexander Graham (b. Edinburgh, Scotland, 1847; d. Cape Breton, Nova Scotia, 1922), inventor of telephone."
Dictionary of American Biography

***"Resolved*, That it is the sense of the House of Representatives that the life and achievements of Antonio Meucci should be recognized, and his work in the invention of the telephone should be acknowledged."**
United States House of Representatives, June 11, 2002

On June 11, to little fanfare, the United State House of Representatives declared that the telephone was invented by an Italian-American named Antonio Meucci, a sausage and candle maker. Forget Alexander Graham Bell. The House declared that Bell's patent for the telephone was based on "fraud and misrepresentation."

News of the House resolution was slow to circulate. When the media contacted the curator of the Bell Homestead Museum in Brantford, Ontario, he said he was surprised. He hadn't heard of the resolution. In Italy the news was greeted warmly, an Italian paper referring to "Bell as an impostor, profiteer and a 'cunning Scotsman' who usurped Meucci's spot in history, while Meucci died poor and unrecognized."

Is it true that Meucci not Bell invented the telephone? HNN asked Robert Bruce, the Pulitzer-Prize winning biographer of Bell, to comment on the House action. Bruce tersely dispatched the Meucci claim. "It's ridiculous," he said.

Meucci claimed that "by means of some little experiments, I came to discover that with an instrument placed at the ear and with the aid of electricity and a metallic wire, the exact word could be transmitted holding the conductor in the mouth." Bruce says he was deluded. Meucci's patent, says Bruce, was "essentially the same as connecting two tin cans with a string."

Italian-Americans have long claimed that Meucci had been cheated of the honor as the telephone's inventor. Only one historian, however, took his claims seriously, Giovanni E. Schiavo, in a book published in 1958. Bruce says that Meucci not only failed to invent the telephone, he "did not understand the basic principles of the telephone either before or after Bell's invention."

The resolution honoring Meucci was introduced by Staten Island Representative Vito Fossella. Fossella, claiming he based the resolution "on our study of historical records," said he pressed for its passage "to honor the life and achievements long overdue of Antonio Meucci, a great Italian American and a former great Staten Islander."

The House allotted forty minutes to debate the measure. Five members of Congress spoke in favor; none spoke against. The resolution was approved by voice vote.

EXCERPTS

Mr. Fossella Mr. Speaker, it is my strong belief that Italian Americans have contributed greatly to the United States and continue to contribute proudly as well. We know Columbus discovered America. Two Italians signed the Declaration of Independence. Enrico Fermi split the atom, and Captain Don Gentile, the fighting ace, was described by General Dwight Eisenhower as a ``one-man force.'' He, like so many other Italian-Americans, did and were willing to give their life in defense of freedom and liberty and supporting these great United States. Mr. Speaker, I wanted to spend a few minutes today to honor an Italian American and former Staten Island resident who is often overlooked, as announced already, and his name was Antonio Meucci.

Mr. Pascrell Mr. Speaker, first I want to commend my good friend, the gentleman from New York (Mr. Fossella). How refreshing it is to talk about an Italian American out of the Hollywood spotlight and an Italian American not recognized. If only we took the time in this society to deal with all ethnics, people of all racial persuasions in fairness, and that is what this resolution is all about: Fairness, honesty, breaking the stereotypes that many of us have learned; in fact, probably, taught without our even knowing.

Mr. Fossella Mr. Speaker, I just wanted to add and commend the two gentlemen, the gentleman from Illinois (Mr. Davis) and especially the gentleman from New Jersey (Mr. Pascrell) for a very strong and passionate defense in support of the life of a great American and great inventor and merely add to the course, so to speak, that he was emblematic and remains so as a representative of all those who have come to this country to seek a better life and an opportunity and, in particular, to those Americans of Italian descent who have and will continue to make this the greatest country in the history of the world and in a small way and a long overdue way but in a small measure. I would ask my colleagues to support it.

Mr. Israel Antonio Meucci was a brilliant inventor but a poor businessman. Despite his lack of success in business, he most certainly invented the telephone. He is honored in my district with a road named for him in Copiague. I am proud that we, the entire House of Representatives, today will honor this man who has been overlooked by history for too long.

Ms. Jackson-Lee of Texas Mr. Speaker, I add my voice to the praise and honor of Antonio Meucci who, through his work toward the invention of the telephone, has brought the world together as few others have. Through his ingenuity and perseverance, this Italian-American changed the way the world communicates, although as a newcomer to America, he was often thwarted by his own inability to communicate with those who could have, and should have given him the recognition he deserved.

HRES 269 EH

H. Res. 269

In the House of Representatives, U.S.,

June 11, 2002.

Whereas Antonio Meucci, the great Italian inventor, had a career that was both extraordinary and tragic;

Whereas, upon immigrating to New York, Meucci continued to work with ceaseless vigor on a project he had begun in Havana, Cuba, an invention he later called the `teletrofono', involving electronic communications;

Whereas Meucci set up a rudimentary communications link in his Staten Island home that connected the basement with the first floor, and later, when his wife began to suffer from crippling arthritis, he created a permanent link between his lab and his wife's second floor bedroom;

Whereas, having exhausted most of his life's savings in pursuing his work, Meucci was unable to commercialize his invention, though he demonstrated his invention in 1860 and had a description of it published in New York's Italian language newspaper;

Whereas Meucci never learned English well enough to navigate the complex American business community;

Whereas Meucci was unable to raise sufficient funds to pay his way through the patent application process, and thus had to settle for a caveat, a one year renewable notice of an impending patent, which was first filed on December 28, 1871;

Whereas Meucci later learned that the Western Union affiliate laboratory reportedly lost his working models, and Meucci, who at this point was living on public assistance, was unable to renew the caveat after 1874;

Whereas in March 1876, Alexander Graham Bell, who conducted experiments in the same laboratory where Meucci's materials had been stored, was granted a patent and was thereafter credited with inventing the telephone;

Whereas on January 13, 1887, the Government of the United States moved to annul the patent issued to Bell on the grounds of fraud and misrepresentation, a case that the Supreme Court found viable and remanded for trial;

Whereas Meucci died in October 1889, the Bell patent expired in January 1893, and the case was discontinued as moot without ever reaching the underlying issue of the true inventor of the telephone entitled to the patent; and

Whereas if Meucci had been able to pay the $10 fee to maintain the caveat after 1874, no patent could have been issued to Bell: Now, therefore, be it

> *Resolved*, That it is the sense of the House of Representatives that the life and achievements of Antonio Meucci should be recognized, and his work in the invention of the telephone should be acknowledged.

Attest:

Clerk.

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NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
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BIOGRAPHICAL MEMOIR

OF

ALEXANDER GRAHAM BELL

1847–1922

BY

HAROLD S. OSBORNE

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1943

FROM A PHOTOGRAPH TAKEN IN 1876, THE YEAR IN WHICH
THE TELEPHONE WAS PATENTED

It was the intention that this Biographical Memoir would be written jointly by the present author and the late Dr. Bancroft Gherardi. The scope of the memoir and plan of work were laid out in cooperation with him, but Dr. Gherardi's untimely death prevented the proposed collaboration in writing the text.

The author expresses his appreciation also of the help of members of the Bell family, particularly Dr. Gilbert Grosvenor, and of Mr. R. T. Barrett and Mr. A. M. Dowling of the American Telephone & Telegraph Company staff. The courtesy of these gentlemen has included, in addition to other help, making available to the author historic documents relating to the life of Alexander Graham Bell in the files of the National Geographic Society and in the Historical Museum of the American Telephone and Telegraph Company.

ALEXANDER GRAHAM BELL

1847–1922

BY HAROLD S. OSBORNE

Alexander Graham Bell—teacher, scientist, inventor, gentleman—was one whose life was devoted to the benefit of mankind with unusual success. Known throughout the world as the inventor of the telephone, he made also other inventions and scientific discoveries of first importance, greatly advanced the methods and practices for teaching the deaf and came to be admired and loved throughout the world for his accuracy of thought and expression, his rigid code of honor, punctilious courtesy, and unfailing generosity in helping others.

The invention of the telephone by Alexander Graham Bell was not an accident. It came as a logical result of years of intense application to the problem, guided by an intimate knowledge of speech obtained through his devotion to the problem of teaching the deaf to talk and backed by two generations of distinguished activity in the field of speech.

Bell's grandfather, Alexander Bell (born at St. Andrews, Scotland, 1790, died at London, 1865) achieved distinction for his treatment of impediments of speech, also as a teacher of diction and author of books on the principles of correct speech and as a public reader of Shakespeare's plays. Young Alexander Graham Bell, at the age of 13, spent a year in London with his grandfather. He was already interested in speech through his father's prominence in this field, and this visit stimulated him to serious studies. Bell afterwards spoke of this year as the turning point of his life.

Bell's father, Alexander Melville Bell (born in Edinburgh, Scotland, 1819, died at Washington, 1905), was for a time professional assistant to Alexander Bell, then he became lecturer on elocution in the University of Edinburgh. He developed "Visible Speech," a series of symbols indicating the anatomical positions which the speaking organs take in uttering different sounds. This won him great distinction and, with improvements made by Alexander Graham Bell, is still a basis for teaching the deaf to talk. On the death of his father in 1865, Melville Bell moved to London, to take over his professional practice. He also became lecturer on elocution at University College and achieved distinction as a scientist, author and lecturer on both sides of the Atlantic.

In 1844 he married Miss Eliza Grace Symonds, daughter of a surgeon of the Royal Navy, a talented musician.

Alexander Graham Bell, the second of three sons of Melville Bell, was born March 3, 1847, in Edinburgh. From his mother, he inherited musical talent and a keen musical ear. He took lessons on the piano at an early age and for some time intended to become a professional musician.

His father's devotion to the scientific study of speech had an early impact on the boy. "From my earliest childhood," said Alexander Graham Bell, "my attention was specially directed to the subject of acoustics, and specially to the subject of speech, and I was urged by my father to study everything relating to these subjects, as they would have an important bearing upon what was to be my professional work. He also encouraged me to experiment, and offered a prize to his sons for the successful construction of a speaking machine. I made a machine of this kind, as a boy, and was able to make it articulate a few words." This early illustrates his energy, his ambition, and his inventive ingenuity.

Always an individualist, Bell decided at the age of 16 to break away from home and teach. His first position was pupil-teacher in Weston House Academy, a boys' school at Elgin, Scotland. After a year here he returned to the University of Edinburgh for a course in classical studies and then returned to the Academy a year later as teacher of elocution and music. His scientific curiosity, a prominent characteristic throughout his life, is illustrated by his studies, made at this early age, of the resonance pitches of vowels. Placing his mouth in position for the utterance of various vowel sounds, he was able to develop two distinct resonance pitches for each vowel, tapping with a finger a pencil placed on the throat or on the cheek. The young man transmitted a lengthy account of his researches to his father and through him to Alexander John Ellis, President of the London Philological Society. Through Ellis, Bell learned that similar experiments had long before been made by Helmholtz with the aid of electromagnetically controlled tuning forks. Unable to repeat Helmholtz' experiments at the time because of insufficient electrical knowledge, he determined to study electricity, including its principal application, telegraphy, for he felt it was his duty as a student of speech to study Helmholtz' researches and repeat his experiments.

In 1868, Alexander Graham Bell took over his father's professional engagements in London while Melville Bell gave lectures in America. Entering into the opportunities of this life in London with characteristic energy and enthusiasm, he was launched on a career of feverish activity with a heavy program of teaching, lecturing, studying and experimenting.

At about this time, tragedy struck the Bell household. In 1867, Bell's younger brother had died of tuberculosis. In 1870 his older brother died of the same cause. The health of Alexander Graham Bell himself became seriously impaired under the strain of his active career. Melville Bell acted swiftly to save his only remaining son. He gave up his professional career in London and in the summer of 1870 moved to the "bracing climate" of America. He settled in Brantford, Ontario, for what was intended to be a two-year trial period.

In the new environment, Alexander Graham Bell's health rapidly improved, so much so that in 1871 his father suggested that he be invited to Boston to fill a request for lectures on visible speech to teachers of the deaf. The invitation was given and accepted.

The success of these lectures, which began in April, 1871, led to a succession of engagements and to the rapid establishment of Bell in Boston as a leader in the field of teaching the deaf to speak. Shortly after taking up this work, Bell was entrusted with the entire education of Mr. Thomas Sanders' five-year-old son George, who was born deaf, and a year or two later, Mr. Gardiner G. Hubbard of Boston brought to Bell his sixteen-year-old daughter, Mabel, deaf since early childhood, for instruction in speech. These associations were destined to have a profound influence on Bell's life.

While in Brantford (August, 1870-March 1871) and later in Boston, Alexander Graham Bell continued his studies of Helmholtz' electrical experiments. Working with electrical circuits controlled by tuning forks led Bell to consider the invention of the harmonic telegraph, that is, a telegraph system making possible a number of simultaneous transmissions over the same wire by the use of different frequencies of interruption of the electric current. The idea was not novel with him, for the harmonic telegraph had for some time lured inventors with the promise of rich reward. Bell believed that his experiments gave him the clue to important improvements in this system and by 1873 he was working hard on this invention.

At that time all experiments on the harmonic telegraph were made with interrupted electrical current, e.g., with circuits in which electrical impulses were produced by alternately opening and closing the circuit. The interrupted current, acting upon a mechanically resonant receiving device, such as a reed, properly tuned, would cause it to vibrate. When the effort was made, however, to achieve harmonic telegraphy by operating simultaneously over the same circuit a number of devices of this sort using different frequencies, inventors, including Bell, found great and unexpected difficulties.

During this period, Bell's intense experimental activities were by no means confined to the harmonic telegraph. His profession was teaching the deaf to speak. His imagination was fired with the idea that if deaf children could "see" speech as it is spoken they might be taught more easily to articulate. With this in mind he worked with the manometric capsule of Koenig, a device which produces a band of light with an outline pattern corresponding to the sound pattern spoken into it; and with the phonautograph, which scratches a pattern on smoked glass conforming with the pattern of the sound spoken before it. His idea was to prepare standard patterns of the various sounds with the phonautograph and have the deaf children enunciate into the manometric capsule until they could produce light patterns identical with the standards. He built a number of phonautographs of his own. For one he used an actual human ear provided by Dr. Clarence J. Blake, a distinguished aurist of Boston whom he had consulted in the matter. While these experiments failed in their direct aim they later were given credit by Bell for suggesting to his mind the great conception of a speaking telephone with a single vibrating membrane.

