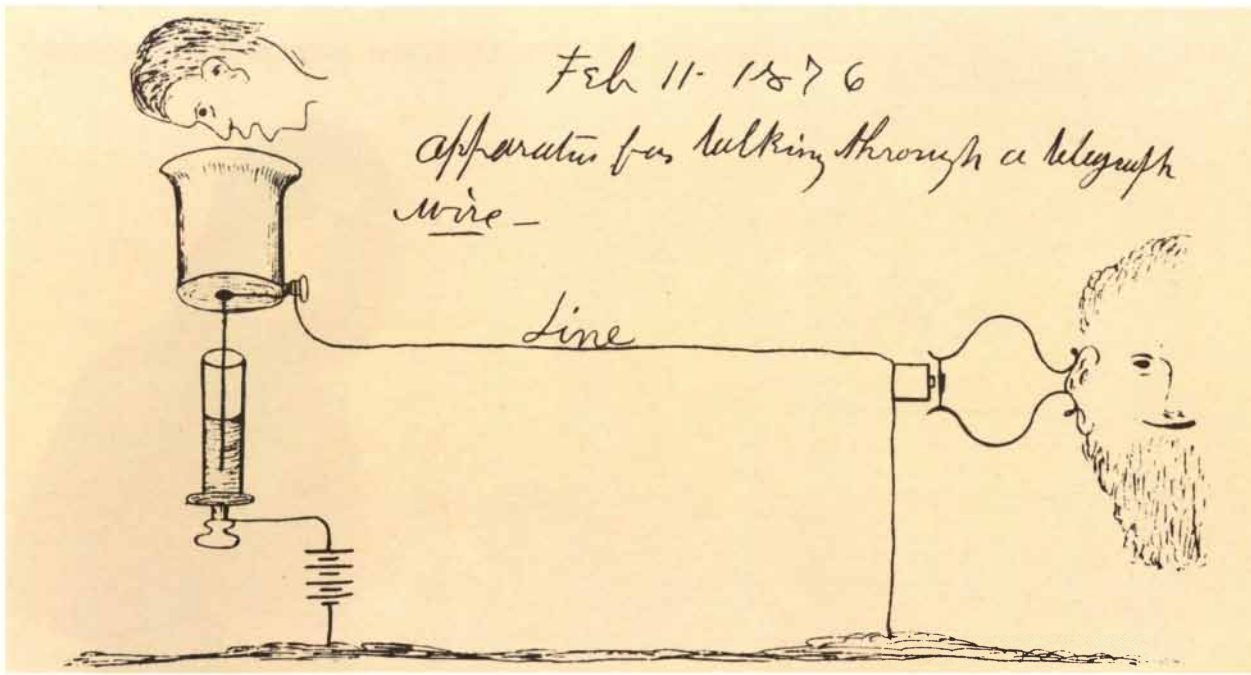
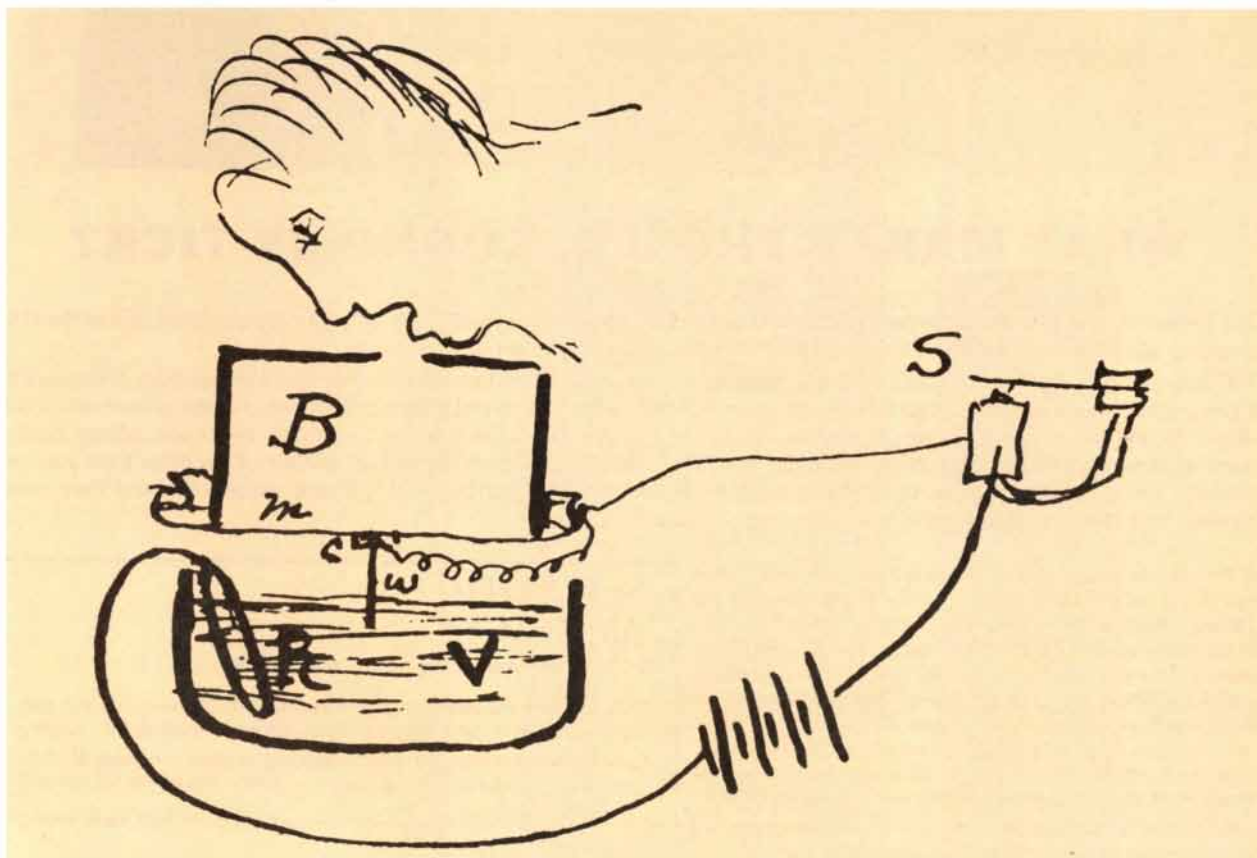




