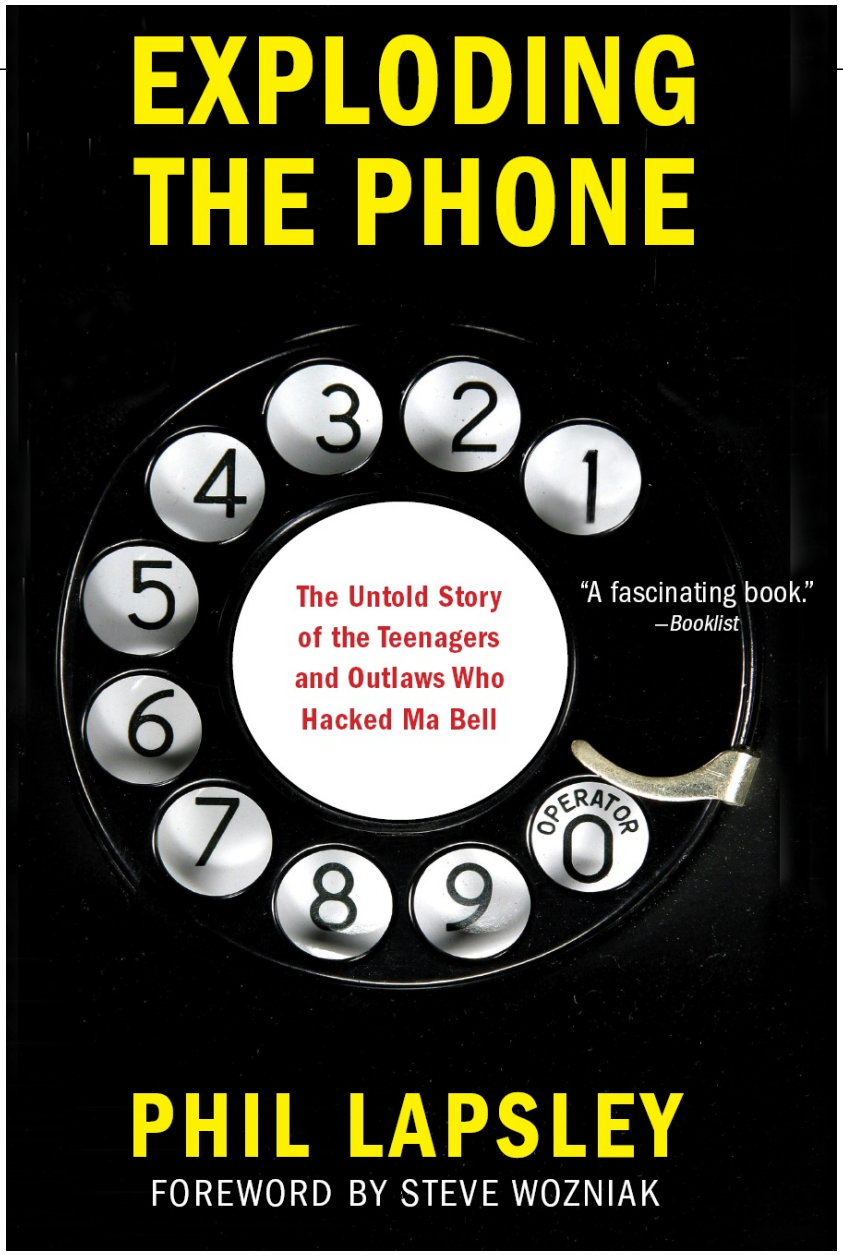
EXPLODING THE PHONE
The Untold Story of the Teenagers and Outlaws Who Hacked Ma Bell
"A fascinating book."
—Booklist
OPERATOR
PHIL LAPSLEY
FOREWORD BY STEVE WOZNIAK

EXPLODING THE PHONE

The Untold Story of the Teenagers
and Outlaws Who Hacked Ma Bell

PHIL LAPSLEY

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To the men and women of the Bell System, and especially to the members of the technica staff of Bell Laboratories, without whom none of this would have been possible

CONTENTS

Phone phreak (n.) 1. A person who is obsessively interested in learning abou exploring, or playing with the telephone network. 2. A person who is interested i making free telephone calls.

FOREWORD

I **FIRST LEARNED ABOUT** phone phreaking from a magazine. In the fall of 1971 I stumbled onto a article that seemed like a bit of science fiction, about these groups of people who knew how to crac the phone system all over the world. I was young, only twenty years old, and I thought this was really cool made up story.

I phoned Steve Jobs halfway through and started reading him the article. I just had to call him. W researched it and found out, "Whoa!" It made sense! Who would ever believe you could put tones in a phone and make calls free anywhere in the world? I mean, who would *believe* it? It was like w stumbled onto to some magical mystery that other people just didn't know about. And I had no ide the impact it would end up having on my life.

We just had to try it, to find out if it really worked. Over the next few months I started designing "blue box," an electronic gizmo that made the tones you needed to control the telephone network. I p so much attention into trying to make it the very best blue box in the world. It was digital, unlike th ones that everybody else had, and it had some of the cleverest, most off-the-wall design techniqu I've ever put into anything I've ever built, even to this day. It was great, and it was my passport int the phone phreaks' underground network.

I had grown up very shy and often felt left out of things. But for me, phone phreaking was a place the world that I was like a leader. It was a place where I could blossom. And it's not that I coul blossom as a criminal—it wasn't that we had lots of people to call or had giant phone bills or reall wanted to rip off the phone company or anything. It's just that it was so exciting! When I went into room and showed off phone tricks with a blue box, I was like a magician playing tricks. I was th center of attention. That was probably partly what drove me. But it was also the fascination of doin something that nobody would really believe was possible.

I was enthusiastic then about very few things, but this one I was enthusiastic about. Phone phreakin was one of the first big adventures I had in my life. And it made me want to have more of tho adventures by designing more things like my blue box, weird things that worked in ways that peop didn't expect. For the rest of my life, that was the reason I kept doing project after project aft project, usually with Steve Jobs. You could trace it right up to the Apple II computer. It was the sta of wanting to constantly design things very, very well and get noticed for it. Steve and I were a tea from that day on. He once said that Apple wouldn't have existed without the blue box, and I agree.