Other inventors had worked on the problem of transmitting speech electrically but had found no way to do it. Bourseul in 1854, had proposed it, but offered no solution of the problem. About 1861 Philip Reis (in Germany) had produced a device in which, by very rapid interruptions of the current in a circuit, an iron rod surrounded by a coil of wire at the receiving end was made to vibrate and thus a musical tone was produced. Reis called his device a telephone. It was, of course, not a telephone in the present sense of the word, as the interrupted current was far too crude a medium for the transmission of speech.

By the summer of 1874, Bell had achieved the conception that "It would be possible to transmit sounds of any sort if we could only occasion a variation in the intensity of your current exactly like that occurring in the density of the air while a given sound is made." It also occurred to Bell that this variation of the current could be caused by the movement of a single steel reed in a magnetic field if some way could be found to move it in the same way as the air is moved by the action of the voice. Speaking later of his phonautograph constructed from the human ear, he said, "I was much struck by the disproportion in weight between the membrane and the bones that were moved by it; and it occurred to me that if such a thin and delicate membrane could move bones that were, relatively to it, very massive indeed, why should not a larger and stouter membrane be able to move a piece of steel in the manner I desired? At once the conception of a membrane speaking telephone became complete in my mind." At the moment, however, Bell did not know how to reduce this conception to practice. While he knew that the motion of iron in a magnetic field would produce magneto-electric currents, he had the idea that "magneto-electric currents, generated by the action of the voice alone" would be too feeble to produce audible effects from a receiving telephone.

In this critical time in Bell's thinking about his great invention occurred the famous meeting between Bell and Joseph Henry. On March 2, 1875, Bell had occasion to visit Washington in connection with his harmonic telegraph patents. Bell had a letter of introduction to Professor Henry, who was then nearly 80, Secretary of the Smithsonian Institution and dean of American scientists. Bell described his experiments on the harmonic telegraph to an attentive ear. One experiment so aroused Henry's interest that Bell brought his apparatus to the Institution the next day and Henry spent much time experimenting with it. A few days later, Bell wrote to his parents, "I felt so much encouraged by his interest that I determined to ask his advice about the apparatus I have designed for the transmission of the human voice by telegraph. I explained the idea and said, 'What would you advise me to do—Publish it and let others work it out—or attempt to solve the problem myself?'

"He said he thought it was 'the germ of a great invention'—and advised me to work at it myself instead of publishing.

"I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to overcome the difficulties. His laconic answer was—'*Get it.*'

"I cannot tell you how much these two words have encouraged me. . . . Such a chimerical idea as telegraphing *vocal sounds* would indeed to most minds seem scarcely feasible enough to spend time in working over.

"I believe, however, that it is feasible, and that I have got the cue to the solution of the problem."

In spite of this encouragement, for several months the idea of the telephone was pushed into the back of Bell's mind. During the hours that could be snatched from his professional work he was working on his invention of the harmonic telegraph which his financial backers, Gardiner G. Hubbard and Thomas Sanders, were anxious to have completed at the earliest possible date. On June 2, while he was engaged in this work with his assistant, Thomas A. Watson, one of the transmitting reeds became out of adjustment so that when plucked it did not interrupt the circuit but merely vibrated before its associated electromagnet without opening the contacts. Bell's musical ear and trained observation caused him to note at once the different quality of the sound produced by the vibration of the corresponding reed at the receiving end. He immediately investigated the cause of this change. He was surprised and delighted to find that without interruption of the circuit the inductive effect of the vibrating reed at the sending end produced enough current to cause the receiving end to vibrate audibly. "These experiments," he said, "at once removed the doubt that had been in my mind since the summer of 1874, that magneto-electric currents generated by the vibration of an armature in front of an electro-magnet would be too feeble to produce audible effects . . ." Immediately he felt that he had the key to the fulfillment of his long cherished dream of the electrical speaking telephone. Before the night was over he had made sketches for the first models and asked Watson to build them without delay.

The following months were difficult for Bell. His inventive interest was centered on his hopes for realizing the electrical transmission of speech, hopes which were aroused to a high pitch. But his time was fully committed elsewhere. Hubbard and Sanders had financially backed his invention of the harmonic telegraph, and he felt obligated to press forward with that project. Nevertheless he found time, by great exertion and excessively long hours, to work on his new idea. The first models did not prove satisfactory and successive modifications were made. At last, early in July, while Bell and Watson were testing a new pair of models, Watson rushed upstairs in great excitement to tell Bell that "He could hear my voice quite plainly, and could almost make out what I said." This was enough to convince Bell that he was on the right track.

The pressure of this program proved too much for Bell's health, and in August he was obliged to return to his father's home in Brantford to recuperate. While there he began writing his patent specifications covering his conception of the undulatory current. Here also he continued his telegraph experiments, especially on means of quenching sparks at contacts. For this purpose he devised a variable water resistance to bridge the contact points. It was this work that suggested the first form of variable resistance transmitter, later used when the first complete sentence was transmitted electrically.

On his return to Boston, Bell's time was largely taken up with the organization and conduct of a normal class for the instruction of teachers of the deaf and with lectures at the Boston University. Now engaged to Hubbard's daughter, he was reluctant to call on his backers for further financial assistance and felt that he should insure adequate support from his teaching before resuming his electrical experiments. He wrote Mabel Hubbard at this period that he would be glad when his plans for the normal class were completed, "for my mind will then be free to bend all its energies upon telegraphy." With his normal class well under way, Bell's time was taken up with the completion of his telephone patent applications and visits to his attorneys in Washington. After his patent was allowed, March 3, 1876 (issued on March 7, 1876), Bell returned to Boston and a few days later, March 10, 1876, transmitted the first sentence ever sent over wires electrically, using the liquid transmitter suggested by his telegraph experiments.

The fertility of Bell's genius is illustrated by the breadth and scope of the first two patents relating to the telephone. They cover the broad conception of the undulatory rather than the interrupted current as applied both to harmonic telegraphy and to the speaking telephone. They cover the production of the undulatory current both by magnetic induction (vibrating iron before a magnet on which a coil of wire has been placed) and by varying a resistance (as is done in the modern transmitter). They cover telephones with a non-magnetic diaphragm to which a piece of iron has been attached, as in Bell's original models, and with iron or steel diaphragms which Bell quickly found to be more effective.

In 1883 a journalist wrote, "The issuance of Bell's patent on March 7, 1876, attracted little or no attention in the telegraphic world. The inventor was practically unknown in electrical circles, and his invention was looked upon, if indeed any notice at all was taken of it, as utterly valueless."

A lively interest in Bell's invention, however, quickly arose in scientific circles. It was stimulated by the successful demonstration of the telephone at the International Centennial Exposition at Philadelphia, to a committee of judges including Sir William Thomson, Joseph Henry and other prominent scientific men. As a result of this demonstration on June 25, 1876, Bell was given a Certificate of Award. Sir William Thomson wrote later of the telephone, "This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of invention which has devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound."

The telephone was described and demonstrated before the American Academy of Arts and Sciences in Boston on May 10, 1876. Demonstrations followed in rapid succession in Boston later on in May, at Brantford in August, between Boston and Cambridge in November. On November 26, Bell talked from Boston with Watson who was in Salem 16 miles away, "the greatest success yet achieved," Bell wrote Mabel Hubbard. On December 3, there was a similar demonstration between Boston and North Conway, New Hampshire, a distance of 143 miles. Other demonstrations and lectures followed.

After the issuance of his second telephone patent, in January, 1877, Bell spent a few months on lectures, demonstrations and experiments. He married Mabel Hubbard July 11 and with her left in August for an extended trip to England to interest English capital in the new invention. On March 5, 1878, he wrote a letter outlining for the British capitalists his ideas of the future usefulness of his scientific toy. To quote merely a single paragraph of this remarkable document:

". . . it is conceivable that cables of Telephonic wires could be laid under-ground or suspended overhead communicating by branch wires with private dwellings, counting houses, shops, manufactories, etc., etc., uniting them through the main cable with a central office where the wires could be connected together as desired, establishing direct communication between any two places in the City. Such a plan as this though impracticable at the present moment will, I firmly believe, be the outcome of the introduction of the Telephone to the public. Not only so but I believe that in the future wires will unite the head offices of Telephone Companies in different cities and a man in one part of the Country may communicate by word of mouth with another in a distant place."

By the middle of 1877, the telephone was put into commercial use in this country under the skillful direction of Mr. Gardiner G. Hubbard. Its immediate commercial success led to a flood of litigation over the Bell patents which lasted throughout their life. A part of this arose from mere fraud, inspired by the great value of the invention. Much of it centered about the fact that other competent men had been interested in this great problem, and had come near to solving it. But the end result of all this welter of litigation was that Bell was upheld as the inventor of the telephone because he was the first to conceive and apply the crucial idea of the undulatory current, in contrast to the older art of interrupted current. As stated in the controlling court decision, an opinion of the Supreme Court of the United States delivered by Chief Justice Waite: "It had long been believed that, if the vibrations of air caused by the voice in speaking could be reproduced at a distance by means of electricity, the speech itself would be reproduced and understood. How to do it was the question. Bell discovered that it could be done by gradually changing the intensity of a continuous electric current, so as to make it correspond exactly to the changes in the density of the air caused by the sound of the voice. This was his art. He then devised a way in which these changes of intensity could be made and speech actually transmitted. Thus his art was put into condition for practical use."

On his return to America in November, 1878, Bell was obliged to give a great deal of time to testifying in these patent suits in defense of his inventions. A man of scrupulous honesty, careful to avoid credit for anything which was not his due, Bell naturally found it distasteful in the highest degree to be subjected on the witness stand to repeated charges of fraud and misrepresentation. He recognized the importance of these suits, however, and fully carried out his obligation to defend his patents. His masterly testimony in the numerous cases was of greatest importance in bringing about the successful outcome.

In addition to testifying in the numerous patent suits, Bell also, acting in a consulting capacity for the telephone companies, made various suggestions for the development of the telephone system and called attention to any developments which he thought might profitably be applied. He wrote in May, 1880, of his success in transmitting sound to a maximum distance of 800 feet using a beam of light and a selenium cell. He asked the company to take out a patent immediately. "If not, I wish to be permitted to publish an account of this discovery at once in some of the leading scientific periodicals."

His interests, however, were much broader than telephony, and the breadth of these interests led him to turn his attention into other fields as rapidly as his obligations to the developers of the telephone made this possible. As leisure and wealth came to him from his telephone invention, it became possible for him to devote his time to researches in numerous subjects which interested him and which gave opportunity for further service to mankind.

Running through all of Bell's adult life is his interest in improving the teaching of the deaf. This began even before he left London, and in this country as early as 1871 he accepted engagements in Boston to explain the application of his father's system of visible speech to teaching the deaf and dumb to talk. At that time, deaf children were generally taught to speak among themselves by sign language. Many leading authorities considered that it was impracticable and a waste of time to try to teach speech to the deaf and dumb—it was even commonly supposed that their organs of speech had been impaired. At one time Bell, as well as his father, had held, as he expressed it, "an obstinate disbelief in the powers of lip reading." Later he became convinced of these powers, partly perhaps through the ease with which he could converse with Mabel Hubbard, who had become adept at lip-reading.

Characteristically, when Bell recognized his misconception he was quick to correct it in an active way. As early as 1872 he began a crusade for recognizing the intellectual possibilities of deaf children and for teaching them to speak and read lips rather than being content to teach them sign language. His influence spread rapidly, helped by the success of his application of visible speech to teaching the deaf to talk. On January 24, 1874, he addressed the first convention of Articulation Teachers of the Deaf and Dumb and he continued to take an active part in this and other organizations of a similar nature. While this work was interrupted in the years 1875 to 1878 by his activities on the telephone and associated inventions, he threw himself into the work again on his return to America in 1878.

In 1880, he received the Volta Award of 50,000 francs for his invention of the telephone. With this he founded the Volta Laboratory Association (later the Volta Bureau), which was largely devoted to work for the deaf. In 1883, after an exhaustive study, he presented before the National Academy of Sciences a memoir: "Upon the formation of a deaf variety of the human race." In this he traced the eugenic dangers of the enforced segregation of deaf people which resulted from teaching them sign language rather than teaching them to speak and read lips. In 1884, he made a plea before the National Education Association for the opening of day schools for the deaf as one means of reducing this danger.

There were tendencies for the proponents of sign language and of articulation to break into two hostile camps. However, Bell's conciliatory policy held the group together and led in 1890 to the organization of the American Association to Promote the Teaching of Speech to the Deaf. Bell was President of this organization and heavily supported its work, giving a total of more than $300,000.

In 1888, at the invitation of the Royal Commission appointed by the British government to study the condition of the deaf, Bell gave exhaustive testimony before them based upon his experience and upon an extensive study of conditions in America. He was appointed an expert special agent of the Census Bureau to arrange for obtaining adequate data regarding the deaf in the census of 1900 in this country and devoted large amounts of time to this work at great personal sacrifice. It is not surprising that at the World's Congress of Instructors of the Deaf held in Chicago in 1893, Dr. Bell was held as the man to whom "*more than any other man* not directly connected with the work, we are indebted for the great advance made in teaching speech to the deaf, and in the establishment of oral schools of instruction throughout the country."

Among the honors received by Dr. Bell, some of those which touched him the most were the naming for him of several schools for the deaf. Among his many honorary degrees, Harvard College in 1896 gave him LL.D. for his scientific achievements and work for the deaf child.

Bell's work on the eugenic dangers of the enforced segregation of deaf people led him into pioneer work in the general field of eugenics which, throughout his life, continued to be one of his important interests. In 1918 and 1919 he published the results of extensive studies of longevity and of the betterment of the human race by heredity. In 1921 he was made Honorary President of the Second International Congress of Eugenics at New York City. During the last 30 years of his life he carried on continuously breeding experiments with sheep, leading towards the development of a more prolific breed. These experiments are still going on with the original line in Middlebury, Vermont, with encouraging results.

In spite of all these accomplishments, Bell's incessant activity gave him time to apply his genius with profit to other fields. One of the most important of Bell's inventions outside of the telephone field resulted directly from the Volta prize. Bell's interest in speech led to the development by the Volta Laboratory of the engraving of wax for phonograph records, applicable to both the cylindrical and flat disk forms. A fundamental patent was obtained on this now generally used type of record. It is of interest to note that one of the original records developed by Bell and his associates, which was deposited at the Smithsonian Institution in 1881 in a sealed package, with instructions that it should be opened in 50 years, was recently played in the presence of Mr. Bell's daughters and of interested scientists.