STRIKING PARALLELS between the telephones envisioned by Elisha Gray and Alexander Graham Bell are evident in their respective sketches of the instruments. Both Gray's transmitter (*top*) and Bell's (*bottom*) depended on varying the resistance to the flow of current from a battery. Both variations would be caused by the vertical movement of a needle in a liquid bath; the motion would be due to the response of a diaphragm to the sound waves of the human voice. In Gray's transmitter the variation in resistance would depend on changes in the distance between the tip of the needle and the bottom electrode. In Bell's the variation would depend on the changes in the area of the wedge-shaped needle tip immersed in the bath. The varying current would then pass through an electromagnet (*right*) at the receiving end of the circuit; variations in the magnetic field would cause a second diaphragm (in Gray's scheme) or a metal reed (in Bell's) to vibrate, thereby reproducing the sound waves that actuated the transmitter. Gray made the sketch of his device on February 11, 1876, some two months after he conceived the idea. Bell made his sketch on March 9, 24 days after filing his patent application.

Two Paths to the Telephone

As Alexander Graham Bell was developing the telephone Elisha Gray was doing the same. Bell got the patent, but the episode is nonetheless an instructive example of simultaneous invention

by David A. Hounshell

In one day in 1876—February 14—the U.S. Patent Office received two communications describing the electrical transmission and reception of human speech by means of variations in the resistance of the transmitter. The variable-resistance device was the original telephone. The first description was in the form of a patent application by a 29-year-old amateur inventor whose name became world-famous: Alexander Graham Bell. The second description, which arrived only hours later, came from a 41-year-old professional inventor who had been granted the first of his many electrical patents almost a decade earlier: Elisha Gray.

Who was Elisha Gray? Why is Bell widely if not universally known as the inventor of the telephone and Gray, who envisioned the same device at the same time, known to few except historians of technology? To answer the question it is helpful to have an understanding of not only the technical aspects of this classic example of simultaneous invention but also the social ones. In the history of the telephone the differences between the world of the professional and the world of the amateur appear at almost every turn, as will be made clear by a brief exploration of the two worlds, first Gray's and then Bell's.

Elisha Gray, born in Barnesville, Ohio, in 1835, attended Oberlin College, but he was not graduated owing to ill health. His early interest in the electrical aspects of telegraphy led in 1867 to his first patent, for a self-adjusting telegraph relay. His device attracted the attention of the principal firm in the field, the Western Union Telegraph Company. It also earned Gray enough money for him to secure a partnership in a Cleveland firm that manufactured telegraphic instruments. He and his partner, Enos Barton, transformed the company into the nation's leading maker of electrical apparatus, renamed it the Western Electric Manufacturing Company and in the early 1870's relocated it in Chicago. In 1872 Western Union acquired a one-third interest in the business, and Western Electric eventually became the sole supplier of telegraphic equipment to Western Union.

Telegraphy had grown steadily in the U.S. from its introduction in 1844, and that growth had accelerated in the Civil War years. By the end of the war some 50,000 miles of telegraph wire had been strung over routes totaling nearly 30,000 miles, and a decade later the figures had risen to 250,000 miles of wire over routes of more than 100,000 miles. Until 1872, however, each wire could transmit only one message in one direction at a time. Enlarging the transmission capacity between any two points could be accomplished only by stringing new wires.

This one-way-at-a-time bottleneck was built into the telegraph system because the transmitted signal consisted of intermittent pulses of direct current. In 1872, however, Western Union adopted a "duplex" system of transmission developed by Joseph B. Stearns, a Boston electrician. A modification of the Morse system, the Stearns system allowed two messages to be transmitted simultaneously, one from each end of the wire. The adoption of the duplex system effectively doubled the capacity of the Western Union network. Could multiplex systems be developed, systems that would increase the capacity many times further? One thing was certain: the inventor of a multiplex system could virtually name his own price.

Gray's close relations with Western Union made him aware of the rewards awaiting the successful inventor, and early in 1874 he hit on a solution almost by pure accident. One day he found his nephew, whom he allowed to use his electrical apparatus, amusing himself in the bathroom with two battery-powered circuits. In one circuit the battery caused a reed "electrotome" to vibrate. The vibrations opened and closed the other circuit, which included an induction coil. Gray's nephew had also connected one lead of the second circuit to the zinc bathtub and was closing the circuit and "taking shocks" from the induction coil by rubbing his hand, which held the other lead, across the surface of the tub.

The vibrating reed made an audible hum, and when Gray's nephew rubbed his hand on the tub, a second hum of the same pitch was heard. Gray's interest was piqued. He changed the frequency of the reed and found that the sound made by the rubbing of his hand on the tub changed to match it. The action of the induction coil was to transform the on-off impulses imposed on the circuit by the vibrating reed into a sinusoidal wave of electric current.

Gray was quick to explore the phenomenon of what he named vibratory currents, seeking to find some practical use for their transmission and reception. Although he found no immediate application, he so resolutely believed vibratory currents would have a major usefulness that he resigned as the superintendent of Western Electric, determined to pursue the matter on an independent full-time basis. In order to do so he secured the financial backing of Samuel S. White, a wealthy manufacturer of dentistry equipment in Philadelphia.