Today a lot of people are computer hackers and a lot of them just want to cause problems for othe —they're like vandals. I was not a vandal, I was just curious. But, boy, I wanted to find out what th limits of the telephone system were. What are the limits of *any* system? I've found that for almo anybody who thinks well in digital electronics or computer programming, if you go back and look their lives they'll have these areas of misbehavior. And I think some of the most creative people hav all, at some point, focused their creativity on doing things that they aren't supposed to do. But the goal is usually, oh my gosh, can I *discover* something? Is there some way to do something that is n exactly in books and not known? Hackers are the ultimate example: every hacker I've ever run into always trying to explore the little tiny nuances of anything looking for a mistake, a crack they can g through.

The blue box was this magical, unbelievable adventure. The fact that nobody else knew about it and did made it special knowledge. But it was no good just to know it inside—it was *only* good when shared it with others. It was playing with magical powers. I would say I had an awful lot of tho experiences in my life, but the blue box was probably the most special of all.

I hope that getting to learn a little bit about phone phreaking turns out to be one tenth as much fun f you as it was for me to experience it.

Steve Wozniak
Cofounder, Apple Computer

A NOTE ON NAMES AND TENSES

ANONYMITY AND PSEUDONYMS have been a thorn in my side throughout the writing of this boo Despite my attempts to convince my interviewees that this all happened a long time ago, that th statute of limitations has long since expired, that the phone company doesn't care and the phon phreaks don't care and law enforcement doesn't care, several people have insisted on either bein anonymous or being referred to by pseudonyms. For those who wished to be nameless, I have tried make their anonymity obvious ("A source familiar with the matter recalls . . ."). Pseudonyms ar marked with a footnote when they are first used to call attention to the shy. Each such footno indicates whether the pseudonym is historical or modern, that is, whether the pseudonym used was th person's nom de phreak back in the day or is a more recent fabrication for purposes of present-da identity protection.

The identity of every source used in the book is known to me; there have been no "Deep Throat" style encounters in which I have received late-night phone calls from truly anonymous sources tellin me outlandish things or, for that matter, any things at all. I guess I'm just in the wrong line of work.

Finally, a note on verb tense: when I have used the present tense to attribute a quote in this boo (e.g., "Acker recalls" or "Perrin remembers"), it means that the quote was taken directly from a interview I conducted between 2005 and 2012 or from a document published during that time. When have used the past tense ("The memo stated" or "Draper said"), it indicates that the quote was take from an older newspaper article, memo, FBI file, or other document, or from notes or audiotapes fro the time in question.

One

FINE ARTS 13

THERE IT WAS again.

Jake Locke* set down his cup and looked more closely at the classified ad. It was ear afternoon on a clear spring day in Cambridge in 1967. Locke, an undergrad at Harvard University, ha just gotten out of bed. A transplant from southern California, he didn't quite fit in with Harvard button-down culture—another student had told him he looked like a "nerdy California surfer," wh with his black-framed eyeglasses, blond hair, blue eyes, and tall, slim build. Now in the midst of h sophomore slump, Locke found himself spending a lot of time sleeping late, cutting classes, an reading the newspaper to find interesting things to do. Pretty much anything seemed better than goin to classes, in fact.

*A pseudonym.

It was a slow news day. The *Crimson*, Harvard's student newspaper, didn't have much in the way o interesting articles, so Locke once again found himself reading the classified ads over breakfast. H had become something of a connoisseur of these little bits of poetry—people selling cars, looking f roommates, even the occasional kooky personal ad probably intended as a joke between lovers—a expressed in a dozen or so words.

But this ad was different. It had been running for a while and it had started to bug him.

> WANTED HARVARD MIT Fine Arts no. 13 notebook. (121 pages) & 40 page reply K.K. & C.R. plus 2,800; battery; m.f. E presidente no esta aqui asora, que lastima. B. David Box 11595 St. Louis, MO 63105.

Locke had seen similar classified ads from students who had lost their notes for one class or anoth and were panicking as exams rolled around. They often were placed in the *Crimson* in the hopes th some kind soul had found their notes and would return them. Fine Arts 13 was the introductory a appreciation class at Harvard, so that fit.

But nothing else about the ad made any sense. Fine Arts 13 wasn't offered at MIT. And what was a the gibberish afterward? 2,800? Battery? M.f., K.K., C.R.? What was with the Spanish? And why wa somebody in St. Louis, Missouri, running an ad in Cambridge, Massachusetts, looking for a noteboo for a class at Harvard? Locke had watched the ad run every day for the past few weeks. Whoever the were, and whatever it was, they clearly wanted this notebook. Why were they so persistent?

One way to find out.

Locke looked around for a piece of paper and a pen. He wrote: "Dear B. David: I have your noteboo Let's talk. Sincerely, Jake."

He dropped the letter in the mail on his way into Harvard Square to find something interesting to do

An envelope with a St. Louis, Missouri, postmark showed up in Locke's mailbox a week later. Lock opened the envelope and read the single sheet of paper. Or rather, he tried to read it. It wasn't English. It seemed to be written in some sort of alien hieroglyphics. It was brief, only a paragraph so long. The characters looked familiar somehow but not enough that he could decipher them.

Locke showed the letter to everyone he saw that day but nobody could read it. Later that evening, Locke sat at the kitchen table in his dorm room and stared at the letter, trying to puzzle it out, one his roommates came home. Shocked that Locke might actually be doing something that looked li homework, his roommate asked what he was working on. Locke passed the letter across the table a told him about it.

His roommate took one look and said, “It looks like Russian.”

Locke said, “That’s what I thought. But the characters don’t seem right.”

“Yeah. They’re not. In fact . . .” His roommate’s voice trailed off for a moment. “In fact, they’ mirror writing.”

“What?”

“You know, mirror writing. The letters are written backwards. See?”

Locke looked. Sure enough: backwards.

Locke and his roommate went to the mirror and transcribed the reversed lettering. It was Cyrillic- Russian letters. Fortunately, Locke’s roommate was taking a Russian class. They sat back down at th table and translated the letter.

“Dear Jake,” the letter read. “Thank you very much for your reply. However, I seriously doubt th you have what I need. I would strongly advise you to keep to yourself and not interfere. This is serio business and you could get into trouble.” Signed, B. David.

Locke sat back. Someone had put a cryptic ad in the newspaper. He’d responded. They sent him letter. In mirror writing. In Russian. In 1967. During the cold war.