Another invention of importance was the telephone probe, an adaptation of the telephone and the electric circuit, to determine the location of a bullet or metallic masses in the human body. In recognition of this, and other inventions, the University of Heidelberg gave him the honorary degree of M. D. in 1886.

Nothing better illustrates Bell's independence of thought than his staunch support of aviation at a time when it was considered so quixotic a subject that Bell risked his scientific reputation in so doing. As Lord Kelvin wrote to Mrs. Bell in 1898, "When I spoke to him on the subject at Halifax, I wished to dissuade him from giving his valuable time and resources to attempts which I believed, and still believe, could only lead to disappointment, if carried on with any expectation of leading to a useful flying machine."

In 1891 Bell contributed $5,000 for Langley's aviation experiments. On May 6, 1896, he saw the successful flight of Langley's steam-driven 16 foot model, which, however, did not carry a man. Speaking of this experience later, he said, "The sight of Langley's steam aerodrome circling in the sky convinced me that the age of the flying machine was at hand."

In 1898, Bell was elected a Regent of the Smithsonian Institution. His enthusiasm for Langley's experiments with small-scale models of a flying machine had much to do with obtaining from the War Department an appropriation of $50,000 to be used by Langley for the development of aeronautics.

Langley's full scale model, carrying a pilot, fell into the Potomac on its trial in 1903, and the whole project dissolved in ridicule. However, soon after this the Wright brothers made their epochal flight at Kitty-Hawk, the first man-carrying flight of a controlled airplane. These events further confirmed the abiding interest in aviation of Alexander Graham Bell.

For years Bell had been studying the flight of kites at his summer home, Beinn Bhreagh, in Cape Breton Island on the Bras D'Or. This he considered the best approach to the problem of aviation. By 1901 he was working with a tetrahedral form of kite structure, a form which gave stability. This work was greatly expanded in the following years. Giant kites of multicellular, tetrahedral form were built and flown. In 1907 his huge kite Cygnet I, towed across Baddeck Bay carrying Lieutenant Selfridge, rose to a height of 168 feet.

While Bell's tremendous experimentation in this field was without direct application to aeronautics, indirectly it was of importance. It led Mr. and Mrs. Bell to become patrons of aeronautical research and greatly to advance aviation in this way. In connection with his experimental work, Bell attracted to his home at Beinn Bhreagh a group of talented young men devoted to aviation. In October, 1907, he entered into an agreement with these men for their joint production of experiments on "aerial locomotion," "all working together individually and conjointly in pursuance of their common aim to get into the air by the construction of a practical aerodrome driven by its own motive power and carrying a man." This organization was named the Aerial Experiment Association, and its work was financed by Mrs. Bell. The Association included Bell, Glenn H. Curtis, F. W. Baldwin, J. A. D. McCurdy, and Lieut. T. Selfridge. Bell was chairman.

The Aerial Experiment Association, during its one and one-half years of activity, principally at Hammondsport, N. Y., made important contributions to the development of aviation. In March 1908, their first machine, piloted by "Casey" Baldwin, made an important public flight, rising 10 feet above Lake Keuka for a distance of over 300 feet. One of the achievements of this flight was a demonstration of the aileron as an improvement over the wing-warping method previously used by the Wrights for obtaining stability. The aileron is fundamental to all airplane construction today. The second machine of the Association introduced the doped fabric which played so important a part as a wing cover through 20 years of the development of flying. The third machine, designed by Curtis, flew so well that it was entered for the *Scientific American* trophy for the first public flight of one kilometer, straightaway. The flight was made July 4, 1908, and the trophy won. The fourth machine of the Association used balloon fabric for the wings and proved very successful. In the winter of 1909, McCurdy made repeated flights at Beinn Bhreagh, sometimes doing nine miles at a stretch. The Association was dissolved at midnight March 31, 1909, with a resolution by the members "that we place on record our high appreciation of her (Mrs. Bell's) loving and sympathetic devotion without which the work of the Association would have come to naught."

As in the case of his work on the telephone, Bell's activity for the advancement of aviation was stimulated by a prophetic vision of the future importance of developments in this field. In 1908, asked by the editor of *Century* to comment on proofs of an article by E. C. Stedman entitled "The Prince of the Power of the Air," Bell wrote: "While, of course, the bird is Nature's model for the flying-machine heavier than air, Mr. Stedman is undoubtedly right in looking upon the fish as the true model for the dirigible balloon. It is certainly noteworthy that the dirigible war-balloon of today already approximates the fish-like form predicted by him. He is also right I think in supposing that of all the nations in the world the interests of Great Britain will be most vitally affected by progress in aeronautics. For it is obvious that sea-power will become of secondary importance when air-power has been fully developed through the use of dirigible balloons and flying machines in war. The nation that secures control of the air will ultimately rule the world."

This brief description of some of Bell's chief accomplishments gives also an indication of some of his outstanding personal characteristics. He was one of driving energy, insatiable scientific curiosity, independence of thought and individuality of action. As a young man, he was tall, dark with flashing eyes, somewhat frail in appearance. He was described by an observer in 1877 as follows: "Professor Bell is a man of most genial and kindly presence, so courteous and gracious in manner that you could not feel yourself an intruder though you chanced to drop into his room when some private class was under special training. At the same time though his affability sets you at ease, you could not fail to observe that he is one of the busiest of men, so intent upon the development of plans which occupy his life that he has no leisure for visitors who are not interested in his work. He is young, apparently not more than five and thirty (he was just 30) with an unusually prepossessing countenance; very happy in his expression; of pale complexion with jet black hair brushed up from his forehead and pleasant, sparkling black eyes—the face of a man all engaged in his work and finding satisfaction in it."

Later in life, Bell's health became more stable, his frame filled out, his hair became white and his whole appearance impressive and commanding.

Bell's code of honor included scrupulous regard for the exact description of his own contributions to inventions or researches and credit to those of others. He was present at the Second Annual Banquet of the Aerial Club of America shortly after the successful flight of the first machine of the Aerial Experiment Association. Cheered to his feet by prolonged applause of this performance, he said, "I really had nothing to do with the success of the experiment. The credit for its success was due to Mr. G. H. Curtis, Mr. F. W. Baldwin and Mr. J. A. D. McCurdy. . . . In this company of experimenters I must include Lieutenant Selfridge of the United States Army and Mrs. Bell who supplied the capital for the scientific experiments to get the machine into the air."

His appreciation of assistance and encouragement received from others was warmly felt and often expressed in some tangible and suitable way. Though Henry died before the telephone was well established, Bell saw to it that an instrument was installed without charge in Henry's residence for the use of his family, "in recognition," Bell said, "of the efforts and services of Prof. Henry in the early history of the instrument and who did a great deal to encourage the inventor."

Bell's services to the promotion of science extended far beyond his own researches. From 1898 to 1903, he was President of the National Geographic Society and did much to develop the policy of that Society and of its magazine in the channels which have led to the present tremendous membership and influence. He served as Regent of the Smithsonian Institution from 1898 until his death. In 1890, a generous gift by him helped start the Astrophysical Observatory of the Institution and in 1894 he brought the body of James Smithson, founder of the Smithsonian Institution, from Genoa to Washington.

Honors came to Bell in great number. Some of these have been mentioned in the discussion of his achievements. He received a large number of honorary degrees from universities in America, in the British Isles and in Germany. He was elected a member of the National Academy of Sciences in 1883. He was made an Officer of the Legion of Honor of France in 1881. He was awarded a medal by the Louisiana Purchase Exposition in 1904, the John Fritz Medal from a group of national engineering societies in 1907, the Elliott Cresson Medal from the Franklin Institute in 1912, the David Edward Hughes Medal from the Royal Society, London, in 1913; the Thomas Alva Edison Medal by the American Institute of Electrical Engineers in 1914, and the Civic Forum (New York) Medal in 1917. In 1917 the Governor General of Canada unveiled a Bell Telephone Memorial erected in his honor at Brantford, Ontario, in the Alexander Graham Bell Gardens and dedicated the Bell homestead and grounds as part of the public parks system of Brantford. In 1920, his native city of Edinburgh elected him a Burgess and a Guild Brother of the city and conferred upon him "The freedom of the city of Edinburgh in recognition of his great achievement in the solution of the problem of telephone communication and of his brilliant and distinguished career as a scientist." This was an honor which deeply touched his heart.

Early in his professional work Bell determined to become a citizen of the United States, taking out his first papers in 1874 and receiving his final papers in 1882. He was immensely proud of his American citizenship, which, as he stated, was his by choice rather than by accident.

In the later years of his life, Bell spent more and more time at his summer estate, Beinn Bhreagh, in Nova Scotia. Here, on August 2, 1922, he died. Here he was buried on the top of a mountain in a tomb cut out of a solid rock, with the epitaph, "Died a citizen of the U. S. A." During the ceremony, every telephone on the continent of North America was silenced in honor of the man who had given to mankind the means for direct communication at a distance.

Not only did Alexander Graham Bell leave the telephone as a perpetual memorial to him but the influence of his personality remains strong on those who knew and loved him. Even now, 20 years later, a scientist who for many years knew him well, writes, "The fact that he never spoke disparagingly of others was a remarkable trait, the value of which nowadays I appreciate more than I did when he was alive. I miss his personality more than that of any other human being who has come and gone in my life."

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2 Sheets—Sheet 1.

A. G. BELL.

TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig. 1

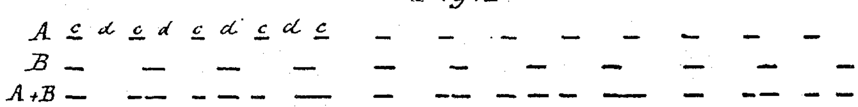


Fig. 2.

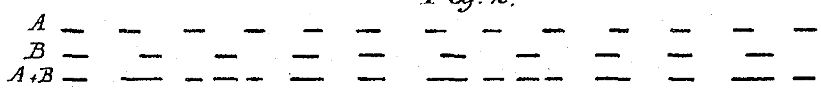


Fig. 3.

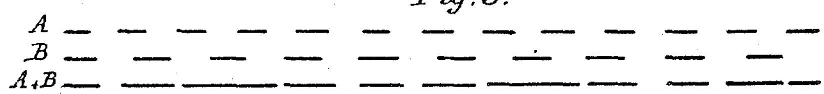


Fig. 4.

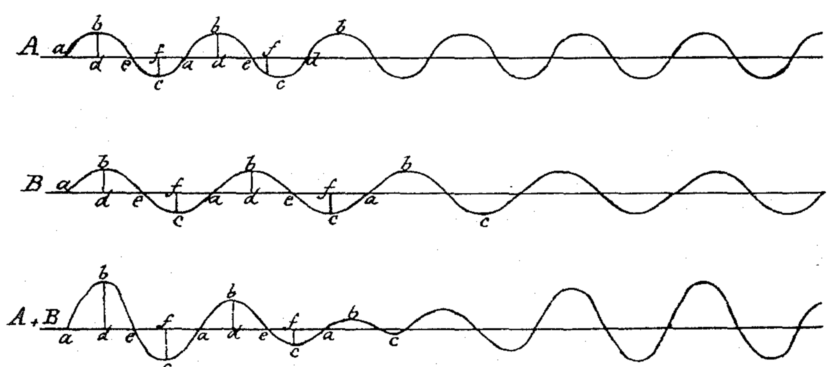
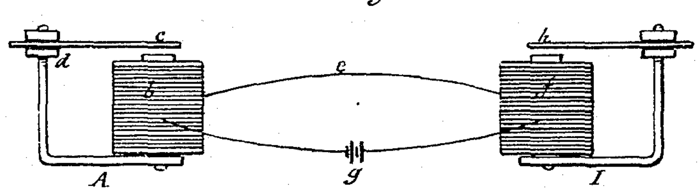


Fig. 5.



Witnesses

Ewell A. Dick.
H. J. Hutchinson

Inventor:

A. Graham Bell
by atty Pollok & Bailey

2 Sheets—Sheet 2.

A. G. BELL.

TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig 6.

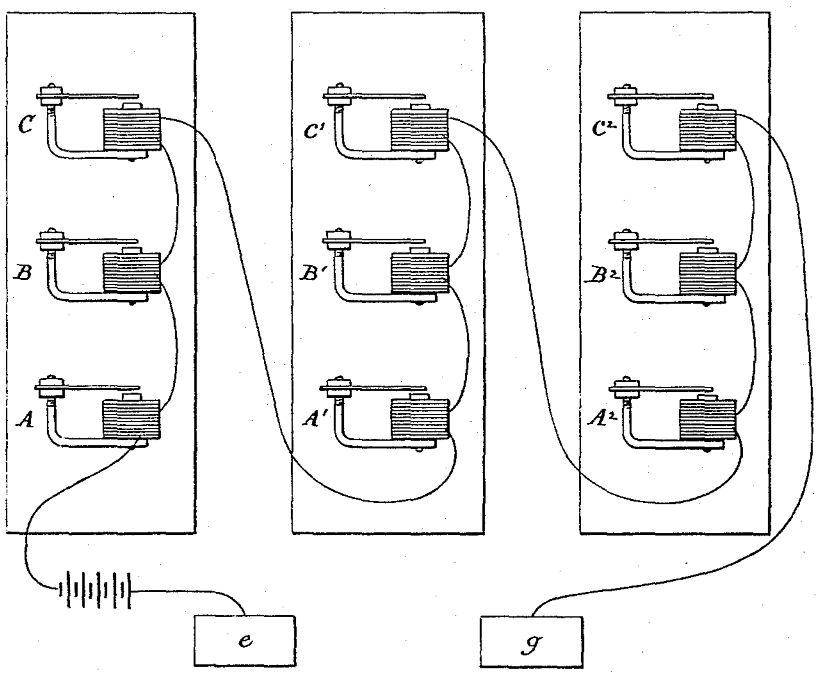
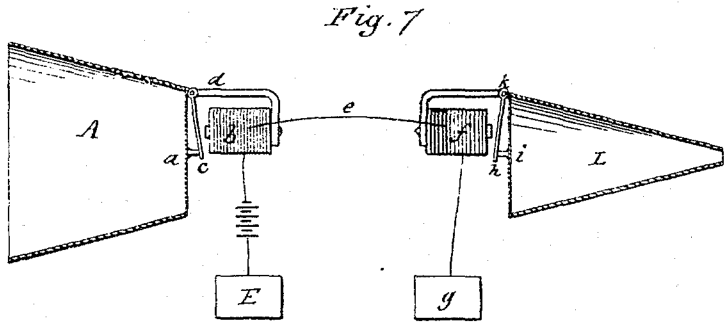


Fig. 7



Witnesses

Ewell A. Dick.