With funds at his disposal Gray soon built four experimental devices: two transmitters of frequencies in the audible range and two receivers. One of the transmitters he called a single-tone transmitter; it was essentially a refinement of his nephew's bathtub apparatus. The other he called a two-tone transmitter; it was capable of simultaneously generating sinusoidal waves of two different frequencies. One of the two receivers seems quaint in retrospect; the other was quite conventional.

The first receiver consisted of a violin with its strings removed and a silver plate attached to the soundboard. When one of the leads of the induction-coil circuit was connected to the plate and the hand holding the other lead was rubbed across the metal surface, as it

was in the bathtub experiment, the tones generated by either transmitter were reproduced with a richer quality. The other receiver consisted of an electromagnet and a metal diaphragm. When the magnet caused the diaphragm to vibrate according to the frequencies of the current in the induction-coil circuit, the tones of the transmitters were faithfully reproduced. The results suggested to Gray three possible applications.

The most obvious application and probably the easiest to perfect was what today would be called an electric organ; Gray thought of it as a "musical telegraph." He would merely have to build a keyboard consisting of switches that would actuate a series of single-tone transmitters, each tuned to a different musical pitch. It would even be possible to sound chords by pressing two or more keys simultaneously.

A more immediate commercial application was implicit in the ability of a telegraph wire to carry a "composite current," one consisting of two, four or a much larger number of frequencies. Could not each tone be made to carry a telegraph signal? The musical telegraph could function as a multiplex-signal transmitter if a receiver could be devised that was able to segregate the individual tones of the composite current. For this purpose, Gray realized, neither of his receivers would be of any use.

The magnet-and-diaphragm receiver, however, was perfectly suited to the third application Gray had in mind. If many combinations of tones could be carried by wire and the composite signal could then be reproduced electrically, would it not be possible to transmit the sounds of the human voice? Gray may have perceived an irony in this application. Just as the potential multiplex system of telegraphy was in need of a receiver, so the potential composite-current system of telephony was in need of a transmitter. Gray saw no easy way to solve the voice-transmitter problem, although he immediately envisioned a complex synthesizing device consisting of a number of individual tone transmitters, each responding to a different tone of the human voice.

RECEIVING APPARATUS, a stringless violin with a silver plate covering the soundboard, was devised by Gray in 1874 to draw attention to the "vibratory currents" first made audible by the bathtub experiment (*see top illustration on opposite page*). Here one lead from the induction coil connects to the silver plate. The demonstrator (Gray in this instance) holds the other lead in his hand and rubs his fingers along the metal surface. The musical tone thus generated duplicated the tone of his transmitter, a metal reed that vibrated at audio frequencies.

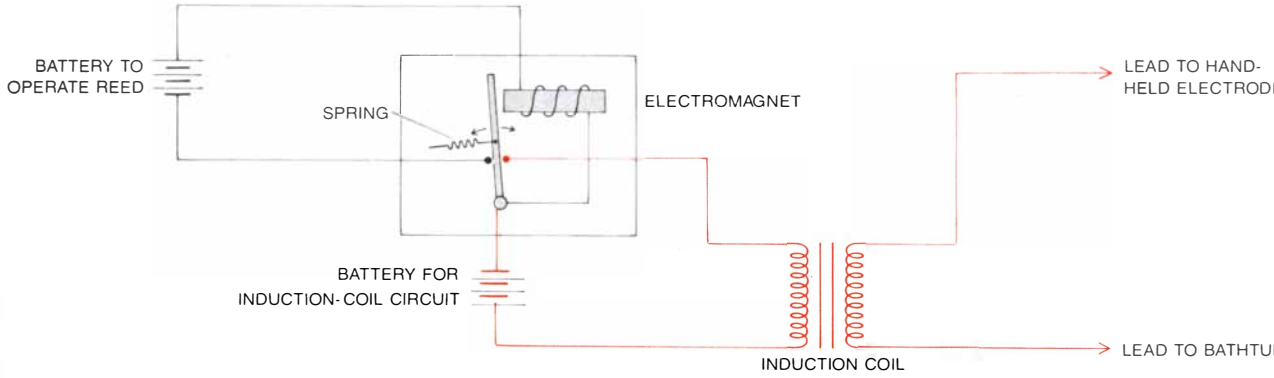
Within a few weeks of the bathtub episode Gray, in a rush of experimental activity, had discovered and in his mind explored the seemingly boundless possibilities of utilizing audible vibratory currents. In May of 1874, confident that he had sufficiently investigated the implications of these currents, he demonstrated his transmitters and receivers to audiences of telegraphy experts in Washington, New York and Boston. Reports of the demonstrations allow the inference that he mentioned all three potential applications of this work: the transmission of music, the transmission of multiple messages and the transmission of the human voice. Gray's tour gave rise to a flurry of debate.

The New York Times reported one Western Union official as saying that Gray had taken "the first step toward doing away with manipulating instruments [that is, telegraph keys] altogether." "In time," the official continued, "the operators will transmit the sound of their own voices over the wire, and talk with one another instead of telegraphing."

The leading journal of the industry, *The Telegrapher,* took the opposite tack. Declaring that the transmission of the human voice was nothing new, the journal cited an account it had published five years earlier describing the Reis telephone. Johann Reis, a German schoolmaster and experimenter, had in 1861 coined the word "telephone" to describe a laboratory device he had built to reproduce music and the voice. *The Telegrapher* noted that the Reis telephone had proved to have "no direct practical application" and remained "a mere scientific... curiosity."