Spy ring.

It just didn’t get much cooler than this, Locke figured. Intriguing. Terrifying, even. And far, f better than going to class.

Locke mailed his reply that day—in English, and not in mirror writing. “Dear B. David: Actually, do have your notebook and I would like to talk to you. Sincerely, Jake.”

Four days went by before the mailman brought Locke an odd letter, a piece of card stock folded half and taped at the top. The fold line was perforated so that it could be torn in half. The writing w in English this time.

“Dear Jake, if you have the information I need, you should be able to complete the other half of th card and mail it back to me. Then we can continue our discussions. Sincerely, B. David.”

Locke looked at the other half of the postcard. It had a handful of questions on it:

Complete the following sequence: 604, 234, 121, ___
What does M.F. stand for?
What equipment were the students at Harvard and MIT using?

Huh?

Locke spent every waking hour over the next several days working on the postcard questions. Th numbers repeated over and over in his mind: 604, 234, 121 . . . 604, 234, 121 . . . 604, 234, 121 . . .

604-234-1212.

A phone number? It wasn’t directory assistance—Locke knew that would have been 555-1212—b it sort of sounded right. Worth a shot, anyway. He picked up the phone and dialed. A woman’ businesslike voice answered on the first ring.

“Cleaner clean,” she said.

“Excuse me?” said Locke.

“Cleaner clean inward,” the woman repeated, more distinctly this time.

Locke hung up. He stared at the phone. Cleaner clean? Inward?

Where was area code 604, anyway? The phone book said British Columbia. And where was tha Western Canada. Locke looked around his dorm room, found an atlas, and flipped to the page c British Columbia. He scanned the map. The big cities had names he recognized, names like Vancouv and Prince George. The smaller towns had less familiar names. Names like Kamloops. Squamis Quesnel. Chilanko.

Kleena Kleene.

At dinner that night Locke mentioned his phone call to Steve, another of his roommates. Steve sai "Huh. That's interesting. My girlfriend Suzy is an inward."

"What? What's an inward?" asked Locke.

"It's some kind of special telephone operator. You should talk to her, she might be able to help yo figure some of this stuff out. She lives over in Revere. Give her a call."

Locke did. Suzy explained that an inward is an "operator's operator." When an operator nee assistance in making a call, she calls the inward operator for the destination city. The inward operat then completes the call to a local number.

"So how do I call an inward?" Locke asked her.

"You can't. Inwards have special phone numbers that only operators can dial. If you wanted to ca the New York inward, you'd have to dial something like 212-049-121. So 121 is what gets you th inward, and 049 is a routing code inside of New York, and New York is the 212 area code. But yo can't dial numbers like 049 or 121 from a regular phone."

Locke explained that he seemed to have found a way to call an inward operator from his regul phone by dialing 604-234-1212.

"Well," Suzy said, "I'm mystified. You shouldn't be able to. I don't know, maybe you found a glitc But here's how you can tell. Call them up and ask them to complete a call to somebody. If they' really an inward, they'll be able to do it no problem."

"I don't know anybody in Canada," Locke said.

"That's okay. An inward can call anywhere. And we sometimes get calls from the test board withi the phone company asking us to complete calls to places for testing purposes. Just tell them you' with the test board. Be confident and self-assured and act like you know what you're doing and th won't give you any trouble."

"Okay. I'll try that. Hey, any idea what 'M.F.' might stand for?"

"Well," Suzy replied, "it could be multifrequency."

"Multifrequency. What's that?" Locke asked.

"It's the system that operators use to make calls. It's kind of like those touch tones used for pus button dialing, but it sounds different." Locke's dorm phone was rotary dial, but he knew what touc tones were—they had been introduced just a few years earlier.

"Okay. Hey, thanks, Suzy." They said good-bye. He hung up.

Locke picked up the phone again and dialed 604-234-1212. Once again the businesslike female voi answered.

"Kleena Kleene inward."

"Hi, uh, yes," Locke said. "This is the test board. Could you connect me to 619-374-8491, please?"

"One moment." There was a pause. The long-distance hiss got louder. A click. Another pause. Mor hiss. Another click. Then a ringing signal.

"Hello?" It was his friend Dave in San Diego.

Locke chatted with his friend for a few minutes and then hung up. He felt as if he were floating. seemed magical. "Act like you know what you're doing and they won't give you any trouble." worked!

Two postcard questions down. One left: "What equipment were the students at MIT using?"

Once again, another roommate came to Locke's rescue—fortunately, Locke lived in a suite and ha lots of roommates. "We're talking about phones and MIT students, right? I remember an article in th *Crimson* about a year ago about some MIT students who got in trouble for playing with the telephon Could that be it?"

"Maybe," said Locke. "But how am I gonna find an old copy of the *Crimson*?"

"The library?" his friend suggested.

This was a challenge. Locke had never been to the university's library before.

Locke was surprised to find it was close to his dorm and that other students seemed able to dire him there. Soon Locke was flipping through page after page of old *Crimson*s. An hour later, in an issu from almost a year earlier in 1966, he found what he was looking for.

Five Students Psych Bell System,

Five local students, four from Harvard and one from M.I.T., spent eight months making long distance and international phone calls as guests of the Bell System before they were finally discovered.

The telephone company accepted the news without bitterness, however, merely impounding the 121-page Fine Arts 13 notebook that contained the records of their "researches" and requiring them to submit a full report, which ran to 40 double-spaced pages of what they had done.

Mesmerized, Locke read on, the words from the classified ad running through his head. The artic described how, starting in 1962, the students had used inward operators—including one in Kleen Kleene—to complete calls all over the world. It tantalized with an infuriatingly brief description how it was possible to build an electronic device to control the telephone system for "$50 of commo electronic components." The article concluded abruptly, stating that the students were caught in Apr 1963 when a telephone company employee turned them in.

Locke was elated. Pieces were falling into place, and now he had enough to respond to B. David. B the article was short on details. He needed to find out more. He needed to talk to the original Harva and MIT students. Locke jotted down the name of the article's author, another student at Harvard.

The next day he filled out the reply postcard and dropped it in the mail to B. David. Then he calle the *Crimson* reporter to pump him for details. The reporter wasn't very helpful. He didn't know th names of the Harvard or MIT students, he said, and it turned out that he had gotten most of h information from an article in the *Boston Herald*. He had then talked to the *Herald* reporter to g some additional context.

