The TELEPHONE *in* AMERICA

THE TELEPHONE IN AMERICA

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Alexander Graham Bell in 1876
When He Was Granted His Original Telephone Patents

The Telephone in America

The Invention of the Telephone

The telephone was invented in Boston, Mass., by Alexander Graham Bell, a young professor of vocal physiology and student of electrical science, who was born in Scotland on March 3, 1847, moved to Canada in August, 1870, and came to Boston in 1871, as a teacher of deaf mutes. The day on which Professor Bell discovered the principle of the telephone was June 2, 1875. His continued experiments, based on his discovery, resulted in an instrument that on March 10, 1876, really "talked" to the extent of transmitting a complete sentence—the first connected human speech to be electrically transmitted and heard over a wire. From this crude beginning came the agency of communication that "has made America a neighborhood," and has reached out across the seas to bring distant continents within speaking distance of one another.

Bell's Theory of the Telephone

Others before Bell had had glimpses of the possibilities of the transmission of speech by wire. In 1854, Charles Bourseul had outlined a method by which he believed that speech could be so transmitted. Phillip Reis, a German, in 1861, working along the lines of Bourseul, produced a mechanism that would transmit pitch but could not transmit speech.

Professor Bell succeeded in producing a speaking telephone because he had thought out the right principle. While experimenting on his harmonic telegraph in 1875, which led to the invention of the speaking telephone, Professor Bell outlined an idea to his associate, Thomas A. Watson, as follows:

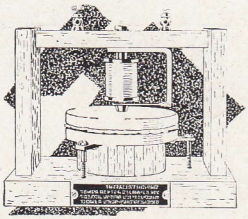
"If I could make a current of electricity vary in intensity precisely as the air varies in density during the production of sound, I should be able to transmit speech telegraphically."

By employing a diaphragm to produce an undulating electric current just as he had foretold, he was able to transmit speech.

Original Bell Patent

On March 7, 1876, Professor Bell was granted his original patent for the invention that was destined to be developed into the carrier of millions of messages daily.

In the summer of 1876 Bell exhibited his telephone at the Centen-



The Original Bell Telephone, 1875

nial Exposition in Philadelphia, where it attracted no public attention until the judges of the Exposition and some visiting scientists had participated in a demonstration and had acclaimed it as a wonderful scientific achievement.

109 Court St., Boston, Where the Telephone Was Born

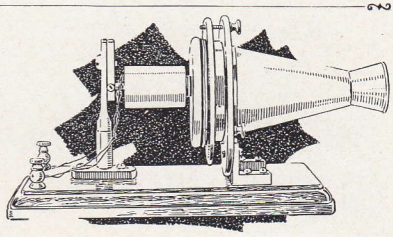
The early telephone apparatus was very crude. It consisted of an instrument to be used alternately as a transmitter and as a receiver, and a connecting length of wire. There have been many changes in the telephone instrument since Bell first designed one that would talk. Since 1877 there have been standardized more than one hundred types of transmitter and more than seventy types of receiver.

Public Apathy

One of the disheartening difficulties faced by Bell was an almost complete apathy on the part of the public. Even the endorsement of men of science failed to convince the "practical" men of the day that the telephone was more than an interesting toy. They saw for it no future as a factor in business and social life. They refused to use it and refused to invest their savings in it.

Early Lectures and Demonstrations

In order to arouse interest in his invention, Bell delivered a series of lectures on the telephone, accompanied by demonstrations. Members of the audience were permitted to talk with friends. At the first of these public demonstrations a representative of a Boston newspaper sent from Salem the first newspaper dispatch ever transmitted by telephone.



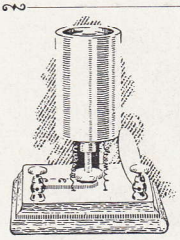
Transmitter Exhibited at Philadelphia, 1876

The public was slow to realize the usefulness of the device. The first commercial telephones were put out in May, 1877. On June 30, 1877, about fifteen months after Bell had been granted his original patent, there were only 234 telephones in the whole country. They were leased in pairs or loaned to individuals by Professor Bell and his associates. All the telephoning was over single iron wire, connecting the two telephones, with grounded circuits. Calling or signalling devices were crude, and transmission was poor and uncertain. There were no switchboards.

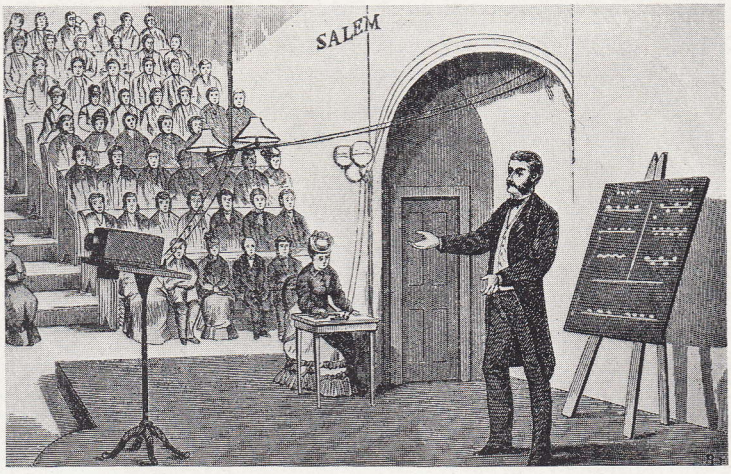
First Telephone Organizations

The first form of business organization to handle the telephone commercially was a trusteeship. It was instituted in July, 1877, by the four owners of the patents, Alexander Graham Bell, Thomas Sanders, Gardiner G. Hubbard and Thomas A. Watson. The trustee was Gardiner G. Hubbard. By the powers vested in him Hubbard decided upon the policy of renting telephones instead of selling them; and started a system of licenses to authorized agents or licensees in many parts of the country for the commercial development of the telephone as an industry.