The Telegrapher also mentioned what it said was an old joke in telegraphic circles. Voice communications had once been tried on the telegraph line between Philadelphia and New York, the story went, "but had to be given up on account of the Philadelphia operator's breath smelling too strongly of bad whiskey." The journal's view of the Reis telephone was echoed by A. L. Hayes, one of Gray's own patent attorneys and himself an expert in electrical technology. Assuring his client of the novelty and importance of the new discoveries, he went on to say the German instrument was "merely a toy" that could be made to work only with careful handling and that amounted to no more than a scientific oddity. Reis had died that same year, and interest in his "curiosity" had languished.

Discouraged by the negative opinions on voice communication, Gray turned in the summer of 1874 to the development of the remaining applications: the musical telegraph and multiplexing. For the transmission of music



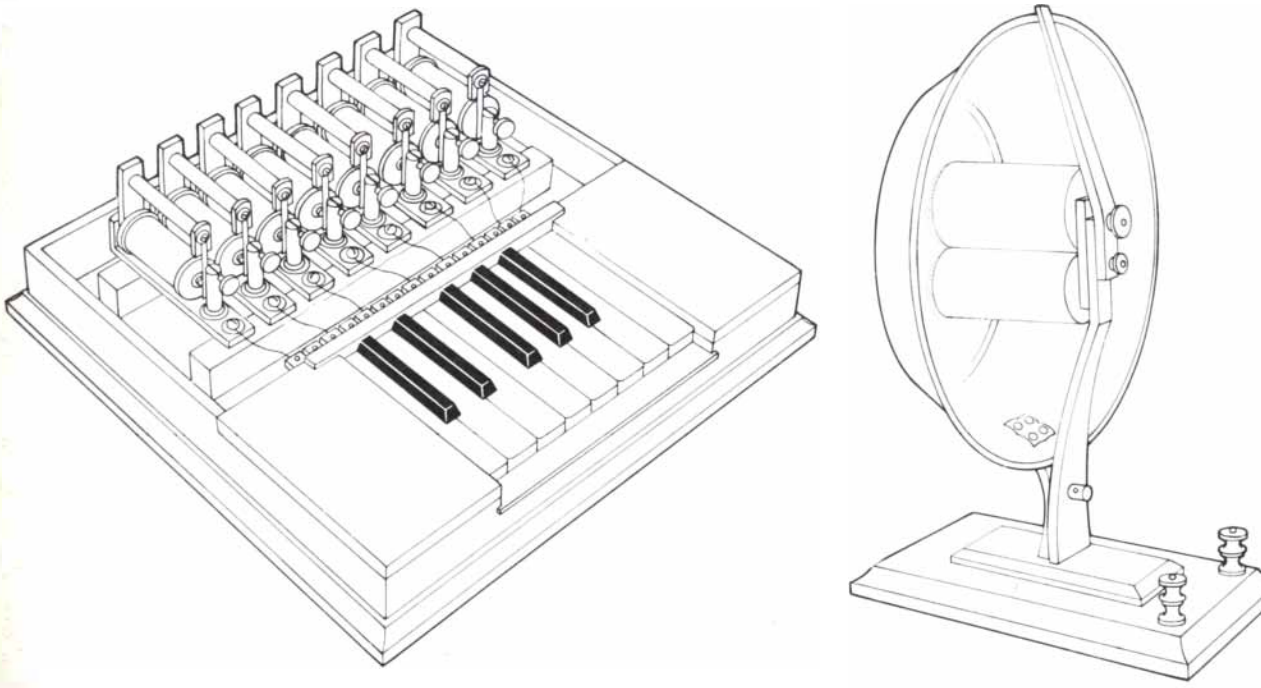
BATHTUB EXPERIMENT, based on a chance discovery by Gray's nephew in 1874, involved the circuits illustrated here. The first circuit, at the left, was closed and opened by the back-and-forth motion of a spring-loaded metal reed that vibrated at a fixed frequency. When the circuit was closed, it energized an electromagnet. The response of the reed to the attraction of the magnet reopened the circuit and the action of the spring promptly reclosed it. A second pair of contacts, one of them fixed to the reed, simultaneously closed and opened a second circuit (*color*). An induction coil in this circuit converted the interrupted current into a continuous sinusoidal current of the same frequency as the tone of the reed. When one of the leads from the induction coil (*right*) was attached to a zinc tub, and the experimenter, holding the other lead, rubbed his hand across the tub's surface, a sound was heard identical in pitch with the tone of the reed.

he built an organlike apparatus with an array of single-tone transmitters covering a range of one octave; later it was enlarged to a two-octave apparatus. To improve the tone quality of the receiver Gray made the diaphragm larger by replacing the flat metal plate with a washbasin; thereafter the device was known as the washbasin receiver.