"Didn't the *Herald* reporter know the names of the students?" Locke asked.

"Oh, sure, but he wouldn't give them to me. And I doubt he'll give them to you either," the *Crimso* reporter replied.

Back to the library. Locke dug up the *Herald* article. It described the Harvard and MIT studen making calls to the president of Mexico and gave a name—"blue box"—to the electronic device th had allowed them to control the telephone network. It spoke of their staying up all night, of spendi eighty hours a week on their research, of dialing ten thousand numbers over two to three days to fi the information they needed. It even said the students were questioned by FBI agents who thought the were stealing defense secrets.

Locke looked up the telephone number for the newspaper. *Be confident and self-assured and act lik you know what you're doing.* He drew a deep breath, picked up the phone, dialed the *Herald*, and aske to be connected to the reporter who wrote the article. When the reporter answered, Locke polite explained who he was and what he was looking for.

"This is Special Agent Stevenson with the FBI Boston Field Office. We've had a report that there ha been some new activity related to an incident that occurred a few years ago with some Harvard an MIT students misusing the telephone system. We're trying to reach them to talk to them about this bu we don't have current contact information for them. I saw your article about them from a year ago so. Do you have telephone numbers for any of them?"

Not a problem, the reporter replied. He'd be happy to help.

Before Locke had a chance to call any of the students his phone rang. It was B. David and he wanted know about the Fine Arts 13 notebook. Oh, yes, *that* notebook: the one that Locke didn't actually hav Locke did his best to keep up the charade. Well, he admitted, he wasn't actually one of the Harvard MIT students but he knew them. He was a friend of theirs. He had participated in some of the "research."

B. David grilled him. It quickly became apparent that Locke didn't know as much as he wa claiming. As Locke would later recall, "You can only fake things so far before they begin to crumble Locke admitted the truth.

Surprisingly, B. David wasn't mad, and now that the cat was out of the bag the two had a pleasa conversation. B. David explained that there was an informal network of telephone enthusiasts lik himself, and that he had been trying to reach the Harvard and MIT students to talk to them about the exploits. "Welcome to our world," he said. Locke asked for pointers. B. David demurred on details: don't want to give you too much information. I will tell you one thing, though: look for missin exchanges. Look for patterns. I'll give you a call back in a few weeks to see how you're doing."

This all seemed fascinating to Locke. He called the former MIT student—now living in Berkele California—whose number he had gotten from the *Herald* reporter. The student was friendly enoug but, like B. David, was also reluctant to provide much information. The MIT student explained that h and his friends had been caught and interrogated by the FBI, although not actually prosecuted. H stressed that Locke could get in trouble playing with this stuff and that Locke should stay away fro the whole thing. Locke pressed him for more information. Finally the MIT student told him, "If yo really want to find out more, everything you need to know is in the library."

Great, thought Locke, a *third* trip to the library.

But what library would have the sort of information he was looking for? Some research led him the physics library and something called the *Bell System Technical Journal*. The one term Locke kne to look up was "multifrequency." From the journal's index he quickly located an article from th November 1960 issue titled "Signaling Systems for Control of Telephone Switching." It was technic but not so technical that Locke couldn't understand a good chunk of it. It laid out in detail exactly ho certain aspects of the telephone system worked, including the multifrequency signaling system. Th article plus the *Crimson* and *Herald* stories, as well as his conversations with B. David and the form MIT student, gave him everything he needed to get serious about this stuff.

Locke started to spend a lot of time on the telephone. "Look for missing exchanges, look f patterns," B. David had told him. Locke knew that an exchange was the first three digits of a loc telephone number. By making a careful study of the telephone book and doing a lot of dialing, Lock discovered that there were indeed missing exchanges in the downtown Boston area. When Lock

found a missing exchange, he would start dialing all the telephone numbers in it. All ten thousand
them.

Weeks later Locke had three things to show for his efforts. The first was an indelible black circ
around his index finger from his repeated dialing. Second was four livid roommates: because Loc
was constantly on the phone, none of them could make or receive phone calls. But third was
collection of some very interesting telephone numbers. Some of these were odd test numbers, numbe
that made weird *beeps*, *boops*, clicks, and tones. More interesting were so-called party lines. The
were typically vacant number recordings ("We're sorry, you have reached a nonworking number . . .'
whose audio levels were very low. All the callers to one of these numbers would be connected, a
because the volume of the recordings was so low people could talk over the recordings. As a resu
they served as primitive conference calls at a time when such things were unheard of.

Most interesting, though, was that several numbers went to inward operators in various places.

Locke's obsession grew. He decided he wanted to build one of these mystical "blue boxes" so that h
too, could directly control the telephone network. That meant he'd need to build electronic oscillato
circuits that would make musical tones. But Locke didn't know anything about electronics. Lookin
for patterns and missing exchange numbers was one thing; electronic circuit design was somethi
else. Locke got a friend of his to introduce him to a graduate student in the physics department
order to persuade him to help build the oscillator circuits he needed for his blue box.

"What do you need them for?" the grad student asked.

Be confident and self-assured and act like you know what you're doing. "I'm a biology major a
I'm studying the effects of high-frequency audio oscillations on fruitfly germination."

The grad student raised an eyebrow but helped Locke anyway.

Locke started haunting the electronics stores in Cambridge, looking for parts and guidance
assembling his blue box. Before long he linked up with students at MIT in the Tech Model Railroa
Club, or TMRC, near the Kendall Square T Station. The TMRC was home to one of the mo
technically sophisticated model railroad setups in the country, possibly the world. MIT students ha
laid out some six hundred feet of track simulating ten scale miles of railroad amid painstaking
detailed scenery. The trains were controlled by a fantastically complex switching system based
many of the same principles as the telephone network. Indeed, the telephone company had donate
equipment to the club for just this purpose, and the club's faculty adviser was in charge of MIT
telephone system, so it was not surprising that model train operators at TMRC used a telephone dial
select the train to be controlled. It was a veritable breeding ground for telephone enthusiasts.