The Garret, 109 Court St., Where Bell Discovered the Principle of Electrical Speech Transmission



Bell's Receiver, at Philadelphia, 1876



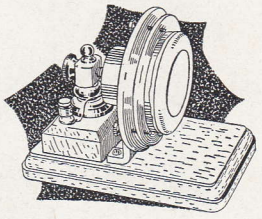
Alexander Graham Bell Demonstrating His Telephone at Salem, Mass., 1877

These license-agencies grew into exchanges and into local companies.

The increasing need of capital for the general development of the telephone resulted, in February, 1878, in the formation of the New England Telephone Company. The money raised for this company was administered by an executive committee, and was restricted to the development of the telephone business in New England. This more common form of business organization proved more practical than the trusteeship, and in July, 1878, a similar corporation, called the Bell Telephone Company, supplanted the trusteeship for the commercial development of the telephone in the rest of the country. As there was no adequate reason for the general development of the telephone being divided between two companies, the Bell Telephone Company and the New England Telephone Company were merged in March, 1879, into the National Bell Telephone Company. About this time new leaders were coming into the management of the telephone business, particularly Theodore N. Vail and William H. Forbes.

The American Bell Telephone Company

The growing demand for telephones called for further capital.

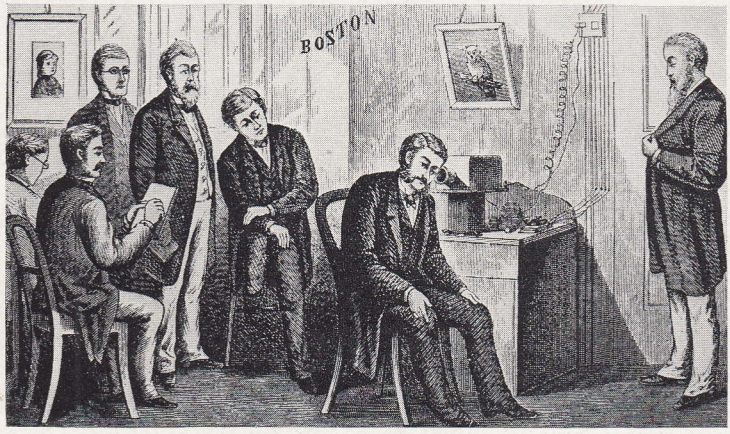


Telephone Used in First Outdoor Talk, 1876

Accordingly, the business was again reorganized in April, 1880, by the formation of the American Bell Telephone Company, which greatly developed the telephone organization and business throughout the country.

The next important step toward the attainment of a national telephone service was the organization of the American Telephone and Telegraph Company in 1885. This company was formed to build and operate long distance lines to interconnect the regional companies that had developed, by merger and growth, from early licensee companies, and that were giving local service.

To realize the ideal of universal telephone service, it became increasingly important to extend the long lines even further, to carry on continuous investigation for the practical development of the telephone art, to make further progress toward the standardization of apparatus, equipment and methods, and to centralize administrative functions as far as possible in the interest of efficient and economical service. In 1900, therefore, the American Telephone and Telegraph Company took over the assets of the American Bell Telephone Company, becoming the central or headquarters company of the coordinated federation that is known as the Bell System.



Scientists and Reporters at Boston Listening in on Bell's Program from Salem

THE SPEAKING TELEPHONE.

REMARKABLE RESULTS—A BROOKLYN SONG HEARD IN NEW YORK—A CORNET SOLO HEARD THREE MILES AWAY.

If Franklin, who caught the lightning with his kite, or Morse, who tamed and put it into leading strings, had been present last evening in one of the quiet parlors of the St. Denis Hotel and heard it talk and play and sing "Hold the Fort," they would doubtless have been as much surprised as they themselves surprised the people of their own day and generation. The occasion was not a public one, yet the interest which attached to it was sufficient to attract a considerable number of gentlemen well known in the scientific world. Among these were President Barnard, of Columbia College; Professors Newberry and Rood; Professor Peet, of the Deaf and Dumb Asylum; Hon. T. N. Gibbes, M. P., of Canada, President of the Dominion Telegraph Company; General Eckert, President of the Atlantic and Pacific Telegraph Company; General Gaylord, Eastman Johnson, Rev. Dr. Armitage and others. It was in obedience to an invitation from these gentlemen that Professor A. Graham Bell, of Boston, delivered a lecture on sound and electricity and gave a striking exhibition of his speaking telephone. To the eye the apparatus used was simplicity itself and might have been taken by a casual observer for the cover of an ordinary sewing machine, except that at one end there was a mouth-piece like that which is attached to speaking tubes. A couple of wires ran from the other through the room across the Brooklyn Bridge and into one of the offices of the Atlantic and Pacific Telegraph Company in that city. In a conversational, but clear and succinct manner Professor Bell told the story of his discovery, and described, as well as he could do so verbally, the operation of his machine. Modestly disclaiming anything like perfection and confessing that the telephone was yet in its infancy, and that he was met at every step by strange results and problems, which seemed to leave him deeper in the dark, he nevertheless gave to his audience various illustrations of the wonderful power which he has achieved that must have satisfied the most sceptical person present that we are upon the eve of strange developments in the philosophy of life. For instance, it was startling to hear the lecturer stop in the middle of a sentence and exclaim, "Ah, my friend is talking to me in Brooklyn!" There is a dead silence in the room, and the low monotone of a man's voice is audible.