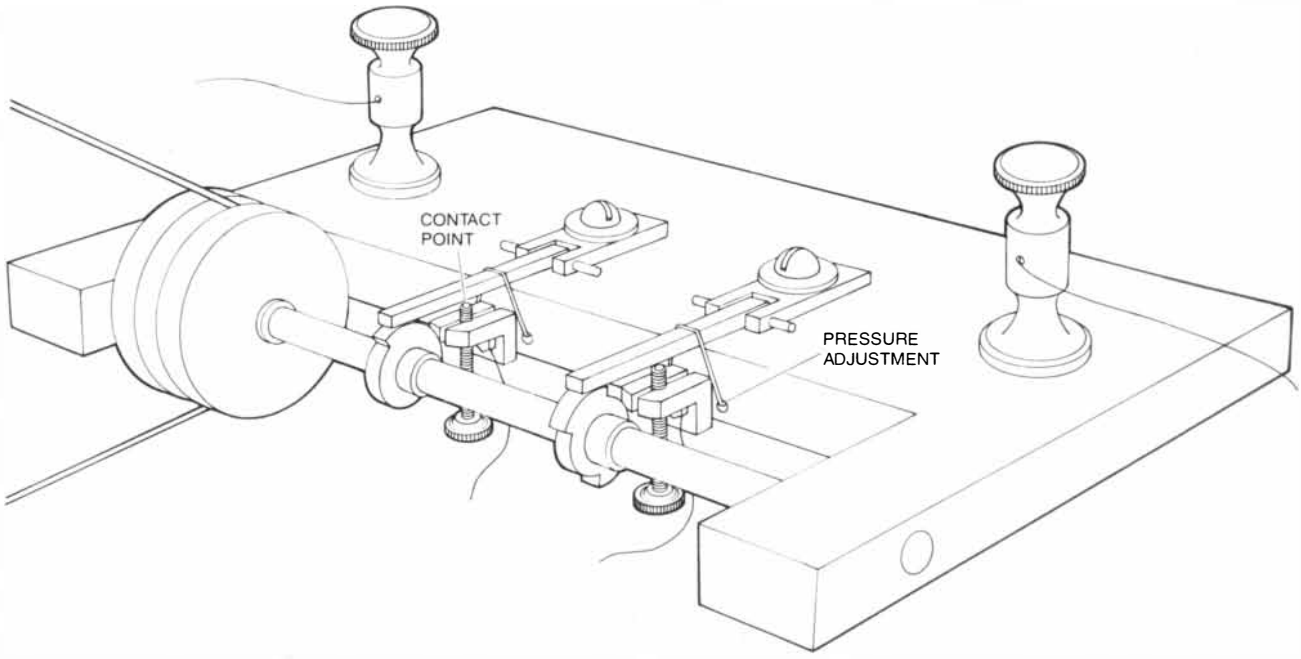
In August and September of 1874 Gray toured England with these devices and others. Among those for whom he demonstrated them was John Tyndall, who succeeded Michael Faraday at the Royal Institution, and J. Latimer Clark, then perhaps the most eminent figure in British telegraphy. Gray also took advantage of the visit to test how well his vibratory currents performed when they were conducted by submarine cables. He concluded that there were no technical obstacles in the way of transforming musical telegraphy into a multiplex-message system, where both he and his backer White knew the greatest financial rewards would lie.

For the rest of 1874 Gray concentrated on multiplexing. In an effort to learn more about audio-frequency currents, as they would be called today, he built what he called a "mechanical" transmitter. The vibrating reed was replaced by two cams, mounted on a shaft rotated at speeds equal to audio frequencies, that opened and closed two sets of contact points. Adjustable "elastic springs" were included for regulating the pressure between the points.

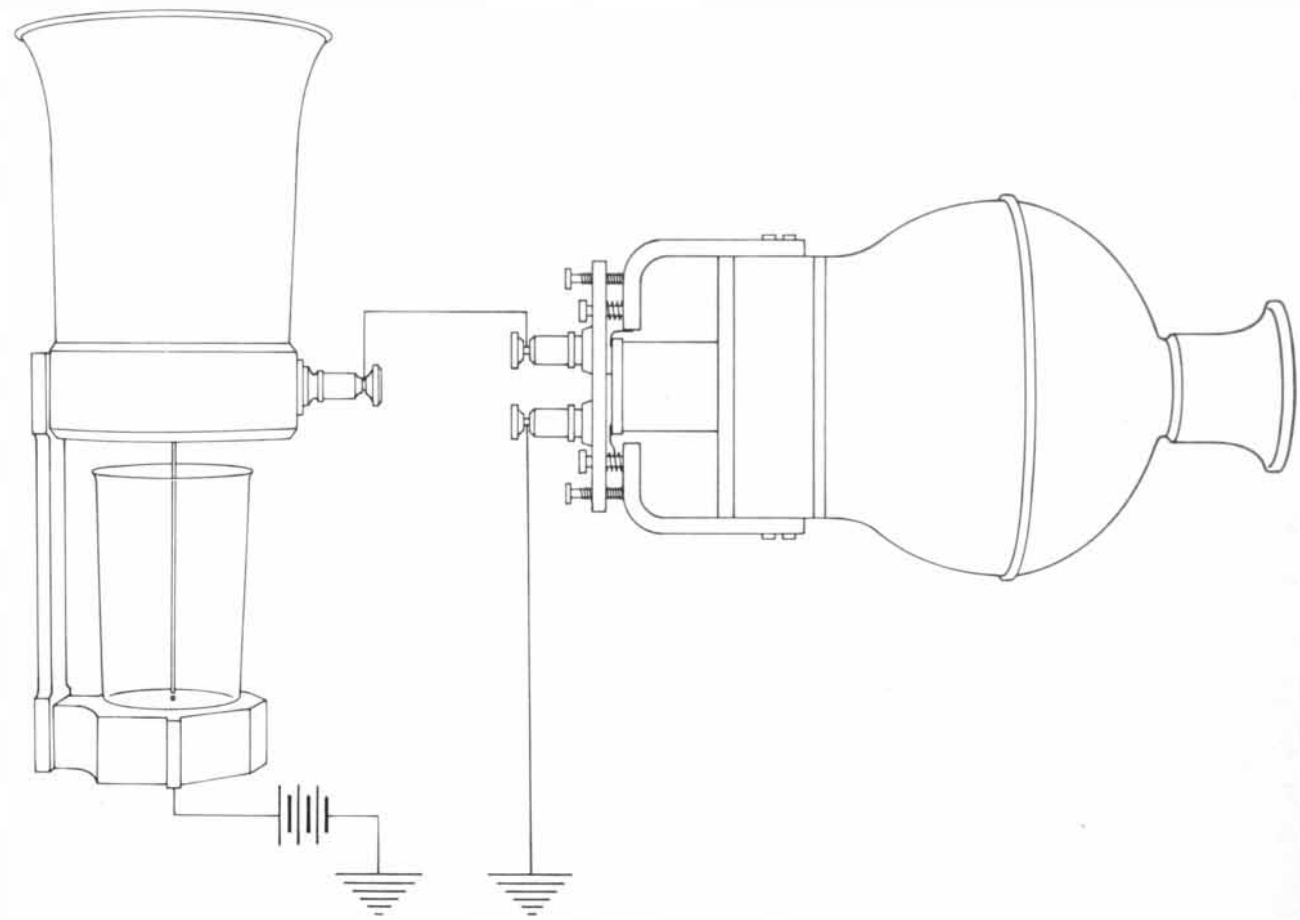
The first time Gray tested his mechanical transmitter, on January 1, 1875, he observed something completely unexpected. With only one set of contact



