

Ma Bell's Great Dream Machine

By N. R. KLEINFELD

MURRAY HILL, N.J. — It has been called by some the greatest of industrial laboratories. Others speak of it as a corporate Edison. At the Inwood Diner on Route 22, a blustery man hunkered over eggs at the counter. When asked about the nearby lab, he said: "That? That's where they make dreams come true."

The rest of the world does seem remote from the hilltop headquarters here of the Bell Telephone Laboratories. Together with 15 similar facilities in eight states, this is where the Bell System, a domain of 128 million telephones and a billion miles of circuits, does its inventing.

The labs — owned half by the American Telephone and Telegraph Company and half by Western Electric, its massive manufacturing arm — dream up the jacks and thin-film circuits and futuristic gadgetry that Western Electric makes and A.T. & T.'s 23 operating telephone companies put to use.

Under the labs' basic charter, they are supposed to do research of "possible value" to telecommunications as well as develop practical systems. The charter is interpreted somewhat loosely. Some of the lab people are looking into the workings of the human nervous system, the scheduling of coffee breaks, what earthquakes do to buildings and the best way to spot a liar.

Down the years, the labs have been granted a prodigious 18,400 patents. Patents are now doled out at the rate of almost two per working day. One man, Andrew Bobeck (co-inventor of bubble memory, a data storage system), has 100 patents under his belt. The transistor was born at the labs. So was radio astronomy. So was the first synchronous-sound movie system. So was the negative-feedback amplifier, clearing the way for high-fidelity recording. So was the laser. Five staff members have collected Nobel Prizes.

Today, though, the labs face problems never before encountered. Their work plods on in the shadow of the Government's huge antitrust suit against A.T. & T., a suit that could dismember the Bell System, including separation of the labs. This is a prospect that laboratory workers grimly believe would cause the place to wither and die.

And, although A.T. & T. still has a firm grip on its virtual monopoly of residential telephone service, there is a proliferation of competition from terminal equipment suppliers and from companies that offer business phone services. This competition has brought about an uncertain regulatory climate. So many court and administrative rulings — concerning who can compete where — remain unresolved that the lab people are a bit confused about what areas they should focus on.

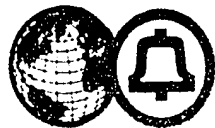
One result of all this has been to make the labs try harder to find out exactly what customers want before they start

tinkering with new ideas. Roughly 17,000 people work in the 16 labs, including more than 2,000 who hold doctorates. The annual operating budget hovers near \$780 million. The money comes from A.T. & T., Western Electric and the regional telephone companies. And a small proportion comes from the Government for defense work.

The headquarters of Bell Laboratories sits sheltered on 200 acres of grassy fields and woods in the middle of this upper-income suburb of New York City. Birds wheel overhead. One sprawling brick building, a stark and almost chilly affair with a modernistic entranceway, dominates the site.

Tacked on the bulletin boards at Murray Hill are notices for meetings of gardening clubs, chess clubs and chamber-music groups. Animated conversations

The Biggest Company On Earth



One of a series on A.T.&T. and its impact on American life and business.

Amid court cases and new competitive pressures, Bell labs delves into DNA and coffee breaks.

can be heard in French, German and Italian. Order and a sense of purpose prevail.

The president of the labs is a small, feisty, professorial man named William Baker. He is a physical chemist whose chief discovery was a new synthetic polymer molecule called microgel, which turned out to be highly useful in the World War II rubber shortage. His view of the labs' future: "Do not underexpect."

Mr. Baker rhapsodized in his office the other day about the role of the telephone: "It appears that the telephone is the principal organizing element in the ordering of an information society. It appears that the switch telephone system is as big an element as anything in reducing the entropy and bringing order in the broad philosophical sense."

People at the labs are somewhat alarmed by the heaps of information people are being exposed to. "Since about 1945, the amount of information in the record doubles every seven years," Mr. Baker said. "It has been determined that a weekday copy of The New York Times has as much to read as the educated individual in 16th-century Europe absorbed during his lifetime. Now

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that imposes on society a huge burden, because people can't absorb information any faster than about 40 bits [binary digits, the smallest measure of information] a second. Our evidence is that people today can't absorb information any faster than Stone Age people. So you can see that getting information fed to you faster over the phone becomes critical."

Down a confusion of hallways, development work was proceeding on laser chips the size of dust particles. The chips convert electrical power into laser power and are at the heart of a light-wave transmission system, one of the hottest areas in telecommunications. In the future, many telephone conversations are going to be transported in the form of laser beams along strings of molten fiber the thickness of a human hair. The system will be smaller, lighter and cheaper than present ones.