From the New York Herald, May 12, 1877

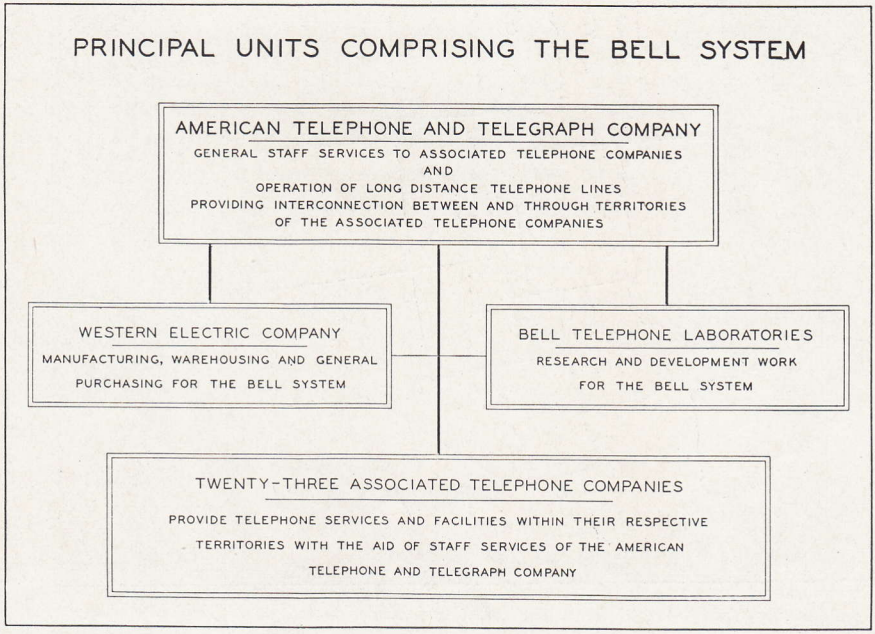
Organization of Telephone Industry

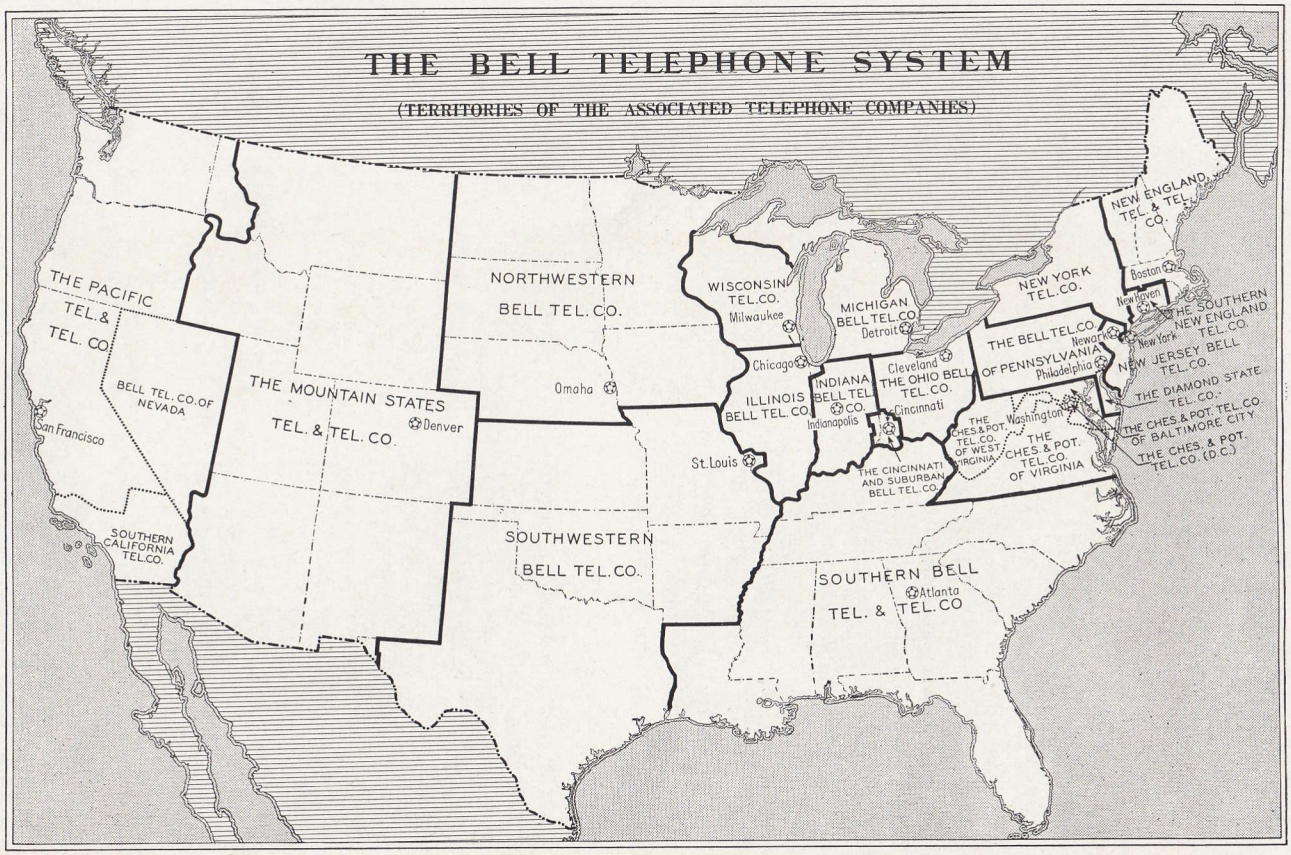
The Bell Telephone System

Thus, a few years after the telephone's invention, the organization took a somewhat similar form to that of the American Union of Federal and State governments, in order to function efficiently and economically as an agency of national service. The American constitution provides a central form of government, equipped to perform national functions adequately, leaving to local governing bodies the responsibility of local affairs, and the Bell System is similar in structure and purpose. Because of this form of organization, the System has been able to expand with the growth of the country, and telephone service is unified and nation-wide.

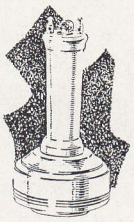
Associated and Connecting Companies

The American Telephone and Telegraph Company and its 23 Associated Telephone Companies comprise the operating units of the Bell Telephone System.





The American Telephone and Telegraph Company, the Parent Company Operating the Long Distance Lines, and its Twenty-Three Associated Companies, Together Comprise the Bell Telephone System



Wooden Hand Telephone
Used in 1877

Besides these 24 Bell companies, there are over 6,600 independently owned companies, together with more than 25,000 rural lines and systems, which are connected with the Bell System lines for the interchange of toll calls, thus making possible an intercommunicating telephone system for over 70,000 cities, towns and rural communities in America.

The American Telephone and Telegraph Company is often called the headquarters company of the Bell System. The twenty-three regional operating companies which it owns in whole or in part are responsible for telephone service in the communities where they are established. Their function is to study and to serve local needs and requirements, present and future. Their policies and practices are shaped to this end. They are state or regional enterprises, operated and managed by local people intimately identified with the activities of the communities where they live and work. Every one of their exchanges is a local institution. Each company is organized and equipped to meet the operating telephone problems within its area, both local and long distance.

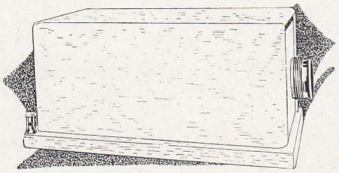