ADVANCED TRANSMITTER AND RECEIVER were two of the devices Gray took to England in 1874. The keyboard device at the left incorporated an array of single-tone transmitters that covered a range of one octave. The upended washbasin at the right formed the diaphragm of a receiving apparatus. Paired electromagnets translated "vibratory currents" into vibrations of the diaphragm.



SUBSTITUTE FOR REEDS, devised by Gray late in 1874, was a belt-driven camshaft. Two cams opened and closed sets of contact points, and springs allowed for adjustment of the pressure between the points. Testing his "mechanical transmitter" in the audio-frequency range on January 1, 1875, Gray found that changing the pressure between points altered the output of interrupted current in such a way that his washbasin receiver emitted various voicelike sounds. He concluded that a simple device could transmit the human voice.



GRAY'S TELEPHONE, in the form presented in his Patent Office caveat application of February 14, 1876, differed little from the apparatus he had sketched three days earlier. The slight changes in current produced by the movement of the transmitter diaphragm at the left resulted in electromagnet-powered vibrations of the receiver diaphragm at the right. Although Gray might have contested Bell's patent application, filed earlier the same day, he accepted the advice of his patent attorney and his financial backer and dropped the matter.

points in operation he found, not unexpectedly, that the washbasin receiver produced tones that varied in frequency according to the speed of the camshaft. When he then adjusted the tension of the spring, however, thereby either lessening or increasing the pressure between the points, he found he "was able to imitate many different [voice] sounds." He at once concluded that the complex synthesizing voice transmitter he had conceived of earlier was unnecessary. Some much simpler device could be made to transmit the human voice.

Even with the prospect of voice communication so much improved, however, Gray did not pursue it. Instead he chose to continue the development of a multiplex telegraph as a potentially far more profitable venture. His strides toward this goal are evident in the number of patent applications he filed early in 1875. He was soon to learn that his work was coming "into interference," as it is said in patent law, with the applications of another inventor. That inventor was Alexander Graham Bell.

By coincidence Bell was also in hot pursuit of a multiplex-telegraph system working within the audio-frequency spectrum. (What Gray called vibratory currents Bell called undulatory currents.) The youthful Bell was an amateur, but he knew that a pot of gold awaited the inventor of a practical multiplex telegraph. Furthermore, although Bell was an amateur inventor, he was a thoroughgoing professional in his own field: elocution and speech therapy. His father, Alexander M. Bell, professor of elocution at the University of Edinburgh, had won international recognition for his system of teaching the deaf to speak, and his son had an intimate knowledge of the physiology of human speech. Indeed, he had already put forward a theory of vowel tones.

One consequence of this work was profound. Alexander J. Ellis, a prominent British phonetician who had learned of Bell's theory, pointed out to him that the same theory had been advanced in a classic work, "On the Sensation of Tone as a Physiological Basis for the Theory of Music," by the German polymath Hermann von Helmholtz. Ellis also called Bell's attention to the electrically driven tuning fork used by Helmholtz in many of his experiments. Bell acquired a French edition of Helmholtz' book and read it during his passage from England to America in 1870.

When Bell settled in Boston in 1871 to teach at the School for Deaf Mutes, he found others who were closely acquainted with Helmholtz' acoustical work, among them Lewis Monroe, a friend of the Bell family's and professor of elocution at the Massachusetts Institute of Technology. Monroe told Bell that experimental apparatus of the Helmholtz type was available at M.I.T. and suggested that he and Bell repeat the experiments someday. He also lent Bell a copy of a recent book on acoustics by Tyndall. Bell was soon in contact with others who were interested in investigating sound, among them Charles R. Cross, assistant to the physicist Edward C. Pickering at M.I.T., and the Boston physician Clarence J. Blake, lecturer on otology at the Harvard Medical School.

The background of Bell's work on the telephone was therefore acoustical. The immediate path to that work, however, was like Gray's the multiplex telegraph. Bell began to pursue such an invention late in 1872, when he read an account in a Boston newspaper of Western Union's adoption of the Stearns duplex system. If Stearns had become rich by devising a system that could transmit only two messages at a time, and those in opposite directions, what wealth awaited the man who invented a system that could do more?

The Helmholtz apparatus gave Bell a starting point. Helmholtz had devised a way of generating an intermittent current at audio frequencies by using the vibrating end of one tine of a tuning fork as an interrupter. He then employed the intermittent current to drive other tuning forks. The method suggested to Bell a way of transmitting multiple messages. If several Helmholtz tuning-fork interrupters were tuned to different frequencies, each interrupter could transmit a separate message. This scheme left Bell facing the same problem Gray had faced: devising a receiver that could sort out the combined messages. Bell, however, was proceeding more on blind faith than Gray. He had yet to learn whether it was even possible to transmit composite tones by wire.

From late in 1872 through most of 1873 Bell worked off and on at his multiplex-telegraph scheme. Unlike Gray, who employed a professional instrument maker, Bell built his own apparatus. Because he had almost no mechanical skill the apparatus was crude. For example, at first he could not rig a Helmholtz interrupter that would work for more than a few seconds. His being an amateur at invention was no mere artificial distinction.