With help from the more electronically knowledgeable students at MIT, and only a few solderi
iron burns, Locke was able to piece together a blue box. By now Locke had been told by enoug
people that he could get in trouble for using his blue box and that he should be careful. So Locke *w*
careful—when it was convenient, anyway. He used his blue box from the pay phone in his dorm qui
a bit, as well as from friends' houses. As Locke figured it, the only thing he was doing with it wa
using it to learn about how the phone system worked. He didn't even really know anybody far away
wanted to call, so it wasn't like he was racking up thousands of dollars in free long-distance calls. H
just couldn't imagine that anyone cared about his activities that much.

Incredibly enough, some people did care, as Locke learned upon returning to his dorm room in Ju
1967, just three months after seeing the Fine Arts 13 ad in the *Crimson*. He knew he was in troub
from the moment he walked in the door: waiting for him in his living room were three men. One
them was the crestfallen house master, the Harvard professor who was the head of Locke's dorm
Locke didn't know the other two, but he did notice that one of them was wearing a trench coat-

strange, given that it was a warm summer day.

"The jig's up, Locke," the house master said.

Trying to stall for time, Locke asked, "Which jig?"

Based on the reactions of his three visitors, Locke surmised this was the wrong thing to have said.

"You know which jig we're talking about, Locke," said one of the men. "The telephone jig. We'v been through your things." He held up Locke's blue box. "We need to talk."

One of his visitors turned out to be from the telephone company, AT&T security. The othe introduced himself as a special agent from the FBI's Boston Field Office. They asked Locke to com downtown with them. The FBI agent told him that this was a very serious matter, that they had som questions they wanted straight answers to, and that they would arrest him if he didn't cooperate.

Locke spent the next twenty-four hours in what felt like a scene from a 1940s detective movie: barren room with nothing more than a wooden table, a chair for him, two chairs for his interrogator and a bare lightbulb dangling from the ceiling. Sitting across from him, the FBI agent and th telephone security man worked hard to get him to confess to using the blue box to make free telephon calls. Despite being scared to death Locke denied everything. He didn't know what they were talkin about, he said.

After several hours of questioning, he finally admitted that yes, the blue box was his, but that he ha used it only to learn about the telephone network. Locke expected them to start grilling him about ho many free calls he had made, but his interrogators shifted focus. They wanted to know who had give him the technical information necessary for him to build a blue box. He explained that he had seen a article in the Boston *Herald* and then found the *Bell System Technical Journal* article and gone o from there. In other words, there wasn't anyone else; he had been all on his own. It took a long tim but he managed to convince them of his version of events.

Again the questioning shifted course. Okay, they said, you figured out this stuff on your own. Fin Now tell us who you've been selling the boxes to.

Locke was flummoxed. Selling the boxes? What boxes? He had built only the one, and he hadn't so it to anyone. The FBI agent grilled him. They were sure he had been selling them—or at lea supplying them—to others. To whom, they wouldn't say. After hours of back and forth, Locke wa able to get across that it was just him, there was just the one box he had built, and he hadn't bee selling them. (In retrospect, Locke says he is glad he never thought of this. "The idea of selling blu boxes had never occurred to me . . . fortunately! It's not a bad idea.")

Locke spent the evening in the care of the FBI. In the morning he was told he could leave, but on after he prepared a written report describing what he had done and the techniques he had used. H spent the morning writing this report.

As he was leaving, Locke turned to the man from the phone company. His face slipped into a gri "By the way," he said, "I'm not doing anything for the summer. You guys wouldn't happen to hav any job openings, would you?"

BIRTH OF A PLAYGROUND

THE OBJECT OF Jake Locke's obsession—the telephone—recently celebrated its 135th birthda Few products can say that. The telephone's staying power is testimony to our species' deep-seate need to talk with one another. For thousands of years we humans have tried every trick we could thin of to communicate at a distance: torches on mountaintops were big with the Greeks, the Roma released carrier pigeons to report the results of chariot races, African bush tribes sounded drum American Indians had smoke signals, and ships at sea hoisted signal flags to communicate with eac other.

The problem, of course, was that these techniques all pretty much sucked; this is why you carry a ce phone in your pocket and not a signal flag or a pigeon. But we didn't get to cell phones overnight. took repeated assaults on the problem to before humanity managed to make a dent in it.

In the late 1700s the new new thing in the world of communications was something called the optic telegraph. A network of windmill-like towers with pivoting shutters, blades, arms, or paddles th could be seen from a distance, the optical telegraph allowed reliable long-distance communication Several systems were built but the best known was created by Claude Chappe and his brothers an deployed throughout France starting in 1793. The Chappe system used relay stations a few miles apa from each other. A station in Lyon, for example, would spin its paddle to send a particular signal. A few miles to the southwest, the operator at the Vénissieux station would be watching, perhaps with th aid of a telescope. He would spin his paddles to repeat the message on to the station at Saint-Pierr de-Chandieu, a few miles farther on down the line. And so the message would go, one station—an one spin of the paddle—at a time.

It was as cumbersome as it sounds. It was expensive, laborious, and slow. Its use was limited to th government. It was also public—anyone could watch it, after all—and it didn't work in foul weath or at night. Despite this, the optical telegraph was the first successful telecommunications networ serving for more than sixty years. By 1852 the Chappe system boasted 556 relay stations and traced network distance of some three thousand miles. Tributaries from the main network connected many o the capitals of Europe—Amsterdam, Brussels, Mainz, Milan, Turin, and Venice. News of Napoleon coup d'état in 1848 would have taken just under half an hour to transit the network, slow by today standards but fast for the time.

Then the electrical telegraph arrived. It was from the future and, like many things from the future, made things from the present—things like the optical telegraph—look like they were from the past.

It was amazing. With a battery and a switch and miles of wire and a sounder—a thing that clicke when you ran electrical current through it—you could communicate over a distance. Instantly. N half an hour to send a message but half a minute. Of course, it wasn't quite as easy as whipping o your cell phone and texting your friend, but you could write out a message—a telegram—and take down to your local telegraph office, pay some money, and have it sent.

It was patented in both England and America in the same year, 1837. In America the inventor wa

Samuel Morse, whose his first functioning telegraph line went live between Washington, D.C., an Baltimore, Maryland, in 1844. Washington to New York followed two years later.

It seems incredibly primitive today. So primitive, in fact, that it is difficult to appreciate just ho stunning this was at the time. It let loose a communications revolution that the writer Tom Standag dubbed the "Victorian Internet." Americans took to the telegraph like teenagers to text messages. B 1850 America had twelve thousand miles of telegraph lines served by some twenty companies. On two years later this had just about doubled to twenty-three thousand miles, with another ten thousan miles under construction. A writer chronicling the telegraph's rapid growth at the time reported: "It anticipated that the whole of the populous parts of the United States will, within two or three years, b covered with a net-work like a spider's web."