These regional companies operate under State laws and, as to service within the states, are subject to regulation by State commissions. They, as well as the American Telephone and Telegraph Company, are subject as to certain matters to regulation by the Federal Government.

Local Responsibility

The problem of meeting the service needs of local communities varies with the character and activities of the communities. It is the specific responsibility of the local telephone organizations, and requires the complete and constant attention of the regional companies.

American Telephone and Telegraph Company

There are also general problems common to all the companies. That these may be handled economically and efficiently, the regional companies contract with the American Telephone and Telegraph Company for centralized services relating to them. This contractual relationship dates back to within a few years of the telephone's invention. It is an outgrowth of the original licensing arrangement whereby the first telephone companies secured instruments for the use of their subscribers. It was founded on the necessities of the business. It still exists for the same reason.



The Box Telephone Used in 1877

Through this arrangement the regional companies, in effect, employ the headquarters company to do for them the things which can be done better and more economically by a centralized organization.

"General Staff" Service

To meet this responsibility the American Telephone and Telegraph Company has organized itself to perform services relating to engineering and operation, to finance, accounting and law, and to give such other assistance to the regional companies as may be helpful to them in conducting their business.

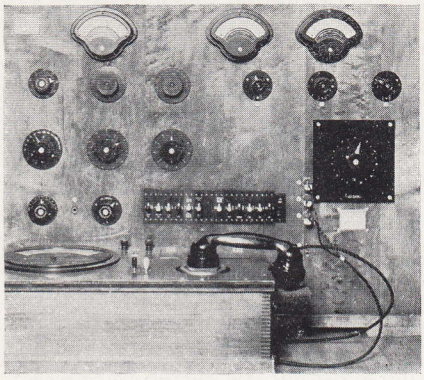
A few illustrations will show how it functions under this arrangement. To furnish financial assistance is one of its important services, particularly in periods of rapid growth, when vast sums are needed for plant additions and replacements to meet the demands of the public for service. More than $1,600,000,000 was advanced to the regional companies in the post-war years before construction activities slackened in the present decade.

Another service of the utmost importance is that enabling the regional companies to utilize every improvement resulting from the research and experimentation of its scientific workers in the Bell Telephone Laboratories, and to keep track of scientific achievements in the world at large that might be beneficial to the telephone industry.