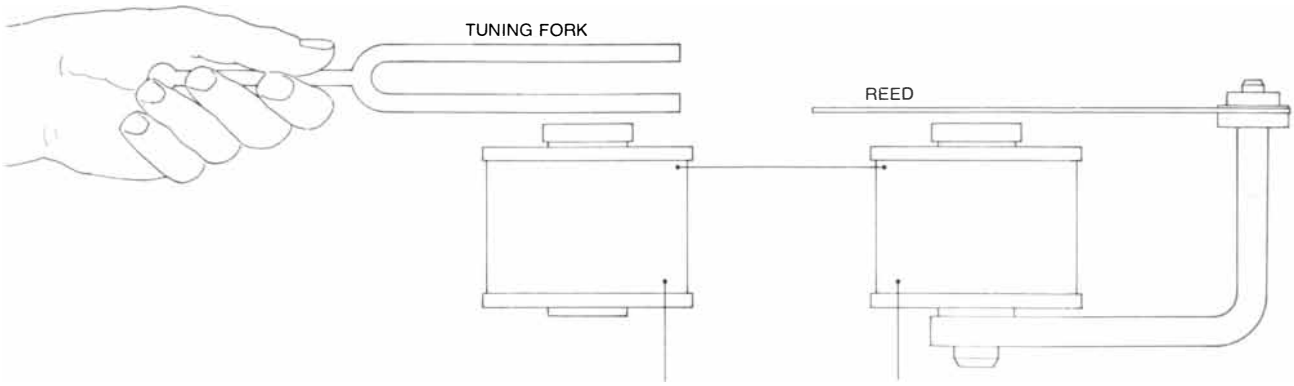
Late in the spring of 1874 Bell learned about Gray's work with vibratory currents. He at once accelerated the pace of his own work. Up to then Bell's efforts had been almost without success, but his faith in his multiplex scheme remained strong. That faith might well have faltered, however, if he had not found himself in partnership with Gardiner G. Hubbard, a telegraphy enthusiast. Hubbard had hired Bell to tutor his daughter, who had been made deaf by scarlet fever. Hubbard viewed Western Union as an enemy of progress in telegraphy, believing the monopoly was stifling innovation. The two men naturally talked about telegraphy, and in October of 1874 Bell disclosed that he was working on a multiplex scheme. Hubbard had predicted even before he knew Bell that "one wire [might eventually] be used for four or possibly eight messages." He now provided Bell with enough money to hire an expert in the field of electrical studies and pay for the services of the expert's instrument maker. The quality of Bell's apparatus soon improved. Perhaps Hubbard's most important contribution to the partnership was his insistence that Bell keep his mind on the main goal: multiplex telegraphy.

By the summer of 1875 Bell's work had convinced him it was possible to transmit speech, the same conclusion that had been reached earlier that year by Gray. Although Gray had set the notion aside in favor of further work on multiplex telegraphy, Bell's keen interest in the voice made him feel that such an achievement would be of the first importance. Like Gray, Bell had initially conceived of a complex voice transmitter, but experiments with tuned steel reeds in transmitters and receivers led him to devise an instrument for both purposes that consisted of a reed attached to the center of a diaphragm. Both the transmitter and the receiver were placed near one of the poles of an electromagnet with a slightly but permanently magnetized core.

With this pair of instruments Bell and his assistant were able, on July 1, 1875, to transmit and receive what Bell described as "vocal sounds." These sounds were not, however, speech. The system required that Bell or his assistant shout into the diaphragm of the transmitting instrument. The diaphragm was agitated by the sound waves, which caused the reed to vibrate. The motion generated a weak "undulatory current" in the transmitting electromagnet, which actuated the receiving electromagnet, causing the receiving diaphragm to reproduce the movements of the transmitting diaphragm.

Bell was captivated by the potential of these instruments. (It is worth noting that the first commercial telephones, which appeared in 1877, were not much more than improved versions of the 1875 magnet-and-diaphragm instruments.) Hubbard, however, was less than interested; like Gray and Gray's backer he kept his sights on the development of the multiplex telegraph.

By this time Gray and Bell were playing cat and mouse with each other. Each suspected that the other was spying on him; each believed his own work was the more advanced, but each wor-



BELL'S EXPERIMENTS, urgently pursued after he had filed his patent application, included some, such as the one illustrated here, that used electromagnets in both the transmitter and the receiver. Bell had tried a similar approach in 1875 but without success. He did not return to the magnetoelectric transmitter-receiver system until after he had successfully transmitted speech with a variable-resistance instrument. Here the vibration of a tuning fork near the electromagnet at the left caused its magnetic field to fluctuate. The fluctuations produced corresponding fluctuations in the current and hence in the field of the electromagnet at the right, making the steel reed above it vibrate with the same frequency as that of the tuning fork. A more advanced state of such a transmitter-receiver was the system Bell exhibited at the Centennial Exhibition in Philadelphia in June, 1876. It was the one used for the first commercial telephone in 1877.