The work has been going well. When Bell Laboratories began measuring the life of laser chips in 1970, they would "die" in a few minutes. The projection now is that they can last a million hours.

James Flanagan, red-haired director of the acoustics research department, had a distant look as if he had just gazed into a campfire. Sitting in his pin-neat office, he was thinking about digital communications — the way computers talk. From the phone company's viewpoint, this method is preferable to analog communications (the voice is an analog signal) because digital signals can be sent over long distances almost distortion-free. Mr. Flanagan and his compeers have been trying to get computers to speak and to get people to be able to talk with computers.

Mr. Flanagan demonstrated a directory assistance system, listing Bell lab workers, that has been tested for about a year. Punching a person's name on a push-button phone makes a computer fish out the person's phone number and deliver it in an assembled recording. The goal, Mr. Flanagan said, is to have all directory assistance done this way in the future.

The acoustics group is also working on a voice recognition system that would let a person in a checkless society call up his bank and have it send money from his account to a store to pay for a purchase. One experimental system has had 98 percent accuracy in identifying voices, Mr. Flanagan said. Besides testing ordinary people, the lab besides in radio and television mimics to see if they could fool the computer. It still

A commission in California has challenged the way costs of the labs are allocated.

managed to be 95 percent accurate. Down another corridor Sol Buchsbaum, vice president for network planning, chatted about the phone system of 50 years in the future. "There won't be such a thing as a telephone," he said. "We'll have an instrument, and at the press of a button you'll either turn it into a telephone or it will connect you with someone else — or something else, like a computer. You'll be able to get a video display as well as a voice. You'll be able to connect to a vendor or a bank. You'll have a communications terminal."

After the technology to accomplish this is introduced, Mr. Buchsbaum said, it might be possible that when you get a busy signal your phone can monitor the line and complete the call as soon as the line is free. You may also have a display on the phone that will show what number is calling you. If you recognize it as that of someone you don't care to talk to, you can ignore the ringing.

Bell scientists are searching for a better understanding of DNA, the stuff that transmits human genetic traits. Mr. Baker explained Bell's interest: "If you are looking at the storage of information and the transfer of information, one of the most impressive ways that that is done in nature is by molecules of this kind. We're not quite ready to connect the phone wires onto the DNA molecules, but we're trying to see what nature can teach us."

Laboratory people sometimes make mistakes. One example was Picturephone, the highly publicized attempt to combine a video display with the telephone. Though technically successful, its cost proved higher than people cared to pay. Its use today is limited to conference calls.

The brightly colored Princess phone was intended for bedroom use, but customers wanted it installed throughout the house. The trouble was that the phone was so light that it kept sliding across desks and flopping onto the floor. So the bottom was redesigned with a corrugated surface.

E signaling, which tells the telephone switching network what number a customer is dialing, must have "talk-off properties" to keep the mechanism from being triggered by random noises. Bell Laboratories did exhaustive testing to provide proper protection. Nevertheless, after the signaling system went into operation, a small number of sounds still disrupted it.

A Midwestern woman, for example, had a laugh with a timbre that regularly cut off her phone calls. A pay phone in Washington kept disconnecting, apparently because of the trip-wire bell at a nearby gasoline station. The labs hastily did some redesign work.

The biggest development effort in Bell Laboratories history was the perfection of an electronic switching system, called ESS. Serious work on it began in the early 1950's. It was expected that reid trials would start in 1959 and that the whole project would cost about \$45 million. The first ESS office actually went into operation in 1965, and the total



The New York Times/William E. Saurio
Research on integrated circuits in a "clean room" at Bell Labs headquarters. Below, synthetic-voice research. On the computer screen, model of vocal cords.



development program ultimately consumed about 4,000 man-years of work and cost \$400 million. But the system works, and electronic systems are rapidly displacing mechanical ones.

Competitors are not particularly ebullient about the Bell Laboratories. They sniff at the big sums of money spent there and wonder aloud if the dollars are really worth it.

A spokesman for the North American Telephone Association, a trade group with more than 250 competitors of the Bell System as members, remarks: "So far as innovation is concerned, I don't think they are any better off than the rest of industry. They aren't forging way in front of us. They aren't ahead in any respect."

Walter Gorkiewicz, vice president of a research firm called Probe Associates and co-author of a book highly critical of A.T.&T., says: "We've looked at the innovation record, and frankly we're not that impressed. Worst of all, we think the amount and accuracy of the information that the Bell System puts out is terrible."