W. J. Hutchinson

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by attys Pollok & Bailey

UNITED STATES PATENT OFFICE.

ALEXANDER GRAHAM BELL, OF SALEM, MASSACHUSETTS.

IMPROVEMENT IN TELEGRAPHY.

Specification forming part of Letters Patent No. 174,465, dated March 7, 1876; application filed February 14, 1876.

To all whom it may concern:

Be it known that I, ALEXANDER GRAHAM BELL, of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification:

In Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for, transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments; and of vibratory circuit-breakers operating to convert the vibratory movement of the receiving-instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed a Morse sounder, register, or other telegraphic apparatus. I have also therein described a form of autograph-telegraph based upon the action of the above-mentioned instruments.

In illustration of my method of multiple telegraphy I have shown in the patent aforesaid, as one form of transmitting-instrument, an electro-magnet having a steel-spring armature, which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for, when a number of transmitting-instruments, having different rates of vibration, are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current.

In a pending application for Letters Patent, filed in the United States Patent Office February 25, 1875, I have described two ways of producing the intermittent current—the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current without actually breaking the circuit. The current produced by the latter method I shall term, for distinction sake, a pulsatory current.

My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of, and apparatus for, producing electrical undulations upon the line-wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity or are alternately positive and negative.

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction-coils; fourth, that cable dispatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use; for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable-signals is prevented; fifth, and that as the circuit is never broken a spark-arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.

That the difference between an undulatory and an intermittent current may be more clearly understood I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously—first upon the one plan and then upon the other. Let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. Now, when the intermittent current is used the circuit is made and broken four times by one transmitting-instrument in the same time that five makes and breaks are caused by the other. A and B, Figs. 1, 2, and 3, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. *c c c*, &c., show where and for how long time the circuit is made, and *d d d*, &c., indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting-instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Fig. 1 the ratio is as 1 to 4; in Fig. 2, as 1 to 2; and in Fig. 3 the makes and breaks are of equal duration. The combined effect, A and B, Fig. 3, is very nearly equivalent to a continuous current.

When many transmitting-instruments of different rates of vibration are simultaneously making and breaking the same circuit the current upon the main line becomes for all practical purposes continuous.

Next, consider the effect when an undulatory current is employed. Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body—that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration—that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body—that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinusoidal curve A or B, Fig. 4, represents, graphically, the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line *a d e f*, &c., represents the zero of current. The elevations *b b b*, &c., indicate impulses of positive electricity. The depressions *c c c*, &c., show impulses of negative electricity. The vertical distance *b d* or *c f* of any portion of the curve from the zero-line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, of 4 to 5—that is, four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A+B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A+B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence, the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire, through which a continuous current of electricity is passing, is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar-magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action; or by the vibration of the conducting-wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting-wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence, the vibration of the conducting-wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet, A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring armature, *c*, is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f* causes vibration in its armature *h* when the armatures *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

A number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus, if A, Fig. 6, is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note the instruments B B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued, but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound.

When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison. Thus the signals of A, Fig. 6, are repeated by A^1 and A^2, but by no other instrument upon the circuit; the signals of B^2 by B and B^1; and the signals of C^1 by C and C^2—whether A, B^2, and C^2 are successively or simultaneously caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

When the armature *e*, Fig. 5, is set in vibration the armature *h* responds not only in pitch, but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So, if A and B, Fig. 6, are sounded simultaneously, (A loudly and B softly,) the instruments A^1 and A^2 repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the center of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound—that is, they are represented graphically by similar curves.

The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

In this specification the three words "oscillation," "vibration," and "undulation," are used synonymously, and in contradistinction to the terms "intermittent" and "pulsatory." By the terms "body capable of inductive action," I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action—brass, copper, and other metals, as well as iron and steel.

Having described my invention, what I claim, and desire to secure by Letters Patent is as follows:

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.

2. The combination, substantially as set forth, of a permanent magnet or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim, whether the permanent magnet be set in vibration in the neighborhood of the conducting-wire form-

ing the circuit, or whether the conducting-wire be set in vibration in the neighborhood of the permanent magnet, or whether the conducting-wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself, in the neighborhood of such bodies, as set forth.

4. The method of producing undulations in a continuous voltaic circuit by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.

5. The method of, and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound, substantially as set forth.

In testimony whereof I have hereunto signed my name this 20th day of January, A. D. 1876.

ALEX. GRAHAM BELL.

Witnesses:
THOMAS E. BARRY,
P. D. RICHARDS.

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pesquisa

O Telefone de Alexander Graham Bell

- O Telégrafo Harmônico
- A Descoberta
- O Primeiro Telefone
- A Patente

O Telégrafo Harmônico

Em 1873 e 74, um escocês chamado Alexander Graham Bell fazia experimentos com um objetivo: enviar notas musicais através da eletricidade. Mas por que será que alguém passaria seu tempo tentando fazer uma coisa dessas? Bell fazia tal pesquisa, pois acreditava que, se pudesse transmitir notas musicais, conseguiria também transmitir a voz das pessoas. Você consegue pensar na importância que isso tinha na época? Não? É simples, basta imaginar sua vida sem telefone... Tem gente que não consegue sequer se imaginar sem celular! Já pensou se, a cada vez que tivesse que dar um recado a alguém ou matar a saudade tivesse que ir até a casa dela? Ia ser bastante difícil, não acha? Mas isso ainda não era o bastante, Bell queria, além de transmitir a voz das pessoas, fazer mais de uma transmissão ao mesmo tempo. Será que ele queria demais?

Um senhor chamado Hermann von Helmholtz, achou que não, pois provou naquela época que era possível sintetizar sons articulados a partir de notas musicais. Mas o que isso significa afinal? Significa que diferentes notas musicais podem ser usadas para enviar diferentes mensagens telegráficas ao mesmo tempo e por um único fio. Essa era a mesma idéia que Elisha Gray , especialista em eletricidade e um dos fundadores da empresa de telégrafos Western Electric Company tentava desenvolver. Ele dizia que usando freqüências distintas, seria possível transmitir entre 30 e 40 mensagens simultaneamente, através de uma única linha telegráfica, substituindo as inúmeras linhas existentes entre as cidades, com grande economia.

Gray trabalhava na construção de um aparelho do mesmo tipo e era, portanto, um dos maiores concorrentes de Bell que, apavorado com a idéia de ficar pra trás, escreveu, em novembro de 1874, a seguinte mensagem: "É uma corrida pescoço a pescoço entre o Sr. Gray e eu próprio para vermos quem completará um aparelho antes".

Essa mensagem foi escrita para Thomas Sanders e Gardiner Greene Hubbard , dois senhores que conheceram, se interessaram e resolveram investir no projeto do "telégrafo harmônico", pois perceberam que, se não conseguissem transformar o projeto do telégrafo em realidade rapidamente, perderiam essa corrida, e com ela, muito dinheiro.
Hubbard, um homem bastante prático, percebeu como a idéia de Bell poderia render dinheiro, e logo foi dar uma olhada no Escritório de Patentes de Washington (para saber se alguém já tinha desenvolvido alguma coisa parecida).

A loja de materiais elétricos de Charles Williams Jr., na Court Street, em Boston

Não é que a idéia era realmente original! Ele não encontrou nenhum registro sequer. Isso fez com que os dois novos parceiros de Bell decidissem de uma vez investir no projeto, pois o primeiro a terminá-lo, seria o dono de sua patente , podendo vendê-lo às empresas de telegrafia.

Hubbard, Sanders e Bell se associaram e, em fevereiro de 1875, criaram a empresa Bell Patent Association , que colocava no papel o combinado que fizeram: Bell entrava com as idéias, estudos e experimentos, Sanders e Hubbard com apoio, sobretudo financeiro, dividindo os lucros em três partes iguais.

No meio dessa corrida contra o tempo, Bell vai a Boston e conhece uma fábrica de aparelhos elétricos como dispositivos para telégrafo, campainhas elétricas, alarmes, etc., que pertencia a Charles Williams Jr., a quem Bell passou a pedir que lhe confeccionasse uma infinidade de aparelhos.

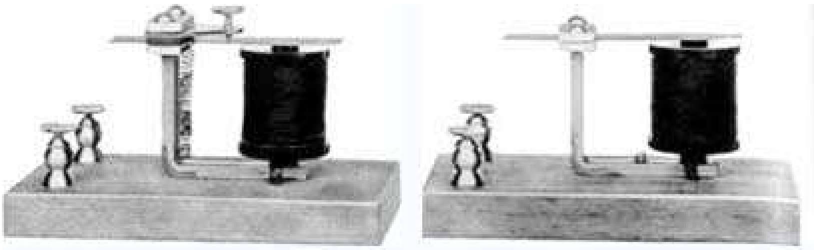
Charles Williams Jr. (esquerda) e um anúncio de sua loja (centro). Thomas J. Watson, em 1874 (direita)

Certo dia, Bell levou a Williams alguns de seus desenhos para que fossem construídos modelos experimentais de seu telégrafo harmônico, e este encarregou Thomas A. Watson desse trabalho.

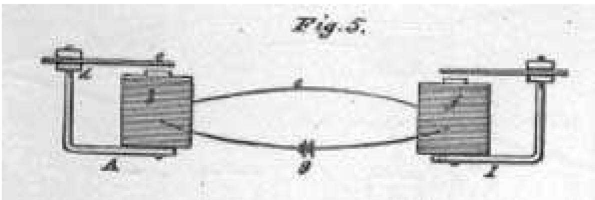
Apesar de não ser o assistente de Sherlock Holmes, Watson ajudaria bastante na investigação de Bell, pois tinha grandes conhecimentos sobre eletricidade e uma incrível habilidade na construção de aparelhos. E foi assim que ambos se conheceram.

Mas afinal de contas... como o telégrafo funciona?

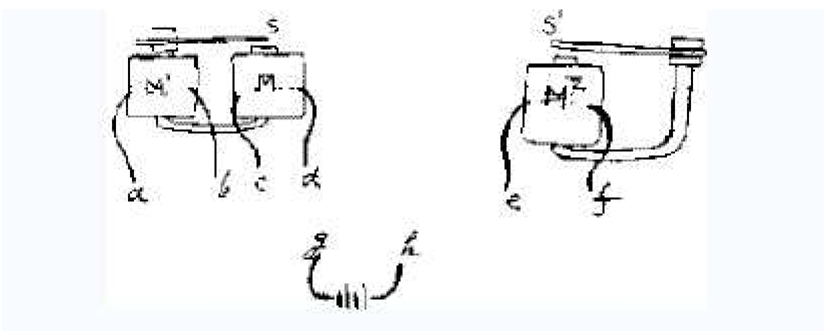
O telégrafo harmônico funcionava da seguinte maneira: um conjunto de eletroímãs , em forma de ferradura, produzia vibrações em pequenas lâminas de aço. Cada extremidade desta ferradura prendia uma das pontas da lâmina de aço. Junto a uma das extremidades dessa lâmina, havia também um contato elétrico. Quando o eletroímã estava ligado a uma pilha, a lâmina de aço passava a ser atraída, separando-se do contato elétrico. Quando este eletroímã era desligado, a lâmina voltava à sua posição inicial aproximando-se do contato elétrico.



Transmissor (esquerda) e receptor (direita) do telégrafo harmônico de Bell



Quando a corrente elétrica do eletroímã passa pelo contato elétrico entre a lâmina e o imã, ele se rompe. Esse rompimento é causado pelo próprio ímã, que corta a corrente elétrica fazendo com que a lâmina volte para seu lugar, produzindo um novo contato. Então, a lâmina é atraída até que seu contato se rompa e assim sucessivamente, até que a pilha - geradora da corrente seja retirada ou se esgote. Essa vibração da lâmina diante do eletroímã produz um zumbido, com diferentes freqüências , o que depende do comprimento e da grossura da lâmina de aço.



Diagramas dos osciladores do telégrafo harmônico, desenhados por Bell em 1875

Bell mandou construir vários sistemas desse tipo formando pares idênticos. Cada um dos aparelhos construídos produzia um zumbido ou som, igual ao emitido pelo seu par, porém, diferente dos sons produzidos pelos outros pares. Complicado não é? Basta prestar um pouco de atenção e você entenderá tudo com "um pé nas costas". Cada par de eletroímãs iguais formava um sistema de transmissão e recepção de sinais elétricos. Bell esperava que quando um eletroímã produzisse um som, se ligasse a um outro eletroímã idêntico. Esse segundo, também começaria a vibrar, produzindo o mesmo som ou zumbido. Quando eletroímãs diferentes fossem ligados entre si, um deles não faria o outro vibrar, ou seja, um não causaria interferência no outro. Bell não tirou tudo isso somente da sua imaginação, mas sim de seus estudos, nos quais conheceu um princípio da física que se tornou a base de suas hipóteses, o da ressonância de oscilações. Se você quiser constatar esse princípio, faça o teste: coloque dois violões idênticos e bem afinados, um na frente do outro. Se tocar uma das cordas de um deles, a mesma corda, do outro violão começará a vibrar, enquanto as outras continuarão paradas. Quando Bell pensou no telégrafo harmônico, estava tentando produzir um fenômeno semelhante, porém com vibrações transmitidas pela eletricidade, e não pelo ar.

Fotografia dos dispositivos do telégrafo harmônico de Bell, juntamente com duas pilhas da época

Se isso desse certo, Bell colocaria um eletroímã de cada tipo de um lado e seus correspondentes do outro, em um circuito elétrico. Ele esperava que, como aconteceu com o violão, apenas o par certo de cada eletroímã entrasse em vibração do outro lado. Se isso funcionasse, cada vibrador poderia ser manipulado por um telegrafista, possibilitando a transmissão de várias mensagens ao mesmo tempo pelo mesmo fio, cada uma com uma freqüência, sem que se misturem, sendo recebidas por diferentes aparelhos do outro lado.

Como pudemos perceber, na teoria, tudo parecia perfeito, porém, depois que Watson fabricou os dispositivos, o sistema ainda não funcionava. Com isso, Bell tentou fazer uma série de modificações, as quais Watson seguia fielmente, ainda assim sem sucesso.

O dia-a-dia de Bell era bastante cansativo, dava aulas durante o dia, e visitava a oficina de Williams à noite. Enquanto trabalhavam, Bell contava a Watson suas idéias - inclusive sobre seu projeto de transmitir vozes à distância.