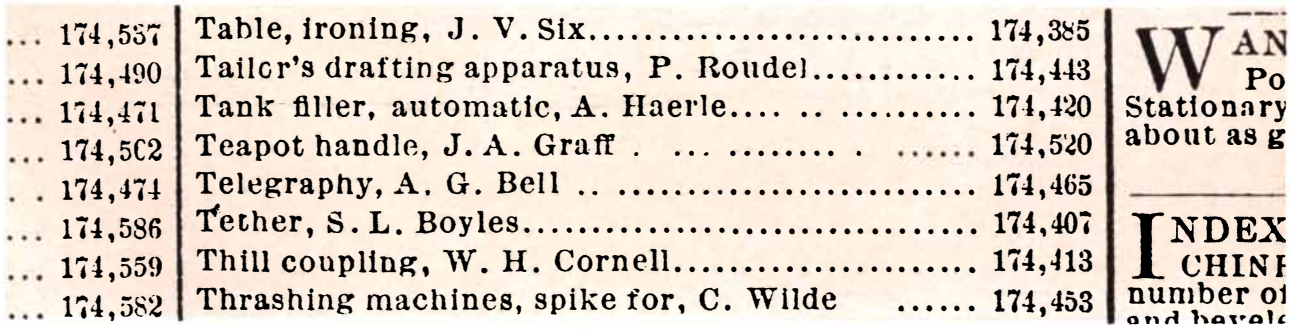
ried that the other might achieve the decisive breakthrough. Gray, however, gradually came to the conclusion that Bell's effort had been derailed. In October of 1875 Gray wrote his patent attorney: "Bell seems to be spending all his energies in [the] talking telegraph. While this is very interesting scientifically it has no commercial value at present, for [the telegraph industry] can do more business over a line by methods already in use than by that system. I don't want at present to spend my time and money for that which will bring no reward."

All the same, when later that month Gray happened to see two boys playing with a homemade toy known as a "lovers' telegraph," he immediately realized how an electric telephone should be constructed. A lovers' telegraph is what would be known today as a tin-can telephone. Two cans with the top removed are connected by a string knotted inside a hole punched in the bottom of each can. When the string is stretched tight, sounds uttered into one of the cans make its bottom vibrate. The vibrations are carried by the taut string to the bottom of the other can, where the sounds are coarsely reproduced.

Gray recognized the electrical analogue of the toy. The electric transmitter would consist of a voice chamber (the can) and a diaphragm (the bottom of the can). If one end of a wire was attached to the diaphragm and the other end was immersed in a liquid with a high electrical resistance, the movement of the wire in response to the vibrations of the diaphragm could be transformed into a vibratory current that faithfully reproduced the various frequencies of speech. Gray already knew that his electromagnet-and-diaphragm receiver could turn the vibratory current back into sound waves.

Although the device seemed to Gray to lack commercial application, he believed it would work and intended to patent it. He already knew that the movement of a wire in a liquid could produce vibrations in an electric current. While he was still a proprietor of Western Electric the company had made and sold liquid rheostats: devices that changed the resistance of a circuit by varying the depth to which a metal rod was submerged in a liquid with a high electrical resistance. Because of his pressing work on the multiplex telegraph, however, he waited more than three months before he took any patent action. In February of 1876 he finally put his ideas on paper. Instead of applying for a patent, however, Gray filed what was known at the time as a caveat, or warning.

A caveat was supposed to give the Patent Office formal notice of an inventor's basic concept. The idea was that after filing a caveat the inventor would develop the concept into a workable device and then apply for a patent. The procedure was intended to give a certain amount of protection to inventors' concepts. On this occasion Gray's patent attorney wrote to White, Gray's backer, that the inventor's "talking telegraph caveat" potentially interfered with a patent application from Bell. "As Gray's caveat was filed on the same day as Bell's application, but later in the day," the attorney reported, "the Commissioner holds that he is not entitled to an interference and Bell's application has been ordered to issue.... We could still have an interference by Gray's coming tomorrow and promptly filing an application for a patent. If you want this done, telegraph me in the morning, on receipt of this, and I will have the papers ready in time to stop the issue of Bell's



... 174,537 Table, ironing, J. V. Six..... 174,385
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... 174,559 Thill coupling, W. H. Cornell..... 174,413
... 174,582 Thrashing machines, spike for, C. Wilde 174,453

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PATENT NO. 174,465 was one of 270-odd granted by the U.S. Patent Office during the week ending March 7, 1876, three weeks after Bell had filed his telephone patent application. This "official notice" was published in the April 8, 1876, issue of SCIENTIFIC AMERICAN.

patent, but my judgment is against it."

When the letter reached White, the inventor happened to be visiting him. White firmly impressed on Gray that he should concentrate on multiplex telegraphy. Since the attorney too had advised against proceeding further, Gray dropped the matter. The telephone was left to Alexander Graham Bell.

The experts in telegraphy, including Gray, had concluded that the telephone was not worth serious attention. Bell had remained steadfast in his belief that a successful telephone would be an invention of the first importance. Most of his draft patent application dealt with the devices tested in July of 1875 (which came to be known as the "magneto-electric telephone"). As an afterthought, however, he inserted a description of a different kind of transmitter.

"Electrical undulations," he wrote, "may also be caused by alternately increasing and diminishing the resistance of the circuit.... 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 liquid, the less resistance does the liquid offer to the passage of the current. Hence the vibration of the conducting wire in a liquid included in the circuit occasions undulations in the current."

Bell had clearly misjudged the electrical properties of mercury; it is a low-resistance liquid, not a high-resistance one. Why he did so is something of a puzzle, because he had been familiar with the electrical properties of mercury since he had first read about them in Helmholtz. It is also not entirely clear just how Bell conceived of a variable-resistance transmitter, that is, what precedents he relied on. There is even some question as to how and when the descriptive paragraph found its way into his final patent specification. Finally, one may wonder why he filed an application rather than a caveat. His concepts had not been, in terms of patent law, "reduced to practice," a fact the Patent Office either overlooked or ignored. These questions have been sources of speculation for more than a century and need not detain us here.

In June of 1876 Gray saw Bell demonstrate his telephone at the Centennial Exhibition in Philadelphia. He later told an associate: "As to Bell's talking telegraph, it only creates interest in scientific circles. [Its] commercial value will be limited." So did the professional Gray continue to misjudge the importance of the telephone even after its successful realization. In contrast, the amateur Bell wrote his father two weeks after filing his patent application (and nearly two weeks before he was first to hear human speech through his instrument): "*The whole thing is mine*—and I am sure of fame, fortune and success."