The prediction was right. The tendrils of the telegraph's spiderweb spread rapidly, its thread vibrating with the dots and dashes of Mr. Morse's code. The web—the telegraph web, like its Intern great-grandchild a century and a half later—conveyed news, facilitated commerce, and whispered gossip. Romance blossomed over the telegraph; even weddings took place telegraphically. It reporte stock prices and winning lottery numbers. Gamblers and scam artists used the telegraphic web as wel passing news of sporting events and devising schemes to cheat and defraud.

The spider that owned the web was the Western Union Telegraph Company. Formed by the merger o several competing telegraph companies in 1855, it controlled 90 percent of all telegraph traffic in th United States within just over ten years. But the telegraph's astonishing growth was just gettin started. In 1867 the telegraph network carried 5.8 million telegraph messages and Western Unio reported revenues of some $6.6 million—almost $700 million in today's dollars. By 1875 the numb of messages had grown to about 20 million. So many messages, in fact, that the lines were becomin clogged. Expanding capacity by adding more telegraph wires was an expensive proposition. Th network cried out for a way to transmit multiple telegraph messages over the same pair of wires, an riches awaited the man who invented the "multiple telegraph."

As a later observer put it, "Nothing, save the hangman's noose, concentrates the mind like piles cash." Of the many minds that concentrated on solving this problem, one belonged to a Bosto professor, amateur inventor, and teacher of the deaf named Alexander Graham Bell. Bell's take on th multiple telegraph came from his studies of hearing, sound, music, and human physiology. Bell kne that sounds, like music and speech, were made up of harmonics, that is, of different simultaneou frequencies. Perhaps it was possible to send multiple telegraph signals over the same wire usin multiple tones of different pitch? Bell called his idea the "harmonic telegraph."

Bell worked intensely on the harmonic telegraph, even going so far as to accept an investment fro Gardiner Hubbard, a Boston lawyer who would eventually become his father-in-law. But Bell's min kept gravitating toward a slightly different—and slightly crazy—idea: if you could send several not simultaneously down a telegraph line for a multiple telegraph then maybe . . . just maybe . . . yo could send a human voice down the wires.

He became obsessed with this new idea, despite his investors' attempts to keep him focused on th piles of cash the harmonic telegraph was going to generate for them. The telephone "could never b more than a scientific toy," Hubbard told Bell. "You had better throw that idea out of your mind an go ahead with your musical telegraph, which if it is successful, will make you a millionaire."

But he couldn't. Bell was consumed by a puzzle that was stuck in his head, a puzzle that wasn't goin anywhere until he figured it out. As the historian Tim Wu writes, "For him the thrill of the new wa unbeatably compelling, and Bell knew that in his lab he was closing in on something miraculous. H nearly alone in the world, was playing with magical powers never seen before." He was also the rig

man for the job, the key that fit the lock. Bell himself recalled later, “I now realize that I should nev
have invented the telephone if I had been an electrician. What electrician would have been so foolis
as to try any such thing? The advantage I had was that sound had been the study of my life—the stu
of vibrations.”

It took three years but on March 10, 1876, Bell finally succeeded: he managed to send spee
through a wire and into the next room. His prototype telephone was an unlikely contraption. To use
Bell spoke into the transmitter, a funnel-shaped mouthpiece that focused his voice upon a flexib
diaphragm. Suspended from the diaphragm was a short length of platinum wire, half immersed in a j
of sulfuric acid, the same sort of corrosive acid you’d find in a car battery. A wire ran from th
platinum to the receiver—a primitive speaker, basically—in the next room. From the speaker, a wi
ran to a battery and then back to a brass pipe that was also immersed in the transmitter’s acid bat
The acid was conductive and completed the circuit between the transmitter and the receiver. Here w
the key innovation, the thing that made it all work: the louder Bell spoke into the mouthpiece, t
more the diaphragm deflected and the deeper the platinum wire was plunged into the acid. The mo
wire dipped into the acid, the less electrical resistance there was in the circuit and the more curre
flowed to the receiver, causing the speaker to move proportionately. Using a jar of sulfuric acid Be
had created what would become known as a variable resistance transmitter. It was this that allowed h
system to accurately mimic the volume fluctuations of speech over a pair of wires.

Bell, Hubbard, investor Thomas Sanders, and Bell’s assistant Thomas Watson turned their attentio
to commercializing the new invention. Western Union, with its telegraph monopoly and millions
messages and hundreds of thousands of miles of wire, was the undisputed telecommunications giant
the day. It would seem to have been the natural home of telephony, an established company with
closely related business, technology, and relevant assets. Bell is said to have offered Western Unio
the rights to his telephone patent in 1876 for $100,000. Western Union’s president is alleged to hav
responded, “What use could this company make of an electrical toy?” Well, then.

Bell and his associates pressed on with the telephone’s commercial rollout. This often took Bell a
Watson on the public lecture circuit in Boston and its surrounds, demonstrating their new invention
crowds that were usually enthusiastic but sometimes skeptical. As one newspaper wrote at the tim
“It is indeed difficult, hearing the sounds out of the mysterious box, to wholly resist the notion that t
powers of darkness are somehow in league with it.” Despite such occasional press commentary th
persevered. By 1877 the first permanent telephone wires were strung in a suburb of Boston, the fi
ads for telephone service appeared, and the first telephone rentals took place. The Bell Telepho
Company itself was founded in July of that year.

If you wanted telephone service between your office in Boston and, say, your home outside of tow
Bell would be glad to set you up. You would be able to call your office from the comfort of yo
home, and your coworkers could call you. But it wasn’t much like telephone service today. Bell
offering was point-to-point: a telephone at your home, a telephone at your office, and a telephone li
run directly between them. In fact, it was your responsibility to hire telegraph contractors to run t
line between your home and office. If you wanted to talk to multiple shops or suppliers, you had set
multiple pairs of telephones—and wires—between them and you.