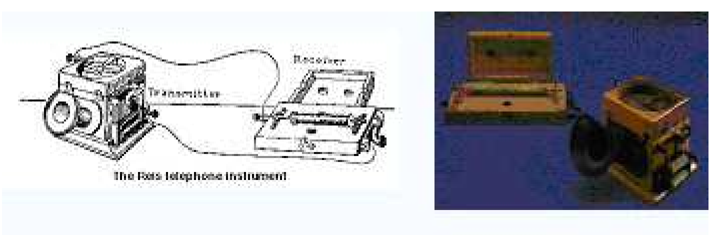
Sem nunca esquecer o projeto de construir o telégrafo, Bell saiu em busca de interessados em seu outro trabalho. Foi a Washington e conversou com Joseph Henry, um importante físico especialista em eletricidade, que conhecia os aparelhos de Johann Philipp Reis (possuía até uma cópia dele), que tinha bastante interesse no assunto. Ao contrário de outras pessoas, Henry incentivou Bell a trabalhar com a transmissão da voz. Apesar da falta de sucesso, Bell estava obcecado pelo trabalho e por isso, em março de 1875, decidiu parar de dar aulas. Tomou tal decisão para poder dedicar mais tempo às suas pesquisas, o que lhe trouxe sérios problemas financeiros. Gastou todas as suas economias, e precisou pedir dinheiro emprestado a seu amigo Watson.

Saiba mais sobre quem foi Reis. 

Um jovem professor alemão chamado Johann Philipp Reis, construiu o primeiro "telefone" elétrico que conseguiu transmitir sons. Este aparelho era muito semelhante ao telégrafo - com um aparelho transmissor e um receptor. A novidade é que, ao invés de enviar sinais batendo com o dedo sobre um interruptor, era a voz que fazia este aparelho funcionar e com uma grande vantagem: os sons ouvidos no aparelho receptor tinham a mesma freqüência do som que saia do aparelho transmissor.

Reis fez uma demonstração de seu aparelho diante da Sociedade Científica Alemã em 1861, em que foi possível ouvir uma música cantada por um cantor profissional que estava a 100 metros de distância. No entanto, só era possível reconhecer a seqüência de sons musicais, pois o aparelho não reproduzia nem as variações de intensidade do som, nem as palavras cantadas, nem tampouco, as características da voz do cantor.

Com o aparelho de Reis conseguia-se distinguir a voz de um homem e de uma mulher, além de reconhecer as notas musicais de uma melodia, porém, não era possível entender uma só palavra.



Esquema e fotografia do telefone de Reis

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- MARTINS, Roberto - *A Fundamentação da Telefonia através da História - Parte 1: Da Invenção ao Início do Século XX* (pesquisa realizada para a Fundação Telefônica, em 2002)

A Descoberta

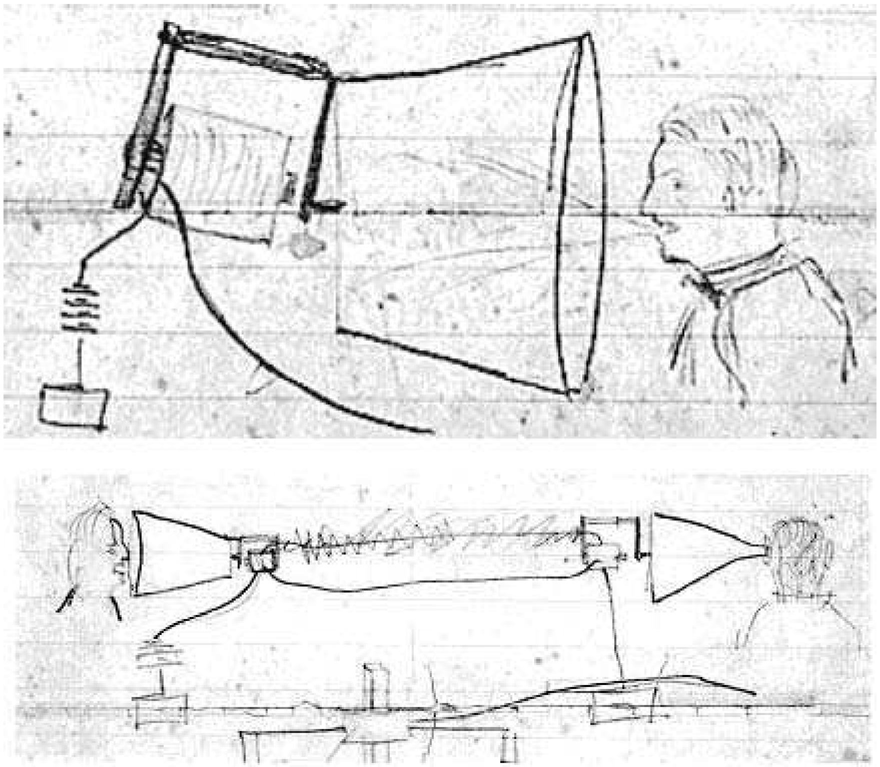
Na tarde do dia 2 de junho de 1875, Graham Bell e Thomas Watson puseram-se a fazer experiências para verificar o funcionamento do telégrafo harmônico . Cada um foi para uma sala, no sótão da oficina de Bell. Watson, em uma delas, tratava de ligar os diversos eletroímãs, enquanto Bell, na outra, observava o comportamento dos eletroímãs de seu aparelho que deveriam vibrar estimulados pelo aparelho de Watson.

Reconstituição artística de Bell escutando os sons do receptor do telégrafo harmônico, em 1875

Como acontecera muitas outras vezes, a coisa não funcionou e para piorar, a lâmina de um dos transmissores não vibrava quando ligada à pilha. Como essa lâmina parecia estar presa, Watson começou a puxá-la e soltá-la para ver se assim, ela começava a vibrar como deveria. Nisso, Bell ouve uma forte vibração no aparelho que estava em sua sala, dá um grito e vai correndo perguntar a Watson o que ele havia feito.

Dando uma olhada na lâmina que estava com problema, Bell viu que um parafuso estava muito apertado, impedindo que o contato elétrico gerado entre a lâmina e o eletroímã fosse rompido, interrompendo a transmissão de pulsos elétricos para a outra sala. Intrigado, Bell começou a quebrar a cabeça imaginando o que havia acontecido.

De repente, compreendeu que, quando a lâmina de aço vibrou diante do eletroímã, ela induziu uma corrente elétrica oscilante na bobina do eletroímã e essa corrente elétrica produziu a vibração no aparelho que estava na outra sala.
O princípio da física que explicava esse fenômeno não era novo. Michael Faraday já havia demonstrado, quarenta anos antes, que o movimento de um pedaço de ferro perto de um eletroímã podia criar vibrações elétricas do mesmo tipo. Porém, apesar desse fenômeno já ser conhecido, foi só nesse dia que Bell percebeu que poderia usá-lo para fazer o que tanto queria: transmitir a voz através da eletricidade.



Os primeiros diagramas do telefone, desenhados por Bell em junho de 1875

Nesse mesmo dia, antes de ir para casa, Bell deu instruções a Watson para que construísse um novo aparelho, adaptando o antigo dispositivo, com a finalidade de captar as vibrações sonoras do ar e produzir vibrações elétricas.

Bibliografia

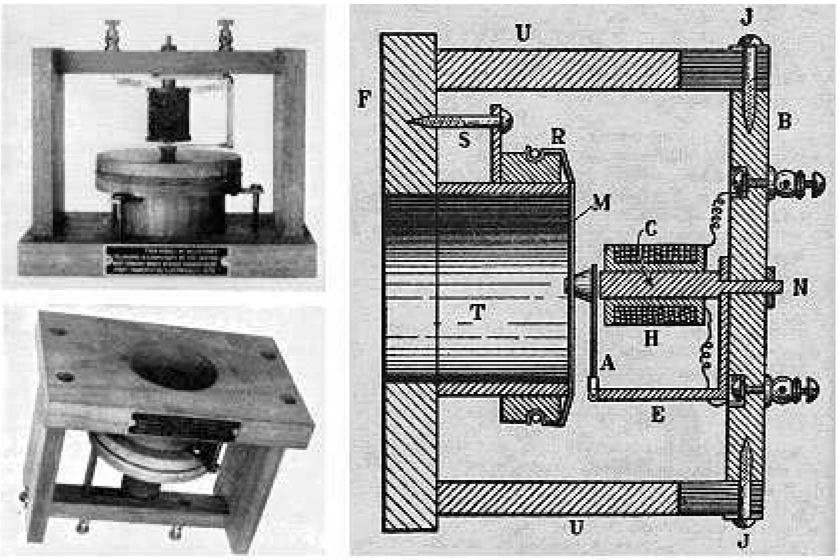
- MARTINS, Roberto - *A Fundamentação da Telefonia através da História - Parte 1: Da Invenção ao Início do Século XX* (pesquisa realizada para a Fundação Telefônica, em 2002)

O Primeiro Telefone

Graham Bell e seu amigo Thomas Watson já tinham construído vários aparelhos e sempre encontravam algum problema .

No dia 3 de junho de 1875, Watson, atendendo mais uma solicitação de Graham Bell, da noite anterior, para que construísse um novo aparelho adaptando um dos antigos dispositivo, construiu dois exemplares. Um deles era de uma estrutura de madeira que tinha uma espécie de tambor mantendo todas as partes do dispositivo nas posições corretas.

Devido ao formato dessa estrutura, esse dispositivo recebeu o apelido de "telefone da forca".



Fotografias (esquerda) e esquema (direita) do telefone em forma de forca, utilizado por Bell em 1876

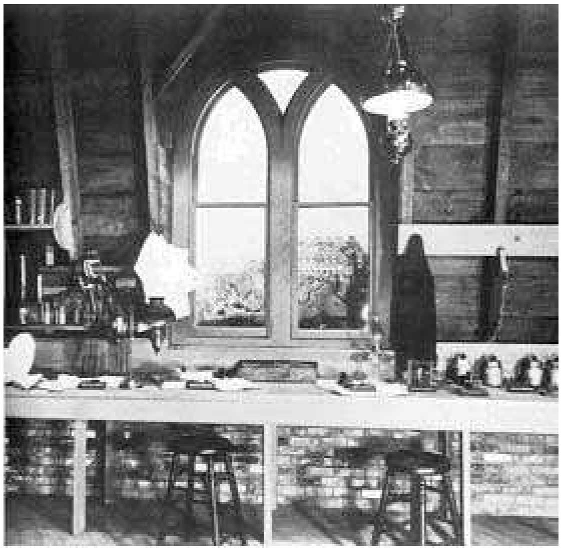
Reprodução do telefone em forma de forca, de Graham Bell, utilizado em 1876.

A idéia de Bell era que ao falar próximo à membrana ela vibraria, fazendo a lâmina tremer perto do eletroímã e induzindo orrentes elétricas variáveis até sua bobina. Ele esperava que essas vibrações sonoras fossem reproduzidas igualmente na forma elétrica que seria conduzida por fios metálicos até um outro aparelho idêntico, fazendo-o vibrar e emitir um som semelhante ao inicial.

Para começar o teste, Watson e Bell colocaram os aparelhos em lugares bem distantes; um no sótão e o outro no terceiro andar do prédio - dois andares abaixo, ligados por um par de fios metálicos. À noite, Bell ficou no sótão e Watson na sala do terceiro andar, tentando se comunicar através do aparelho. Por mais que Watson falasse alto ou mesmo gritasse, Bell não ouvia nada, no entanto, quando Bell falava em seu dispositivo, Watson ouvia alguns sons . Não que fosse possível entender alguma palavra mas, certamente ele escutava alguma coisa.

Hoje é possível entender quais eram os problemas técnicos desse primeiro aparelho. Um deles era a lâmina de aço, que deveria vibrar livremente induzindo as correntes elétricas, mas que tinha, nesse aparelho uma de suas extremidades presa, o que a impedia de acompanhar as oscilações da membrana. O outro problema é que, para emitir sons com mais força, era preciso dimensionar o aparelho de maneira mais adequada, levando em conta, por exemplo, as distâncias entre o eletroímã e a lâmina. Enfim, era preciso aperfeiçoá-lo.

Apesar de todos esses avanços, Hubbard continuava a pressionar Bell para que se dedicasse ao telégrafo harmônico, e não à transmissão de voz.



O sótão da loja de Williams, onde Bell e Watson realizaram seus primeiros experimentos (reconstrução montada a partir de fotografias da época)

Bibliografia

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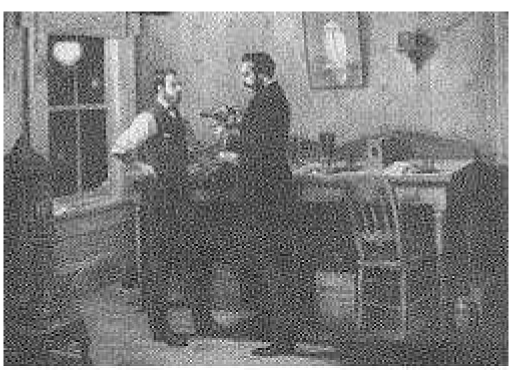
A Patente

Em setembro de 1875, Graham Bell foi visitar seus pais no Canadá e enquanto esteve lá, trabalhou na redação do pedido de patente de seu mais novo invento - um aparelho de transmissão elétrica da voz. No final desse mesmo ano, voltou a Boston e alugou dois quartos no andar superior de uma pensão. Dormia em um e fazia quase todos os seus experimentos no outro, transformado-o em um verdadeiro laboratório, pois acreditava que este era um lugar mais reservado. Mas por que Bell se preocuparia em manter todo esse segredo? O projeto no qual trabalhava era muito valioso e, por isso, acreditava que alguém pudesse querer roubar suas idéias. Todo cuidado era pouco, sobretudo nessa fase final de desenvolvimento.



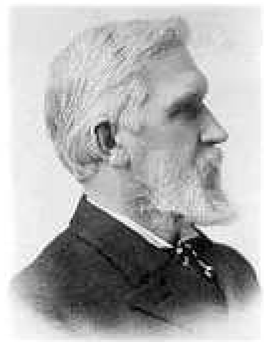
Bell e Watson discutindo seus experimentos (concepção artística)

No início de fevereiro de 1876, Bell, percebendo a urgência de patentear seu invento, mesmo antes que funcionasse perfeitamente, redigiu a versão final de seu pedido. Hubbard, seu patrocinador e futuro sogro, prontamente levou o pedido a Washington e entregou-o ao Escritório de Patentes no dia 14 de fevereiro.