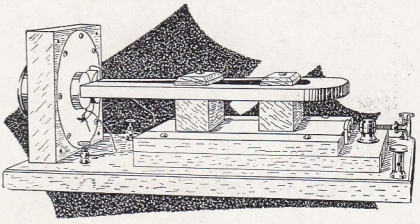
Thousands of patents covering the results of Bell System research activity are owned by the headquarters company for the benefit of all the operating units of the Bell System.

These results, of course, are expressed physically in the apparatus and equipment that the regional companies use to give service. They have been of enormous importance in improving the quality and reducing the cost of their service.

But the problem of apparatus is only one of the multitude of prob-



Making Electrical Tests on a Hand Telephone



Interior View of Box Telephone

lems that the Bell regional companies share in common. There is a best way of doing everything and this best way applied to the innumerable details of operation is what they are constantly seeking to know.

Another service, therefore, that the regional companies engage the American Telephone and Telegraph Company to provide, though classified as "telephone engineering," is so broad in its scope as to include the entire range of construction, operation, maintenance and business practices. No single company could afford to make these studies for itself.

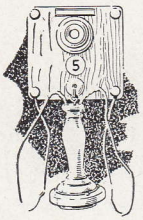
New ideas for improved equipment and operating practices are constantly being studied by the staff of the headquarters company and from time to time are suggested by the men in the operating companies. These new ideas are developed and tested and the resulting improvements spread over the whole Bell System.

Every phase of telephone operation and activity is studied in behalf of the regional companies. The sole purpose of this centralized work is to insure continued improvement in telephone service. The cost of this research and advisory service is more than the headquarters company receives for rendering it. The

A Telephone Building that Harmonizes with its Surroundings in a Residential District

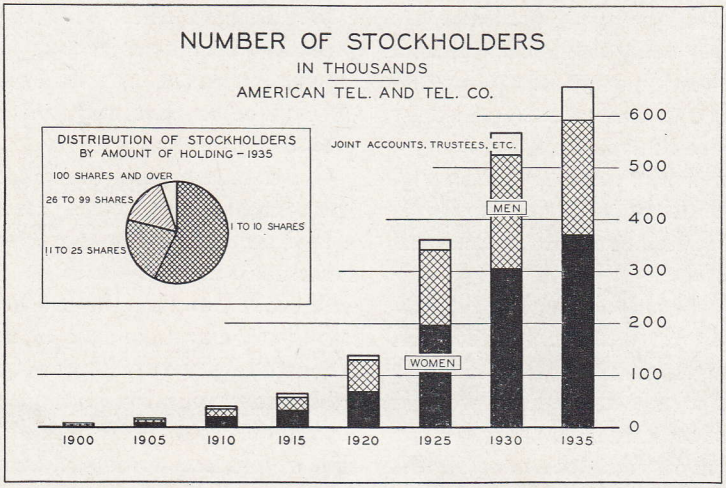
American Telephone and Telegraph Company functions in the manner of a General Staff, ready to provide expert assistance in solving any new problem that may arise, but is principally occupied in studies and developments that will anticipate problems.

One department of the headquarters company, for example, develops a new technique for the System's construction forces—such as a new and more economical method of laying cable and conduit, or details for installing armored cross-country cable underground without conduits. Another studies the System's collective experience with buildings and equipment in order that the knowledge gained from this experience may be applied to central office de-



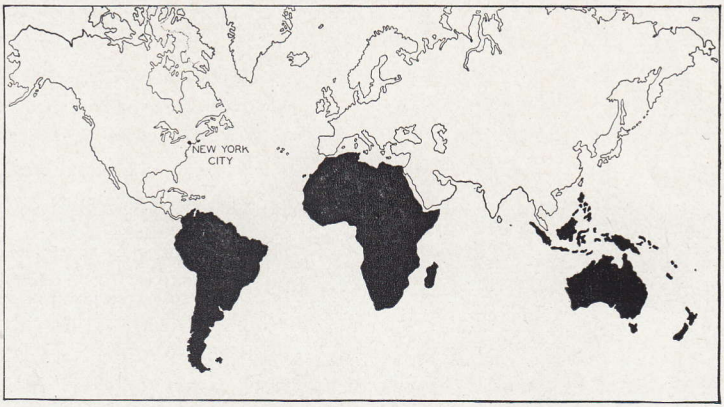
Wall Telephone Used in 1878

sign. A third group sets up practices for the design of the plant from a transmission standpoint to insure that any subscriber in the Bell System can at all times talk satisfactorily to any other subscriber and furthermore that this be achieved at the least possible overall cost. Another, specializing in traffic matters, perfects operating practices that cut many seconds from the time required for handling calls and that further improve their accuracy. Another helps the regional companies to develop business practices and office routines. It studies markets, assists in formulating promotional plans and in the carrying forward of a great number of other necessary functions. Still another department advises the companies as to the most efficient methods involved in accounting work and in the statistical analyses of the results of operation needed for local administrative purposes. Thus it is possible for the Bell System to give the best, the most economical and the most comprehensive telephone service in the world.



Stockholders of the American Telephone and Telegraph Company Are Located in Every State—12 States Each Having More than 10,000, and No State Less than 500 Stockholders

Achievements and Aims



Nearly as Many Telephones in One City in the United States as in Three Continents of the Southern Hemisphere

Bell System Ownership Widely Diffused

The total number of owners of Bell System securities is about 825,000. The American Telephone and Telegraph Company alone was owned on Jan. 1, 1936, by 657,465 stockholders, including nearly 100,000 stockholders who are Bell System employees.