This was high-tech wizardry back in the day. But it suffered from some obvious drawbacks. Th
maximum distance you could cover was about twenty miles. Basic service was $20 per year for a pa
of telephones for residences, $40 per year for businesses—equivalent to about $400 and $800 per ye
today. But the killer expense was telegraph line installation, which cost between $100 and $150 p

mile, that is, between $2,000 and $3,000 per mile in present dollars. Note that telephones were rente never owned outright; this was a key part of the Bell plan to maintain ownership over the enti telephone system.

Forget about all that, though, because these are all small potatoes compared to this: you couldn't ca anyone you didn't have a connection to. Want to talk to Aunt Mabel? Better get the telegrap installers busy running wires between your house and hers.

Bell and others were aware of this problem and knew how to fix it. Instead of running wires direct from one place to another, why not run them all to a central place? When you wanted to make a ca you'd pick up the phone and do something—push a button, turn a crank—to get the attention someone at "central." There a person—an operator—would answer the phone. You'd ask to b connected to Mr. Smith (who needed telephone numbers when only a few people had telephones? Central would ring Mr. Smith's telephone line. When Mr. Smith answered, the operator would conne the wires together, switching your call from central to your party.

As Bell himself put it in a memo from early 1878, "Instead of erecting a line directly from one another, I would advise you to bring the wires from the two points to the office of the Company ar there connect them together . . . the company should employ a man in each central office for th purpose of connecting wires as desired. A fixed annual rental could be charged for the use of th wires, or a toll could be levied. As all connections would necessarily be made at the central office, would be easy to note the time during which any wires were connected and to make a charg accordingly—bills could be sent in periodically." He added, prophetically, "However small the rate c charges might be, the revenue would probably be something enormous." The switchboard, and with the concepts of a telephone central office or exchange—to say nothing of your monthly telephone bi and its per-minute charges—was born.

The first commercial switchboard debuted in January 1878 in New Haven, Connecticut, connecti twenty-one subscribers over eight telephone lines to a single operator, all under license from Be Telephone. The first switchboards were primitive affairs: pieces of wood with a handful of metal bit something that a fourth-grade science fair participant would scoff at today. But they worked, quick establishing their superiority over point-to-point connections.

Switchboards rapidly grew in size and complexity. The first switchboard operators? Teenage boy As John Murphy writes in his book *The Telephone*, "It was believed that they would have the energ dexterity, quicksilver reflexes, and mechanical know-how to connect hundreds of calls an hour on switchboard composed of a bewildering maze of thousands of cords and jacks. It turned out, howeve that they were often impatient, rude, and foulmouthed to callers." Goodness, who could hav predicted? The teenage boys soon found themselves out of their jobs, replaced by women. The ladie Murphy says, provided a "warmer human voice for the phone company" and also injected some se appeal for the telephone's primary user base: businessmen.

By now Western Union recognized its mistake in dismissing the telephone as a toy. Sure, Bell ha three thousand installed telephones and Western Union had none. But Western Union was the larges company on earth at the time, with financing, engineering and operations skills, and 250,000 miles installed telegraph wire. In December of 1877 it went head to head with Bell Telephone, launching th American Speaking Telephone company, with inventor Thomas Edison as one of its technical wizard Within the year Western Union had surpassed Bell Telephone in several markets and looked poised t crush Bell entirely; it didn't even resemble a fair fight.

But Bell had something that Western Union didn't: the fundamental patent on the telephone. Be

sued Western Union for patent infringement in September 1878. It took more than a year but in th end Bell won. In November 1879 Western Union settled the lawsuit, agreeing to exit the telephon business and transfer its telephone exchanges and thousands of telephone subscribers to Bell. exchange, Bell Telephone agreed to limit its involvement in the telegraph business and to share portion of its telephone revenues with Western Union for seventeen years. By the 1880s Be Telephone's publicly traded stock had become the belle of the Boston Stock Exchange, where it trade under the ticker symbol "T"—for "telephone."

The legal victory also helped Bell go after a smaller but still vexing problem: people who ha illegally connected telephones—some stolen, some leftovers from independent telephone compani —to Bell Telephone lines. "During the past few months the American Bell Telephone Co., of Boston has had detectives at work in this city endeavoring to ascertain how many 'bogus' or outlawe telephones were in use here," an 1890 trade journal reported. "Over 200 have been discovered, and la Thursday the first batch of fifteen or twenty liverymen, doctors, dentists, druggists, and fuel deale who have been using these infringing telephones were summoned to appear in the United Stat Circuit Court." As a Bell agent in Philadelphia said, "I cannot understand how many good busine men can permit themselves to use what they know it is against the law to use."

Despite having to deal with the occasional pirate telephone user, Bell was now positioned to own th majority of the telephone network in the United States for the next one hundred years—but there w one problem. Bell Telephone's sacred patents would start expiring in 1894, opening the field fo competition. To prepare for this coming onslaught, Bell Telephone formed a new subsidiary American Telephone and Telegraph. AT&T's mission was to build long-distance telephone line —"long lines," as they were called. The idea was to use the time remaining before its patents expire to develop the nation's long-distance telephone network. Then, when the patents ran out, the compan would have a formidable barrier to would-be competitors. AT&T would be the only company wit long-distance telephone service and it could either charge other companies for access to its lon distance network or simply refuse to let other companies use it.

AT&T's first long-distance line, between New York and Philadelphia (capacity: one call), went liv in 1885. AT&T reached Chicago in 1892, St. Louis in 1896, Minneapolis in 1897, and Kansas City i 1898. The far west took longer, as telephone engineers struggled with the challenge of sending voic over greater and greater distances. But the engineers persevered; Denver was reached in 1911 and Sa Francisco in 1915.

Switchboards, meanwhile, still based on the same fundamentals as the piece of wood wi connectors, became larger and more sophisticated. Electrical cords insulated in woven cloth were use to connect incoming calls to destination telephone lines; these are the "cordboards" you see in o movies, the ones where dozens of operators sit next to one another, arm by arm, plugging an unplugging wires into the large connector panels in front of them.

By 1888 a switchboard had been designed that could serve more than ten thousand subscribers New York City. In the cordboard's eventual form, an operator would sit in front of about two hundre answering jacks and roughly three thousand calling jacks, that is, she could answer calls from abo two hundred customers and connect them to about three thousand others. Multiple individu switchboards could be placed next to each other and ganged together, allowing one operator (with certain amount of standing and stretching) to connect calls on the boards to her left or right, triplin her capacity. The result was that her two hundred subscribers could be connected to about nin thousand others. Put fifty of these switchboards and operators in the room and you had a comple telephone exchange: almost ten thousand people could be connected to one another.