Neste dia, apenas duas horas depois, Elisha Gray foi ao mesmo escritório depositar um pedido preliminar de patente ("caveat") para um aparelho de transmissão elétrica de voz bastante semelhante ao criado por Bell . Essas duas horas foram fundamentais para que a patente fosse dada a Bell como inventor do telefone, ao invés de Elisha Gray.

Não se sabe ao certo se Bell estava ciente de que Elisha tentaria patentear um invento semelhante ao seu, porém, existem indícios de que Hubbard, sempre esteve bem informado sobre os passos do concorrente.

Escritório de patentes, em Washington



Elisha Gray - 1878

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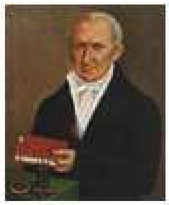
Linha do tempo

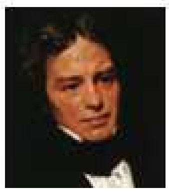
- Século XIX
- Século XX
- Século XXI

- **1667** 

  O físico inglês Robert Hooke propõe o emprego de "fio esticado" para transmitir o som

- **1801** 

  Alexandre Volta, físico italiano, inventa a pilha elétrica, que tem seu nome

- **1831** 

  Michael Faraday, físico inglês, demonstra a possibilidade de produção de uma corrente elétrica a partir da indução magnética (é a comprovação da reciprocidade eletricidade-magnetismo).

- **1861** 

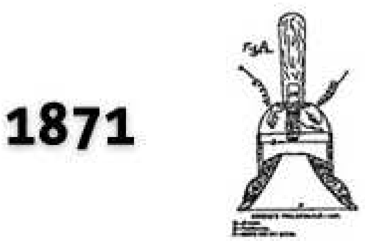
  Philipp Reis, professor alemão, faz as primeiras transmissões de sons musicais por meio de fios. E o telefone musical (também chamado telefone "filosófico").

- **1863**

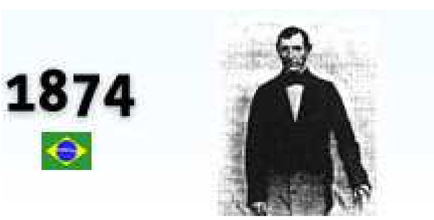
  Primeiro sistema comercial de facsímile (fax) entre Lyon e Paris, por Giovanni Caselli.

- 

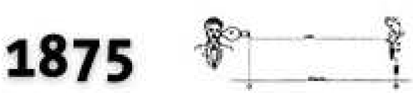
  No dia 5 de maio, nasce em Mimoso, Mato Grosso, Cândido Mariano da Silva Rondon, futuro Marechal Rondon, Patrono das Comunicações do Brasil. A data de 5 de maio é, no Brasil, o Dia Nacional das Comunicações, enquanto o 17 de maio é o Dia Mundial das Telecomunicações.

- 

  O italiano Antônio Meucci, nos Estados Unidos, registra um aparelho que consiste (...)"num diafragma vibrante e de um magneto eletrizado por um fio espiral que o envolve. Quando o diafragma vibra(...) modifica a corrente do magneto(...) Esta modificação da corrente transmite-se ao outro fio e vai imprimir análoga vibração ao diafragma que a recebe e que, desse modo, reproduz a palavra"(...) Antonio Meucci foi considerado por alguns como o verdadeiro inventor do telefone e em 2002, o Congresso Americano, através da resolução 269 reconhece-o como o verdadeiro inventor do telefone.

- 

  Brasil inaugura o seu primeiro cabo submarino, que cruzava o Atlântico Sul e ligava a América do Sul à Europa. Idealizado por Mauá, o cabo foi construído por uma companhia inglesa e funcionou até 1973.

- 

  Elisha Gray e Alexandre Graham Bell descobrem que estão trabalhando no mesmo projeto: a invenção do telefone. Enquanto Bell buscava solução pelo lado acústico, Gray buscava pela aplicação da corrente elétrica.

- 

Alexandre Graham Bell obtém a patente nº 174.465, de invenção do telefone, concedida no dia 7 de março. Três dias depois, acidentalmente, Bell e Watson conseguem a transmissão da primeira frase completa por telefone ("Mr. Watson, come here, I need you"). A 25 de junho desse ano, Dom Pedro II, Imperador do Brasil, visitando a Exposição de Filadélfia, exclama diante do telefone de Graham Bell: "Meu Deus, isto fala!"

- 

Instalado, no Rio de Janeiro, o primeiro telefone do país.

- 

Thomas Edison realiza na prática o aparelho projetado por Cros (o fonógrafo). \ Hughes inventa o microfone de carvão, cujo princípio é utilizado até hoje nos telefones. Edison aperfeiçoa ainda nesse mesmo ano o receptor de Bell. Instalado, nos EUA, o primeiro telefone público.

- 

Decreto imperial de D. Pedro II autoriza o funcionamento da primeira empresa de telefonia no país. Começam a funcionar os primeiros telefones do Rio de Janeiro.

- 

Instalada por Walter Hemsley, com 75 assinantes, a primeira estação telefônica na cidade de Santos, talvez a primeira do Estado de São Paulo.

- 

Começam a funcionar comercialmente os primeiros telefones na cidade de São Paulo, instalados em janeiro desse ano por dois concessionários que se unem, fundando a Companhia Telegraphos Urbanos, após uma semana de discussões

- 

Lars Magnus Ericsson, baseado nas idéias de Anton Avén e Leonard Lundqvist, coloca em prática a utilização do monofone, isto é, o acoplamento numa só peça do fone e do bocal (auricular e transmissor), uma revolução industrial do telefone, que será industrializado em 1892.

- 

Willian Gray instala o primeiro telefone público com caixa coletora automática nos EUA, em Connecticut, no Hartford Bank

- 

O Bell System comemora pela primeira vez o Dia da Telefonista, em 29 de junho, Dia de São Pedro; pois, como ele detém as chaves do céu, elas detinham as chaves da comunicação

- 

  Almond Brown Strowger inaugura a 3 de novembro, em La Porte (Indiana), a primeira central telefônica automática do mundo, com 56 telefones, aplicando sua invenção, cujos primeiros resultados bem-sucedidos são de 1889

- 

  O Padre Landell de Moura realiza com êxito, na cidade de São Paulo, as primeiras transmissões de sinais telegráficos e da voz humana em telefonia sem fio no mundo.

- 

  Inaugurada a Companhia Rede Telefônica Bragantina, que, à época (1896 a 1916), talvez tenha sido a maior companhia a operar em território brasileiro (1.641 km de linhas telefônicas).

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Personagens

- Alexander Graham Bell
- Antonio Meucci
- Marechal Rondon
- Padre Landel de Moura
- Phillip Reis

Alexander Graham Bell nasceu no dia 3 de março de 1847, em Edimburgo, na Escócia. Era o segundo dos três filhos do casal Alexander Melville Bell e Eliza Grace Symonds. Sua família tinha tradição e renome como especialista na correção da fala e no treinamento de portadores de deficiência auditiva.

O avô , Alexander Bell, foi sapateiro em St. Andrews, na Escócia e, enquanto consertava sapatos, recitava Shakespeare.

Ser ou não ser? Eis a questão.

Fazia isso com tanta freqüência que, aos poucos, admirado com a própria voz, passou a se dedicar à melhoria da dicção com o valor exato para cada palavra.

Abandonou o ofício de sapateiro e seguiu o caminho do teatro, porém, alguns anos no palco foram suficientes para que descobrisse outra profissão; tornou-se professor de elocução e dava conferências dramáticas sobre Shakespeare, desenvolvendo boa prática no tratamento dos defeitos da fala, especializando-se em foniatria .

O pai , Alexander Melville Bell, passou a se interessar, não só pelo som das palavras, como também pelas causas desse som. Estudou anatomia - laringe, cordas vocais, boca, etc criando o que chamava de " fala visível ". É autor do livro "Dicção ou Elocução Padrão".

Bell, seu pai e seu avô tinham o mesmo prenome - Alexander. Até os 11 anos, se chamava simplesmente Alexander Bell, até que um dia na escola, a professora sugeriu que adotasse mais um nome para diferenciar-se do avô. Depois de consultar os familiares, optou por Graham, em homenagem a um grande amigo de seu pai.

Aos 14 anos, ele e seus irmãos construíram uma curiosa reprodução do aparelho fonador . Numa caveira montaram um tubo com "cordas vocálicas", palato, língua, dentes e lábios, e com um fole , sopravam a traquéia, fazendo a caveira balbuciar "ma-ma", imitando uma criança chorona.

Alexander Graham Bell cresceu assim, em um ambiente rico de estudo da voz e dos sons, o que certamente influenciou no seu interesse nesse campo, além de ter a mãe que, muito jovem, ficou surda.

Estudou na Universidade de Edimburgo, onde começou a fazer experimentos sobre pronúncia . Certo dia, um amigo de seu pai falou sobre a obra de um certo cientista alemão chamado Hermann von Helmholtz , que havia investigado a natureza física dos sons e da voz. Excitado com a novidade, apressou-se em conseguir uma cópia do livro. Só havia um problema: o livro estava escrito em alemão, língua que não entendia. Além disso, trazia muitas equações e conceitos de física, inclusive relativos à eletricidade, área que tampouco dominava.

Apesar de todas as dificuldades, Bell teve a impressão de que (por meio de alguns desenhos do livro), Helmholtz tinha conseguido enviar sons articulados , como vogais, através de fios utilizando eletricidade. Na verdade, o que Helmholtz estava tentando fazer era sintetizar sons parecidos com a voz, utilizando aparelhos e não transmití-los à distância. Ao contrário do que vocês podem estar pensando, foi exatamente esse engano que fez com que Bell começasse a pensar sobre os modos de enviar a voz à distância por meios elétricos.

Em 1868, em Londres, tornou-se assistente do pai, assumindo seu cargo em tempo integral quando este tinha de viajar aos Estados Unidos para dar cursos.

Nessa época, seus dois irmãos, o mais velho e o caçula, com intervalo de um ano, morreram de tuberculose . As dificuldades econômicas aumentaram e a ameaça da doença, também encontrada em Bell, levou o pai a abandonar a carreira em Londres, em seu melhor momento e, em agosto de 1870, mudar-se com a família para o Canadá.

Compraram uma casa em Tutelo Heights, perto de Brantford, província de Ontário, que era conhecida como " Casa Melville " e que hoje é conservada como relíquia histórica com o nome de "solar dos Bell".

O pai de Bell era famoso e foi muito bem recebido no Canadá. Em 1871, recebeu o convite para treinar professores de uma escola de surdos em Boston, nos Estados Unidos, porém, preferindo continuar no Canadá, mandou o filho em seu lugar. Bell passou a ensinar o método de pronúncia desenvolvido por seu pai, treinando professores em muitas cidades além de Boston, pois, nessa época, antes da descoberta dos antibióticos, a surdez era muito mais comum, podendo surgir como resultado de muitas doenças.

Em 1872, abriu sua própria escola para surdos (onde depois conheceu D. Pedro II, em 1876). No ano seguinte, em 1873 tornou-se professor da Universidade de Boston, época em que começa a se interessar por telegrafia e estudar modos de transmitir sons utilizando a eletricidade.

Por meio de seu trabalho como professor de surdos, A. Graham Bell - como assinava e gostava de ser chamado - conheceu pessoas influentes que, depois, ajudaram-no muito. Um deles foi Thomas Sanders, um rico comerciante de couro que morava em Salem, próximo a Boston, cujo filho - George - foi aluno de Bell. O menino mostrou progressos tão rápidos que Sanders, agradecido, convidou Bell a morar em sua casa. Outra pessoa importante foi Gardiner Greene Hubbard, um advogado e empresário bem-sucedido, que viria a ser seu sogro em 1875.

Em 1898, Bell substituiu o sogro na presidência da National Geographic Society, transformou o velho boletim da entidade na belíssima National Geographic Magazine, semelhante à que temos hoje.

Alexander Graham Bell morreu em sua casa de Baddeck, no Canadá, no dia 2 de agosto de 1922, aos 75 anos.

Muitos conhecem Bell como o inventor do telefone, muito embora hoje já se reconheça que o verdadeiro inventor foi o italiano Antonio Meucci , mas poucos sabem de seus outros feitos. Dê uma olhada na galeria:

Discos de Cera Para gravação de sons, o que aprimora o fonógrafo de Edison.	**Sondas tubulares** Para exames médicos	**"Colete à Vácuo"** Uma forma primitiva de pulmão-de-aço.
Raios Laser Foi um dos precursores na descoberta.	**Barcos Velozes** Inventor de barcos capazes de superar os 100 quilômetros por hora.	**Carneiros** Selecionando raça.
Sistema de localização de icebergs Desenvolveu sistema semelhante ao sonar.	**Fotofone** Inventor do sistema de transmissão de mensagens por meio de raios luminosos em 1887.	**Aviação** Foi o primeiro homem a voar num aparelho mais pesado que o ar no Império Britânico em 1907.

Ao longo da sua vida, Bell obteve 18 patentes em seu nome e 12 em conjunto com colaboradores. Desse total, temos os seguintes assuntos:

Telégrafo / Telefone	14 patentes	Fotofone	4 patentes
Vinculos Aéreos	5 patentes	Fonógrafo	1 patentes
Hidroaviões	4 patentes	Célula de Selênio	2 patentes

"Inventor é um homem que olha para o mundo em torno de si e não fica satisfeito com as coisas como elas são. Ele quer melhorar tudo o que vê e aperfeiçoar o mundo. É perseguido por uma idéia, possuído pelo espírito da invenção e não descansa enquanto não materializa seus projetos." (Palavras de Alexander Graham Bell gravadas numa placa no museu que tem o seu nome, em Baddeck no Canadá.)

Bibliografia - CAUDURO MARTINO ARQUITETOS ASSOCIADOS - Museu do Telefone - 1977 - Companhia Litographica Ypiranga
- MARTINS, Roberto - A Fundamentação da Telefonia através da História - Parte 1: Da Invenção ao Início do Século XX (pesquisa realizada para a Fundação Telefônica, em 2002)
- RUIZ, Roberto - O TELEFONE, uma das mais simples e fabulosas criações do engenho humano - 1973 - CTB

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- Antonio Meucci
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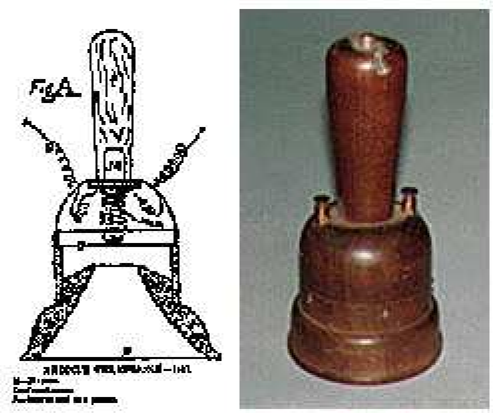
- Padre Landel de Moura
- Phillip Reis

Nascido em Florença em 1808, Antonio Meucci, foi para Cuba, perseguido por suas idéias liberais e lá viveu por algum tempo. Segundo ele, na época em que vivia em Havana, observou, por acaso, que a voz de uma pessoa podia ser transmitida por um sistema elétrico e, desde então, pôs-se a investigar o fenômeno. Pouco tempo depois, em Nova York - Estados Unidos - desenvolveu um tipo de telefone elétrico, por meio do qual conseguiu estabelecer uma comunicação entre o quarto de sua esposa (que estava doente) e seu laboratório.