Of the total number of stockholders on January 1, 1936, 376,000 or 58 per cent owned from 1 to 10 shares each, while 623,000 or 95 per cent owned less than 100 shares each. The average number of shares of the American Company's stock held per stockholder was 28.

Some Physical Assets of the Bell System

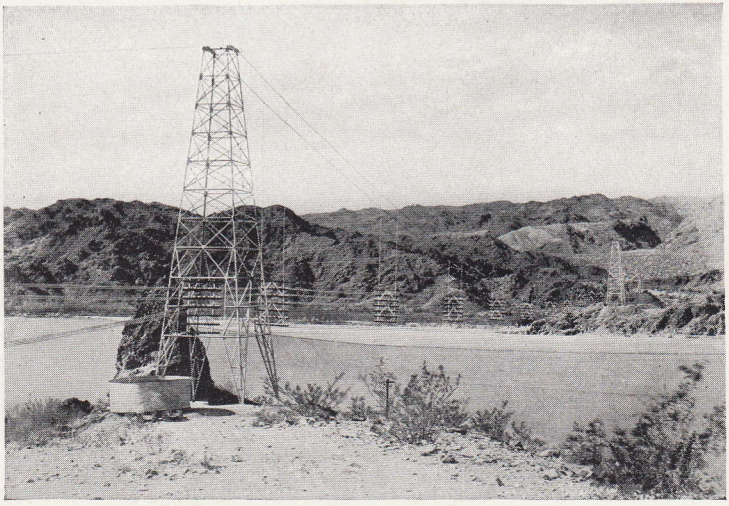
The vast amount of equipment and the large trained organization employed to maintain efficient telephone service to meet all the telephone requirements of a nation of over 127,000,000 people are shown by the following comparisons:

In the Bell System there are:

POLES. More than 15,000,000 of them, enough to build a solid transcontinental fence 30 feet high from New York to San Francisco. Fifteen million poles represent a forest over 800 square miles in extent.

WIRE. More than 80,000,000 miles of exchange and toll wire. This is

Desk Telephone
Used in 1879



Unusual Engineering Problems Are Frequently Encountered Along Telephone Routes

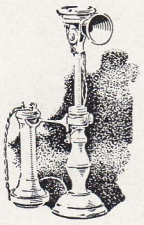
enough to reach from the earth to the moon and back again more than 165 times.

CABLE SHEATH. More than two billion pounds of lead alloy. It would fill 20,000 fifty-ton freight cars, making a train 150 miles long.

UNDERGROUND CONDUIT. More than 633,000,000 duct feet. This would go through the earth more than fifteen times from pole to pole.

TELEPHONES. More than 13,840,000 Bell-owned and about 3,510,000 Bell-connected, representing in the aggregate over 50 per cent of the total telephones in the world. Practically any two of these 17,350,000 telephones may be interconnected, and, in addition, service is available between them and about 14,750,000 other telephones in North America, Central America, South America, Europe, Asia, Africa, and Australia, as well as Hawaii, the Philippines, Japan and other island groups.

BUILDINGS. The Bell System buildings number about 2900, not including some 5500 leased properties, and represent an investment equal to the real estate valuation of some of our larger cities. These building spaces, comprising central offices, repeater stations, garages, warehouses, shops and office buildings, are of all sizes,



Desk Telephone Used in 1886

from one room to a 30-story building covering a city block. They are dotted all over the country in a variety of locations ranging from isolated sections, through residential areas to down-town sites.

MOTOR VEHICLES. Over 17,000 in use. If parading in single file, they would make a column over 125 miles in length.

During the past fifteen years the Bell System has spent on net plant additions alone over $2,750,000,000 or enough money to build six Panama Canals and nine Holland Vehicular Twin Tunnels. It is interesting to note that the investment in Bell System plant has more than tripled during the past fifteen years.

Telephone Directories

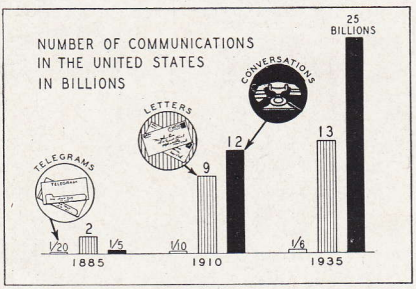
For the use of telephone subscribers, the Bell System prints and distributes each year an aggregate of 25,000,000 copies of over 2,000 different directories. The printing of these directories requires the use of over 25,000 tons of paper.

Bell System Employees

There were only two men in the telephone industry at the beginning —Bell, the discoverer, and Watson, his assistant. Today, after 60 years of growth and development, the industry employs more than 325,000 persons in the United States. Of this vast army about 270,000 are in the Bell organization, including the operating companies, the Western Electric Company and the Bell Telephone Laboratories.