But what if you want to talk to somebody served by an entirely different switchboard? To do this yo need a way of connecting switchboards in different locations. Wires called trunk lines were installe between central offices for this purpose. The central offices are the branches on the tree and the wir connecting them form the tree's trunk. But Bell Telephone quickly ran into the same problem it ha with the original telephone system: trunk lines are point to point. If you have ten central offices in given city, and they all need trunk lines between them, you find yourself having to run forty-five lin due to all the possible combinations of central offices that need connections with each other—a bi expensive mess, and one that gets worse with each central office you add.

The tandem switchboard solved this problem. You can think of a tandem switchboard as switchboard of other switchboards, a special switchboard in a special central office that was used on for connecting other switchboards together. Just like the original central offices had all the telephon wires for a given exchange brought to a central place, a tandem central office had the trunk lines fro other offices brought to a central place. There an operator on a tandem switchboard could conne trunk lines from one central office to another. The network was starting to become hierarchical.

By 1903 there were about 3 million switchboard connected phones. The interesting thing about the millions of lines is that, in every case, a human being was the switch. It was the operator's hand, arm and reach that switched an incoming call to its destination, and the operator's brain that told the han and arm where to reach and what to do. Telephone switching was an intensely manual proces requiring warehouses full of people. By 1902 the Bell System employed some thirty thousan operators; by 1914 it was about a hundred thousand.

Humans as switches have lots of advantages, qualities such as judgment, sympathy, warmth—th personal touch that is part of customer service. But they have disadvantages too. For one thing, yo have to pay them. For another, they're slow. Between a lack of long-distance capacity and human having to put through the calls, a coast-to-coast call in 1922 might have taken fifteen minutes or mo to be connected. They make mistakes, for instance, plugging the wrong cord into the wrong jack. An then there are their all too human frailties. They eavesdrop on conversations. They gossip. They hav loyalties.

The last of these qualities, legend has it, was the straw that broke an undertaker's back. Back in th late 1880s Almon Strowger, a mortician in Kansas City, Missouri, noticed a disturbing drop in h business. As it happened, the wife of a competing undertaker worked as an operator at th neighborhood switchboard. She, the story goes, tended to connect callers to her husband's business- not Strowger's—when someone would call in and ask for the undertaker.

You can think of many solutions to such a problem. You could complain to the telephone company You could have a friendly chat with your competitor. You could even sue. But Strowger could se through to the root of the problem: pesky humans. Eliminate human operators and you'd eliminate th problem. Strowger set upon inventing a system to make human operators obsolete. Who needs a bunc of people plugging cords in boards when a machine could do the work more quickly, more accuratel less expensively —and more honestly?

Strowger's first mechanical telephone switch was patented in 1891. It allowed telephone subscribe to "dial" their own calls without needing to go through an operator. The original Strowger syste didn't involve an actual circular telephone dial; rather, each telephone had three buttons: one for th hundreds digit, one for the tens digit, and one for the ones digit. To call telephone number 315, yo pressed the hundreds button three times, the tens button once, and the ones button five times. Insid the fiddly bits of the switch worked together to connect you to the person you wanted. Look Ma Be no operator!

Strowger formed the Automatic Electric Company to build and sell his mechanical telephone switc
The first automatic telephone exchange, based on the Strowger switch, opened in November 1892
La Porte, Indiana, with seventy-five subscribers and room for ninety-nine total.

Like many inventions, the first Strowger switch wasn't quite ready for prime time and required
great deal of additional work before it became a commercially solid product. But it got the
eventually, and with tremendous success. Bell eventually began using Strowger switches fro
Automatic Electric in 1915, and by 1926 Bell had licensed the Automatic Electric design and wa
manufacturing the switches itself. Telephone switches based on the Strowger switch—called "step-by
step" switches within the Bell System—would go on to become the dominant type of telephone switc
for more than seventy years, seeing widespread use around the world. In the United States, th
popularity of the Strowger switch reached its peak only in 1972 when more than 42 million telephon
lines were connected to step-by-step switches descended from Strowger's original design.

Other types of automatic telephone switches followed the Strowger switch. The Bell System began
metamorphosis, from a purely human affair to a gigantic cyber-mechanical-human endeavor: a mix
operators and machines switching calls, supported in the background by still more humans designin
building, installing, and caring for the switching machines. Functions that were once the domain
human operators slowly became increasingly mechanized: switchboards became switching machine
tandem switchboards became tandem switches ("tandems" for short)—specialized machines designe
to connect trunk lines from other switching machines, building up the long-distance telephon
network link by automated link.

Bell Telephone's worries about competition starting when its patents began expiring in 1894 turne
out to be well founded. Just ten years later there were more than six thousand competing independe
telephone companies providing local telephone service. For Bell Telephone and its shareholders, th
competition was bad enough. But in some ways it was worse for the customers. Prices varie
considerably, with some telephone companies opting for flat-rate service in which customers paid
fixed yearly fee for all the local calls they could make, while other companies went with measure
rate service and charged customers per call (and sometimes per minute) for local calls. Worst of al
the telephone lines of independent companies didn't connect with those of the Bell System, or, for th
matter, with other independents. Cities would have multiple telephone companies and subscribers
one company couldn't call those of another. Businesses had to have different phone lines installe
from different telephone companies to support their customers.

Despite the chaos caused by these kinds of problems, the independents looked to be winning. B
1903 Bell had about fifteen hundred telephone exchanges and about 1.2 million subscribers. Th
independents had more than six thousand exchanges and about 2 million subscribers.

Bell Telephone fought back with everything it had. It drove independents out of business throug
what some would call predatory pricing, and it bought up many of those it could not drive out
business. It denied the independents the use of its long-distance network. And it engaged in mo
underhanded tricks, including bribing public officials to prevent the establishment of independe
telephone companies as well as using company influence with banks to deny its competitors bad
needed loans. It also launched an effort to dominate the telegraph industry, buying a controllin
interest in its old nemesis Western Union in 1908. AT&T was described as a "ruthless, grinding
oppressive monopoly."

The U.S. Justice Department began an antitrust investigation against AT&T in 1913, culminating in
recommendation that the Interstate Commerce Commission dig into AT&T with an eye towar