Isso significa que, entre 1854 e 55 já havia um aparelho transmissor da voz humana à distância que funcionava regularmente. Em 1857 Meucci construiu um instrumento eletromagnético que seguia o mesmo princípio empregado, anos depois, por Graham Bell.



Esquema do telefone eletromagnético de Meucci (esquerda), e reconstrução moderna baseada em sua descrição (direita)

O invento de Meucci foi noticiado em 1861 no jornal "L'Eco d'Italia", publicado por italianos em Nova York. Noticiou também, em 1865, seus primeiros experimentos e, por fim, no dia 28 de dezembro de 1871 entrou com uma solicitação preliminar de patente ("caveat") de um "teletrofone" - aparelho de transmissão da voz à distância por meio da eletricidade, - não renovando este pedido em 1874 por não ter tido condições financeiras.

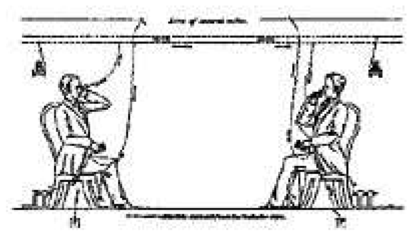


Diagrama de Meucci, mostrando duas pessoas se comunicando pelo seu "telégrafo sonoro"

Depois que o telefone de Graham Bell se tornou famoso, Antonio Meucci tentou provar que havia inventado o mesmo aparelho anos antes, apresentando documentos e testemunhas. Em 1887 o Governo Americano entra com pedido de anulação da patente de Bell. No entanto, dois anos depois Meucci morre e como a patente de Bell expiraria somente em 1893 o processo foi arquivado.

Na Itália, Meucci é considerado o verdadeiro inventor do telefone, e em 2002, finalmente o Congresso Americano, através da resolução 269 , também reconhece Antonio Meucci como o verdadeiro inventor do telefone.

No entanto, a bem da verdade, Meucci só teve a quantia suficiente para manter a patente por três anos de um protótipo rudimentar do telefone, isto cinco anos antes da patente de Bell, e ao não renová-la deixou o caminho livre.

Bibliografia - LA PEÑA, José de - Historias de las telecomunicaciones. Cuando todo empezó. Ed. Ariel, 1ª e 2ª ed, 2003, Espanha
- MARTINS, Roberto - A Fundamentação da Telefonia através da História - Parte 1: Da Invenção ao Início do Século XX (pesquisa realizada para a Fundação Telefônica, em 2002)
- Resolução 269, do Congresso dos Estados Unidos

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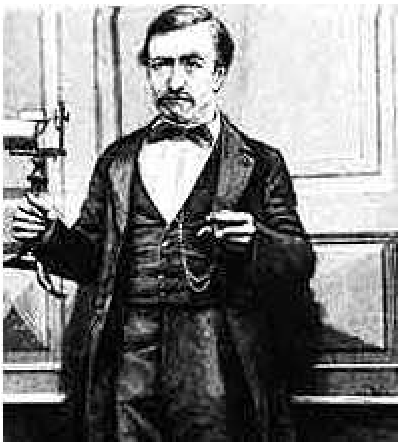
- Phillip Reis



Fechar

Saiba mais

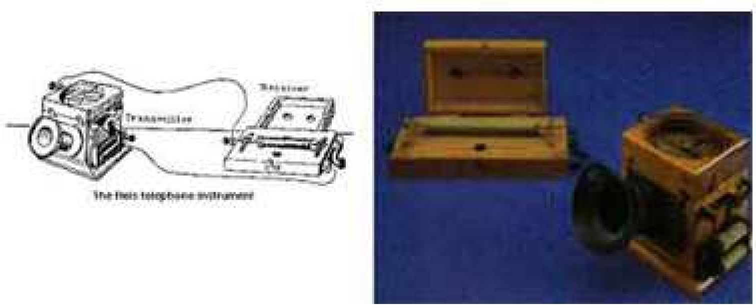
Esse fenômeno é produzido porque o ferro se contrai quando é imantando - um fenômeno chamado "magnetostrição". Se um pedaço de ferro for colocado dentro de um eletroímã e a corrente elétrica desse eletrímã variar muito rapidamente, o pedaço de ferro pode vibrar e emitir sons.

Johann Philipp Reis era professor alemão e dava aulas de física na Universidade de Friedrichsdorf.

Em 1861, projetou diversos aparelhos para a transmissão do som, especialmente musicais, baseado no princípio constatado pelo médico norte-americano Charles Grafton Page em 1837, de que a imantação e desimantação de um pedaço de ferro doce produzia um som peculiar, o que ele chamou de *"música galvanica*".

Saiba mais +

Reis deu ao seu aparelho o nome de "telefone" - das Telephon , em alemão. Essa palavra já havia sido utilizada antes, em outros sentidos - por exemplo, para descrever tubos de comunicação . Mas o aparelho de Reis foi o primeiro "telefone" elétrico que conseguiu transmitir sons.

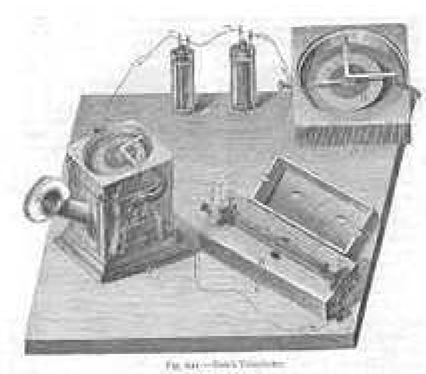


Esquema do telefone eletromagnético de Meucci (esquerda), e reconstrução moderna baseada em sua descrição (direita).

Em 1860, Reis conseguiu transmitir música cantada a 100 metros de distância, por meio de um aparelho elétrico. Seu aparelho produziu uma enorme sensação.Possuía um transmissor e um receptor . O transmissor tinha uma membrana esticada - como a pele de um tambor - com uma lâmina metálica no centro. Bem próximo a essa lâmina, havia um contato metálico. A lâmina e o contato eram conectados a fios metálicos e a uma bateria. Quando se falava perto do transmissor, a membrana vibrava. A lâmina metálica batia em um contato metálico e produzia sinais elétricos. Quando a lâmina encostava no contato, passava dessa forma uma corrente elétrica e quando ela se separava, a corrente elétrica parava. Assim, se produzia uma corrente elétrica descontínua, que vibrava com a mesma freqüência do som que atingia a membrana do transmissor.

O aparelho de Reis era essencialmente um tipo de telégrafo - porém, ao invés de enviar sinais batendo com o dedo sobre um interruptor, era a voz que fazia uma membrana vibrar e bater em um interruptor muito sensível.

Essa corrente elétrica era levada pelos fios metálicos até o receptor. Esse receptor era constituído por uma barra de ferro fina - semelhante a uma agulha de tricotar -, presa a uma caixa de ressonância. Em volta dessa barra de ferro eram enroladas muitas voltas do fio que vinham do transmissor. Quando os sons produziam vibrações no transmissor , a corrente elétrica vibratória produzia também vibrações de mesma freqüência na barra de ferro. A vibração da barra fazia a caixa de ressonância vibrar, e assim eram ouvidos sons com a mesma freqüência do som que atingir a membrana do transmissor.



Esquema do telefone eletromagnético de Meucci (esquerda), e reconstrução moderna baseada em sua descrição (direita).

Reis fez uma demonstração de seu aparelho na Sociedade Científica Alemã, em 1861. Foi possível ouvir uma música cantada por um cantor profissional que estava a 100 metros de distância. No entanto, somente era possível reconhecer a seqüência de sons musicais - as diferentes freqüências. O aparelho não reproduzia nem as variações de intensidade do som, nem as palavras cantadas, nem as características da voz do cantor. Era possível distinguir a voz de um homem da voz de uma mulher - a da mulher é mais aguda -, e reconhecer as notas musicais de uma melodia. No entanto, não se conseguia entender uma palavra.

Numerosas outras demonstrações de sons musicais foram feitas efetivamente por Reis. Mas era preciso que o som fosse sempre muito forte para manter a oscilação da corrente. Um som débil não movia a agulha. As demonstrações em conferências tornaram bastante conhecido o "telefone" musical do professor alemão, que chegou a considerá-lo apenas um "brinquedo filosófico" e permitiu sua fabricação e venda para demonstrações didáticas.

Pode-se dizer que Reis inventou o primeiro aparelho para transmitir sons à distância por meio da eletricidade, o qual, porém não transmitia voz à distância.

Bibliografia - MARTINS, Roberto - A Fundamentação da Telefonia através da História - Parte 1: Da

Invenção ao Início do Século XX (pesquisa realizada para a Fundação Telefônica, em 2002)
- Museu do Telefone - Companhia Lithographica Ypiranga - 1977

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A história da comunicação

Confira a história da comunicação.

1. Só no papo

A fala surge quando gestos, expressões faciais e o uga-uga da Pré-História não são mais suficientes

2. A mensagem eternizada

A escrita libera o cérebro da tarefa de memorizar. Com ela, o saber pode ser acumulado fora do corpo e é possível deixar registros que serão vistos mesmo depois da morte. A palavra escrita torna-se sagrada e os livros, pilares das religiões

3500 a.C.

Os egípcios criam os hieróglifos

4000 a.C.

Já havia serviço de correio entre chineses

8000 a.C.

As primeiras inscrições em carvernas são dessa data

3. Reprodução em série

A prensa, inventada por Gutenberg em 1452, permitiu a reprodução fiel e a difusão de uma mesma mensagem. Os acontecimentos circulam com rapidez. Notícias ganham alcance continental, de forma periódica. Instala-se a idéia da liberdade de imprensa: é preciso dizer tudo

305 d.C.

Primeiras prensas de madeira inventadas na China

1450

Jornais aparecem na Europa

1650

Primeiro jornal diário aparece na Alemanha

4. A mensagem sem fronteiras

O ar é um suporte mais dinâmico e democrático do que as folhas de papel. Com os veículos "de massa", é possível atingir uma multidão de anônimos. As ondas do rádio encurtam distâncias. O telégrafo e o telefone possibilitam a comunicação instantânea - com a interação quase imediata de emissor e receptor - e, por isso, funcionam quase como extensões do corpo

1835

O telégrafo elétrico é inventado por Samuel Morse

1876

Alexander Graham Bell patenteia o telefone elétrico

1887

Emile Berliner inventa o gramofone

1894

O italiano Marconi inventa o rádio. Trinta anos depois, o veículo está no auge da sua popularidade

1899

Primeira gravação magnética, ponto de partida de fitas cassete

1948

Inventado o LP de vinil de 33 rotações

5. A ilusão do mundo real

A comunicação audiovisual poupa-nos o esforço da imaginação. Da urgência de captar o movimento de uma sociedade industrializada, surge a fotografia. Logo o cinema cria a ilusão do movimento real. A TV traz o mundo para dentro da sala - e, com ele, as mensagens publicitárias. Há uma nova maneira de perceber o planeta: é o começo da globalização

1827

Joseph Nicéphore Niépce faz a primeira fotografia de que se tem notícia

1888

Aparece a câmera fotográfica de filme de rolo

1895

Os irmãos Lumière inventam o cinema na França

1910

Thomas Edison faz a demonstração do primeiro filme sonoro

1923

A televisão é inventada por Vladimir Kosma Zworykin

1927

Primeira transmissão de televisão na Inglaterra

1934

Inventado o videotape

6. Tudo ao mesmo tempo agora

O mundo virtual é um imenso arquivo de dados sempre disponível. Não há fronteiras: tudo está ligado em rede planetária. E um minúsculo aparelho é capaz de nos dar acesso a todo esse universo. Os impactos da internet mudam as relações de trabalho, o aprendizado e a vida social. É preciso rever alguns conceitos, como a liberdade de expressão

1971

Surge o primeiro disquete de computador

1976

Inventado o computador pessoal Apple I

1981

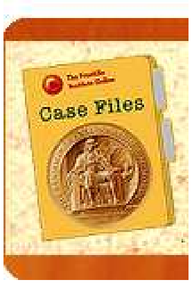
Vendido o primeiro PC da IBM

1994

Nasce a World Wide Web

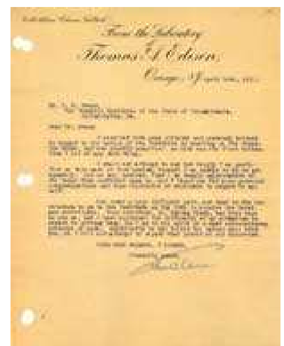
THE FRANKLIN INSTITUTE

Search



Introduction Scientist Science Rewards Resources Credits

Telephone Transmitter



Thomas A. Edison Letter (1.7M)

To R.B. Owens, Expressing surprise and gratitude on receiving the Franklin Medal, 4/14/1915

The telephone, invented by Alexander Graham Bell in 1876, converted the sound waves from the human voice to electric impulses, conducted the impulses through a wire, and converted them back to the human sound at the other end of the wire. The originating transmitter contained a parchment membrane that vibrated in response to sound. A metal button attached to the membrane sent the varied movements to an electromagnet and electric current corresponding to the vibrations was induced. This induced current traveled to the receiving device and where the process was reversed, the electricity caused movement of a magnet which then caused a membrane to vibrate and emit the corresponding sounds.

Thomas Edison worked to improve a drawback in Bell's invention: the weakness of the electric signal limited the quality and distance of the message. His approach was to improve the sensitivity of sound detection at the transmitter by replacing the parchment membrane with a disc of compressed carbon set between metal plates. The electrical resistance of carbon is extremely sensitive to the minute pressure changes caused by sound waves. Edison's solution—improved later by substitution of granulated carbon and then roasting of the granules—became a basic component of telephones for almost a hundred years.