The Bell Laboratories are also caught in a potentially explosive dispute with the California Public Utilities Commission, known as a stern regulatory agency. A recent committee report to the commission, yet to be acted on, has concluded that the Pacific Telephone and Telegraph Company, one of A.T. & T.'s operating subsidiaries, is being unjustly billed by A.T. & T. for product-development costs at Bell Laboratories. Those bills, the report said, should be paid by Western Electric as the entity benefiting from the work. The way it is, the committee said, Western Electric is able to price its products lower than competitors. Pacific, the report asserts, had to pay \$14 million in 1976 in unfair expenses.

Dean Gillette, executive director of the labs' systems research division, says the costs borne by operating companies is for work done for their benefit. He says he is gravely concerned about the California case because he wonders whether some of the research work would ever get done if the operating companies no longer paid their share.

Recently the labs have been emphasizing psychological research. A lot of work, for example, is related to how people learn. This is logical because the Bell System, with its in-house schooling, is one of the nation's biggest educators. It spends about \$750 million a year training portions of its one million employees.

One of the behavioral science re-

searchers described a learning theory that, among other things, can be applied to memorizing a phone number. The theory assumes that repeating a number over and over as fast as you can is not the best way to remember it. Instead, you should recite the number, then let several hours (maybe even a full day) pass, recite the number, let more time elapse, recite it again and so on. Telephone people hope that customers can sharpen their memories and thus dial fewer wrong numbers and need less directory assistance. One of the newest departments at the labs involves interpersonal communications research. Myron Wish, curly-haired and

fast-talking, is the head of this group. Some of its work, all preliminary so far, has contrasted communications by phone against communications in person. One of the more provocative findings is that it's apparently easier to know when someone is lying to you over the phone than if the conversation is face-to-face.

"Most people have a sort of intuitive feeling that you have to see a person to tell if he's lying, that the lie sort of oozes out of him," Mr. Wish said. "Our findings suggest the opposite. Part of the problem is that people may believe what they see more than would be warranted."

A department known as the human factors group seeks practical applications for psychological research. It is based at the biggest lab installation in Holmdel, N.J., a huge affair of glass and steel perched on the New Jersey coastal plain.

The group consists of psychologists who do not necessarily know anything about telephones (other than how to use one) when they start at the lab. A recent arrival, for instance, has applied for a patent on a new bit for a horse. Based on positive rather than negative reinforcement, the bit is rigged to put a sugar solution into the horse's mouth when the horse does something right.

One man has been investigating the kinds of electronic tones that are pleasant to the ear. A new tone, soon to be added to the phone network, will alert customers when they are about to hear a recorded message. The phone company says this should keep people from talking to machines and wondering why they don't get a reply.

Research by the human factors group led to the square shape of push buttons on phones. Triangles, half-moons and crosses were among possibilities that were considered and rejected. The group also introduced the white dots inside the holes of a standard phone dial because people dial more efficiently with a finger target.

Elsewhere in the labs, mathematicians were puzzling over such matters as how to schedule operators' coffee breaks so that there are always enough people to answer the phones.

Development work continued on an automated coin phone. It computes the charge for a call, announces the amount and then counts the coins thrust through the slots. Some of the phones are being tested in Phoenix.

A research and development effort has resulted in 120 computer-based systems to help the phone company's personnel do their work, with more to come. For instance, a telephone repairman can dial a number where trouble has been reported and immediately see displayed on a terminal screen all the vital information about that line. Another system helps automate the production of telephone directory pages.

At the Whippany, N.J., installation, a dank relic built as a temporary structure but never replaced, there is a building and energy systems lab. Its purpose is to devise ways to save energy and to build efficient telephone buildings. The Bell System boasts that it accounts for only one-tenth of 1 percent of the country's total energy consumption while contributing 1 percent of the gross national product.

California is earthquake country, a fact that has not been forgotten by the telephone company, which has several buildings out there. A giant room at Whippany contains a big steel platform that is an earthquake simulator. Telephone equipment is placed on the platform and secured as if it were in a building. Then an "earthquake" is activated with the help of a computer, thoroughly shaking the equipment.

Sometimes people at Bell Laboratories are plucked from their heady scientific environment and hurled into the everyday world. Some years ago a New York man was standing on a ladder in his kitchen, above a phone mounted on a cabinet. As his wife bounded by, the phone came off the hook and hit her on the head. She took her husband to court and accused him of attacking her. (The marriage had not been going well.)

The husband then sued the phone company, contending that the phone was poorly designed. A man from Bell Labs was summoned to testify. Using angular measurements, he showed how difficult it is for a phone to fall off the hook. Nothing came of the suit.