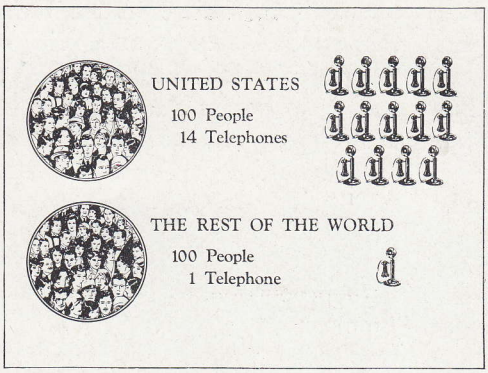
Use of the Telephone

There are more than 19,300,000,000 exchange messages and 730,000,000 toll messages over the Bell System wires yearly. Including messages sent over the wires of other telephone companies, more than 25,000,000,000 exchange and toll messages are transmitted annually in this country, or an average of one conversation daily for every two persons, men, women and children, in the country. The Federal Post Office, which ranks next in point of number of service contacts, handles about 13,000,000,000 letters and postcards annually.



Americans Rapidly Acquired the Telephone Habit Between the Year of Incorporation of the A. T. & T. Co. and its 25th and 50th Anniversaries

Desk Telephone
Used in 1892



The Public Telephone

Public telephones form an important link in America's nation-wide telephone service. Located in hotels, railway stations, stores and other public and semi-public buildings, they make telephone service available when one is away from the office or home—make it doubly a public service. Nowhere in the world is the use of the public telephone so common as in the United States.

The World's Telephones

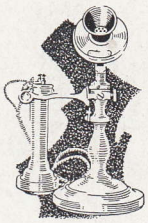
The latest statistics available showing the distribution of telephones throughout the world relate to January 1, 1935. On that date, the United States with about one-twentieth of the world's land area had over half its telephones or 16,869,000 telephones of the 33,540,000 telephones then in use throughout the world.

On the basis of telephones per 100 population, the United States had over six times the telephone development of Europe as a whole, four times the development of France, three times that of Germany and more than two and one-half that of Great Britain.

On January 1, 1935, New York City with 1,493,374 telephones, had more telephones than any other city in the world. The number of telephones in this one American city was greater than the number in the whole of each foreign country in the world, with the exception of Germany and Great Britain.

On this same date Chicago had more than twice as many telephones as Switzerland, Los Angeles almost three times as many as the Union of South Africa and San Francisco four times as many as British India.

Equally striking, as showing the superiority of the telephone development in the United States, are figures on the development of the less populated sections as compared with the urban centers. In the

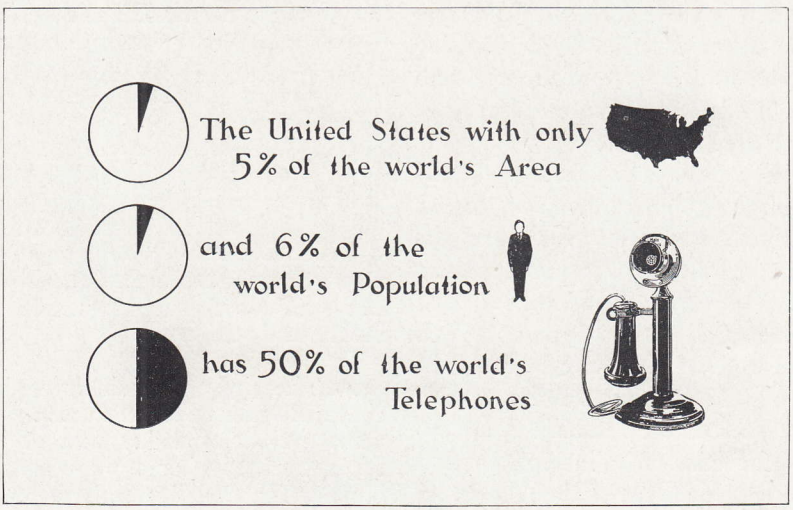


Desk Telephone Used in 1896

United States, places having less than 50,000 people were served on January 1, 1935, by 9.6 telephones per 100 population, as against 18.9 telephones per 100 population for communities of 50,000 population and over. In no other country was the telephone development of the smaller places as high as that in the United States. In fact, in many foreign countries the development of the less populated regions is relatively so low that it is no exaggeration to say that their telephone service is confined largely to their principal cities. For example, London on January 1, 1935, had more than one-third of the total telephones in Great Britain, and Paris had about one-third of the total number in France. Even Germany, with its otherwise progressive rural communities, had more than 25% of all its telephones concentrated in the four cities of Berlin, Cologne, Hamburg and Munich.

In proportion to population, on January 1, 1935, New York had almost two and one-half times as many telephones as London; Chicago, on the same basis, had more than twice as many as Berlin.

These figures indicate how large a place the telephone fills in the



Desk Telephone
Used in 1897

American mode of life. They reflect, too, the activity of the telephone companies in calling attention to the possibilities for maximum comfort and convenience afforded by adequate telephone facilities.

Fundamental Policies of the Bell System

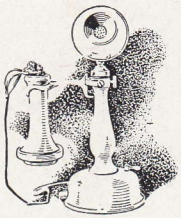
In an address before the National Association of Railroad and Utilities Commissioners at Dallas, Texas, in 1927 and in successive annual reports to the stockholders, President Walter S. Gifford of the American Telephone and Telegraph Company had outlined the fundamental policies of the Bell System. These policies relate to the carrying out of the management's three-fold obligations to its investors, to the telephone-using public, and to its employees, and are predicated upon the fact that there are over 650,000 stockholders of the American Telephone and Telegraph Company; 270,000 employees of the Bell System, including the Western Electric Company and the Bell Telephone Laboratories, and that the Bell System owns more than three-quarters of the telephones in the United States and connects with nearly all of the remainder, affording facilities for interconnection among 99 per cent of the telephones in the country and about 93 per cent in the entire world. The policies as laid down by President Gifford may be summarized as follows:

1. The fact that the responsibility for such a large part of the entire telephone service of the country rests solely upon the American Telephone and Telegraph Company and its Associated Companies imposes on the management an unusual obligation to the public to see that the service shall at all times be adequate, dependable and satisfactory to the user.