<< A FITTING TRIBUTE | ELECTRIC LAMP >>

Major Inventions And Events In The Life Of

Thomas Alva Edison

Another Award-Winning "*CleanContents*" Document By Gerald Beals

1847 Born on February 11th at Milan, Ohio.

1854 Moved to Port Huron, Mich.

1857 Set up a chemical laboratory in the cellar of his home.

1859 Became a newsboy and "candy butcher" on the trains of the Grand Trunk Railway, running between Port Huron and Detroit.

1862 Printed and published "The Weekly Herald," the first newspaper ever to be typeset and printed on a moving train. The London Times features a story on him and his paper, giving him his first exposure to international notoriety.

1862 Saved - from otherwise certain death in a train accident - the young son of J. U. Mackenzie, station agent at Mount Clemens, Mich. In gratitude, the child's father taught him telegraphy.

1862 Strung a telegraph line from the Port Huron railway station to Port Huron village and worked in the local telegraph office.

1863 Obtained his first position as a regular telegraph operator on the Grand Trunk Railway at Stratford Junction, Canada. Later, is resigned by them to help develop a duplex system of telegraphy

1863-1868 Spent nearly five years as a telegraph "tramp operator" in various cities of

the Central Western states, always experimenting with ways to improve the apparatus.

1868 Entered the office of Western Union in Boston as a telegraph operator. Becomes friendly with other early electricians - especially a later associate of Alexander Graham Bell named Benjamin Franklin Bredding - who was much more knowledgeable than both himself and Bell on the state-of-the-art of telegraphy and electricity. Entered the private telegraph line business on a very modest scale. Resigned from Western Union - was about to be fired anyway - in order to conduct further experimentation on multiplexing telegraph signals.

1868 Came up with his first patented invention, an Electrical Vote Recorder. Application for this patent was signed 0n October 11, 1968. Because the invention was way ahead of its time, it was heartily denigrated by politicians... He now becomes much more oriented towards making certain there is a strong public demand and associated market for anything he tries to invent.

1869 Landed in New York City by way of a Boston steamship, poor, penniless, and in debt. While seeking work, chanced being in the operating room of the Gold & Stock Telegraph Company when their ticker apparatus broke down. No one but he was able to fix it, As a result, he was given a job as superintendent at the remarkable wage of $300 per month.

1869 Went into partnership with Franklin L. Pope as an electrical engineer. Radically improved stock tickers and patented several associated inventions, among which were the Universal Stock Ticker and the Unison Device.

1870 Received the first cash payment for one of his inventions, a $40,000 check. Sent money back to his financially desperate parents. Opened a manufacturing shop in Newark, where he made stock tickers and worked on developing the *quadruplex* telegraph.

1871 Assisted Sholes, the inventor of the typewriter, in making the first successful working model of that device.

1872-1876 Worked on and patented several of his most important inventions, including the motograph and automatic telegraph systems such as the quadruplex, sextuplex and multiplex telegraph which saved Western Union many millions of dollars in wiring. Also invented paraffin paper (which was first used for wrapping candies), the electric pen, the forerunner of the present day mimeograph machine, the carbon rheostat, the microtasimeter, etc.

1876-1877 Invented the carbon telephone transmitter "button", which finally made telephony a commercial success. Significantly, this invention not only led to the development of the microphone, which made early radio possible, but the solid state "diode" or transistor which makes so many of today's electronic devices possible. Invented the phonograph. (The patent on which was later issued by the United States Patent Office - within two months after its application - without a single reference.)

1878 Continued to improve the phonograph. Later in the year, went with an astronomical party to Rawlins, Wyoming for rest and to test his new microtasimeter

during an eclipse of the sun. Associates key him in to the world-wide need for a workable incandescent light bulb. Upon returning, he began to investigate the "electric light problem in earnest."

1878 Became the first to apply the term "filament" to a fine wire that glows when carrying an electric current. In a prophetic article in the North American Review he foreshadowed ten prominent uses for the phonograph - all since accomplished - including its combination with the telephone, which became a reality in 1914 with the perfection of the Telescribe.

1879 Invented the first commercially practical incandescent electric lamp. The lamp itself was perfected on October 21st, 1879, on which day there was put into circuit the first bulb embodying the principles known as the "Edison modern incandescent lamp." This bulb maintained its incandescence for over 40 hours.

1879 Made radical improvements on the construction of dynamos, including the mica laminated armature and mica insulated commutator. Also constructed the first practical generators for the systems of distribution of current for lighting. Invented and improved upon numerous systems of generation, distribution, regulation and, measurement of electric current and voltage. Invented sockets, switches, insulating tape, etc. (Meanwhile, he also invented gummed paper tape now commonly used in place of twine or string for securing packages.)

1879 Constructed the first electric motor ever made for a 110 to 120 volt line at Menlo Park, N. J. This device is still in existence and operative, and is located in the Edison Historical Collection in New Jersey. On December 31, gave the first public demonstration of an electric lighting system in streets and buildings at Menlo Park, N. J., utilizing underground mains.

1880 Invented further improvements in systems and details for electric lighting and laid the first groundwork for introducing them on a commercial basis. Established the first incandescent lamp factory at Menlo Park, N. J.

1880 Invented a magnetic ore separator. Invented and installed the first life-sized electric railway for handling freight and passengers at Menlo Park, N. J.

1881 Opened business offices at No. 65 Fifth Avenue, New York City. Established his second and improved commercial incandescent lamp factory at Harrison, N. J. Also organized and established shops at 104 Goerck St., 108 Wooster St., and 65 Washington St. in New York City, for the manufacture of dynamos, underground conductors, sockets, switches, fixtures, meters, etc.

1882 On September 4th, he commenced operation of the first profit oriented central station in the United States in New York City, for the distribution of current for electric lighting.

1882-1883 Designed and contracted for the first three-wire central station for distributing electric light, power, and heat - in standardized form - in Brockton, Massachusetts. By October, had completed construction of that station. Discovered a previously unknown phenomenon that later came to be known as the "Edison effect,"

but he called "Etheric Force." Specifically, determined that an independent wire, grid, or plate placed between the legs of the filament of an incandescent lamp acted as a "damper" or valve to control the flow of current. The associated Patent No. 307,031 was issued to him later that year. Twelve years later these previously unknown phenomena were recognized as electric waves in free space and became the foundation of wireless telegraphy. Most significantly, this discovery - along with his carbon button - involved the foundation principles upon which the diode was later invented, and upon which radio, television, and computer transistors are based. Moved from Newark to a new laboratory at Menlo Park...

1883 Constructed the first, relatively crude, three-wire central system for electric lighting in a simple wooden structure in Sunbury, Pa.

1880-1887 Underwent his most strenuous years of invention as he extended and improved greatly upon his electric light, heat, and power systems. Took out over three hundred patents, many of which were of extraordinary and fundamental importance. The most were those relating to "dividing" electric power and standardizing the three-wire system and improving its associated generation and feeder system.

1881 - 1887 Invented a system of wireless telegraphy, (by induction) to and from trains in motion, or between moving trains and railway stations. The system was installed on the Lehigh Valleys R. R. in 1887, and was used there for several years. Invented a wireless system of communication between ships at sea, ships and shore and ships and distant points on land. Patent No. 465,971 was issued on this invention, the application having been filed May 23, 1885 - two years prior to the publication of the work of Hertz. Most significantly, this patent was eventually purchased from Edison by the Marconi Wireless Telegraph Company.

1887 Moved his center of experimentation to the laboratory at West Orange, New Jersey.

1887-1890 Made major improvements on the brown wax and black wax cylinder phonograph. Obtained over eighty related patents, while establishing a very extensive commercial business in the manufacture and sale of phonographs and records, including associated dictating machines, "shaveable" records, and shaving machines.

1891 Made a number of inventions associated with improving electric railways.

1891 Invented and patented the motion picture camera. This mechanism, with its continuous tape-like film, made it possible to take, reproduce, and project motion pictures as we see and hear them today.

1891-1900 Developed his great iron ore enterprise, in which he did some of his most brilliant engineering work. One of his most important inventions of this period was a giant roller machine for breaking large masses of rock and finely crushing them. Invented the Fluoroscope...realizing the necessity and value of a practical fluorescent screen for making examinations with X-rays, he made thousands of crystallizations of single and double chemical salts and finally discovered that crystals of Calcium Tungstate made in a particular way were highly fluorescent to the X-ray. Also made

many several improvements on the X-ray tube.

1900 - 1910 Invented and perfected the steel alkaline storage battery and made it a commercial success.

1900 -1909 Established his once famous Portland Cement Co. and made many important inventions relating to the processes involved in the production of pre-cast buildings. In 1907, he introduced the first concrete mold for making one-piece houses called "single piece cast concrete homes." The unique type of kiln he developed for making these houses proved to be of great importance in the cement industry.

1902-1903 Worked on improving the Edison Primary Battery. Continued to invent improvements to his phonograph - his favorite invention - and associated cylinders.

1905 Introduced a revolutionary new type of dictating machine, which enabled the dictator to hear repetitions and make paper scale corrections.

1907 Introduced the Universal Electric Motor which made it possible to operate dictating machines etc. on all lighting circuits.

1910-1914 Worked on - and much improved - the disc phonograph, resulting in the production of records and playing instruments which reproduce vocal and instrumental music with overtones that had relatively "extraordinary fidelity and sweetness." Introduced the diamond point reproducer and the "indestructible" record, thereby commencing a new era in phonographs.

1912 Having spent many previous years in its general development and perfection, finally introduced the Kinetophone or talking motion picture.

1913 Introduced an important automatic correction device for the dictating machine.

1914 Being the largest individual user in the United States of carbolic acid (for making phonograph records), he found himself at the onset of World War One in danger of being compelled to close his factory by reason of a related embargo placed on exporting said substance by England and Germany. The basic issue was that carbolic acid was in great demand for the purpose of making explosives. He now devised an alternative method for making carbolic acid synthetically, and finally put crews of men to work twenty four hours a day to build a related plant. By the eighteenth day, was producing carbolic acid, and within four weeks was turning out a ton of it per day.

1914 On the night of December 9th his great plant at West Orange, N. J. was the scene of a spectacular fire. As soon as he saw the scope of this conflagration he enthusiastically sent word to several friends and members of his family, advising them to "Get down here quick.... you may never have another chance to see anything like this again!" Within hours after the fire had been extinguished, he had given orders for the complete rehabilitation of the plant. Early the next morning he arrived with a gang of men and began to supervise the task of clearing the debris. Hundreds more workers were added throughout the day, and the project continued around the clock for several months until an even larger and more efficient facility than the original had been completed.

1914 Invented the Telescribe, combining the telephone and the dictating phonograph, thus permitting - for the first time - the recording of both sides of a telephone conversation.

1915 Because military conflicts in Europe had created an enormous demand for phenols, and supplies were uncertain, he invented the first synthetic form of carbolic acid (C6H6O). Next, after evaluating all of the literature available on the erection and operation of benzol (C6H6) absorbing plants, he drew up plans for benzine-making facility that could be *readily* installed. Although it had previously taken nine months to a year to install such a facility, his first such structure was put into operation in just forty five days. A larger plant designed for the Woodward Iron Company at Woodward, Ala., was completed in only 60 days. At about this time, he also built two other large benzol plants in Canada, each of were was put into operation in less than sixty days. All these plants became highly successful commercial operations, producing benzol, toluol, solvent naphtha, xylol, and naphthalene.

1915 In the early months of this year, he conceived the idea of helping out the struggling textile and rubber industries of America by making myrbane, aniline oil, and aniline salt, which, are still important commercial substances, and which had been previously imported from Germany. Following his usual procedure, he first exhausted the literature on the subject, and then laid out the plant. By bringing great pressure to bear on his workers - and by working day and night himself - he constructed the plant in just forty five working days, commenced deliveries in June, and was soon turning out over 4,000 pounds of these products per day.

1915 During World War One, the dyeing industry was suffering from a great scarcity of paraphenylenediamine, formerly imported from Germany. Since he was using the chemical in the manufacture of records for his Diamond Disc Phonograph and was no longer able to procure it, he experimented until he found a way to synthesize it. Much pressure was now brought to bear upon him to supply some of it to fur dyers and others. He equipped a separate plant for this purpose and ultimately manufactured over a ton a day.

1915 The great scarcity of carbolic acid in America now brought innumerable requests to him to sell some of this product. His first such plant worked well, producing about 7,000 pounds a day. This, however, soon proved to be insufficient to supply the demand. He now projected and installed another plant with a capacity of about 7,000 pounds additional per day. As he devised improved processes for use in the latter plant there were a vast number of difficult problems to overcome. However, with his usual energy and dogged perseverance - involving many weeks of strenuous work - he finally prevailed.

1916 Worked several months making important improvements in the manufacture of disc phonograph records and new methods and devices for recording. Worked on improved methods and processes producing his chemical products. Worked out processes for making a paramidaphenol base, hydrochloride benzidine base, and sulphate and constructed new plants for their manufacture. As President of the Naval Consulting Board, he did a great deal of work connected with national defense.

1917-1918 Worked on special experiments relating to defense for the United States Government. See below.

I Locating positions of guns by sound ranging.

2 Detecting submarines by sound from moving vessels.

3 Detecting, on moving vessels, the discharge of torpedoes by submarines.

4 The faster turning of ships.

5 Strategic plans for saving cargo boats from harm by enemy submarines.

6 Development of collision mats for submarines and ships.

7 Methods for guiding merchant ships out of mined harbors.

8 Oleum cloud shells.

9 Camouflaging ships.

10 Blocking torpedoes with nets.

11 Increased power for torpedoes.

12 Coastal patrol by submarine buoys.

13 Destroying periscopes with machine guns.

14 Cartridges for taking soundings.

15 Sailing lights for convoys.

16 Smudging skyline.

1 17 Underwater searchlights.

18 High speed signaling with searchlights.

19 Water penetrating projectiles.

20 Airplane detection.

21 Observing periscopes in silhouette.

Edison was awarded 1,368 separate and distinct patents during his lifetime. He passed away at age 84 on October 18th, 1931 - on the anniversary date of his invention of the incandescent bulb.

ADDENDUM

Among all of the above patents, only one is associated with the field called "pure science." Discovered in 1883 - the same year Edison constructed the world's first

standardized central power plant - it eventually became known as *the Edison effect*. Although he never successfully applied this concept to any of his own inventions, it clearly anticipated the later development of vacuum tubes and transistors. Accordingly - it was of major significance in effecting the first wireless transmission, and the later development of the radio and television industry. Perhaps of even more significance, the principle is still of fundamental importance in today's silicon chip and computer industry.

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