2. The fact that so large a share of the responsibility for meeting the telephone needs of today rests upon the Bell System implies that it must also be responsibile for meeting the needs of the future. It has a peculiar obligation to carry on the research and experimentation necessary for the further development of the telephone art.

3. The fact that the ownership of Bell System securities is so widespread and diffused imposes an unusual obligation on the management to see that the savings of these hundreds of thousands of people are secure and remain so.

4. The policy which recognizes these obligations to the telephone-using public of today and of the future and to its investors recognizes equally the Bell System's responsi-



Desk Telephone
Used in 1899

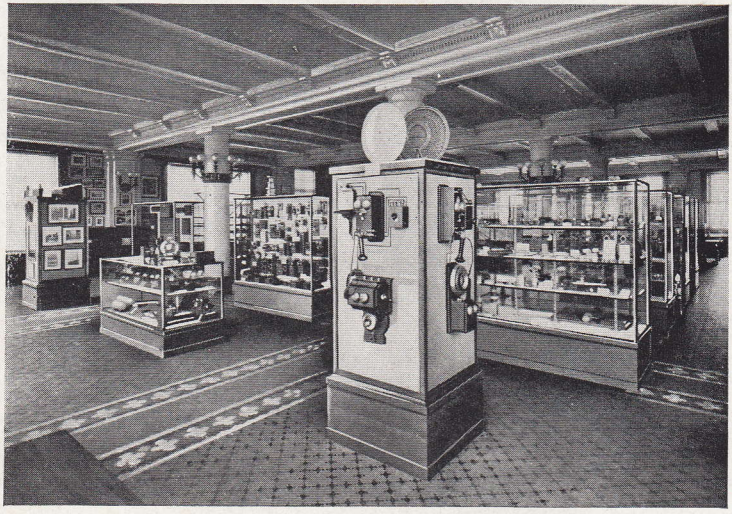
bilities to its employees. It is and has been the policy and aim of the management to pay salaries and wages in all respects adequate and just and to make sure that individual merit is discovered and recognized.

Obviously the only sound policy that will meet these obligations is to continue to furnish the best telephone service at the lowest cost consistent with financial safety.

Earnings must be sufficient to assure the best possible telephone service at all times, the further development of the art and the continued financial integrity of the business. Earnings that are less than adequate must result in telephone service, in the present and in the future, that is something less than the best possible. Earnings in excess of these requirements must either be spent for enlargement and improvement of the service furnished or the rates charged for the service must be reduced.

This is the four-fold basis of the fundamental policy and purpose of the Bell System—the most telephone service and the best, at the least cost to the public, consistent with these obligations.

Research and Progress



A View of the Bell Historical Museum, New York City

The Bell System Historical Museum

Less than a normal life-time, a period of only sixty years, bridges the gap between Alexander Graham Bell's discovery that human speech could be transmitted over a wire and the successful demonstration of a telephone call around the world in April, 1935.

Physical expression of the scientific and technical achievements that have crowded this brief span is found in the apparatus and equipment that have been developed to speed the spoken word ever more clearly and ever farther.

The years have been filled with scientific discoveries of immense value to mankind and with notable practical development of these discoveries. The story of the growth of the telephone art has been written, chapter by chapter, in this constant effort to improve the transmission of speech in the nation's service.

Concretely illustrating the story are the apparatus, instruments and equipment items, all triumphs of scientific imagination in their day, all for a while the latest and best of their kind, but then surpassed.

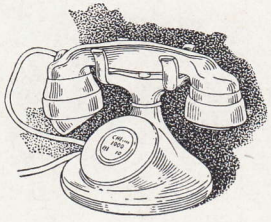
Desk Telephone Now in Use

Gathered together in the Museum of the Bell Telephone Laboratories, in New York City, these monuments to unceasing effort in the development of the telephone art provide both an invaluable record of the past and inspiration for the present and the future. Much more than mere exhibits are the instruments of types long since obsolete, the switchboards that bore the early burdens of inter-communication, the sections of cable that mark by stages the conquest of barriers to progress in the art. All these historic things, from the piece of wire that bore the first spoken sentence between two rooms to treasured transmitters that have carried presidential utterances to multitudes, are symbols of the continuing search for what will serve the people best.

Development and Research

The importance of scientific research in the development of the telephone early became apparent. The Bell System pioneers who laid the foundation upon which America's telephone system was to be erected found that they had to create a new art. Nothing then existing provided a precedent for what they were to undertake. Isolated theories and un-

This Bell Laboratory Machine Automatically Tests the Life of the Switchhook Contacts on Eighteen Telephones Simultaneously



Modern Hand-set Telephone

related facts were all that other sciences could contribute, and these had to be wrested by the new art from its older sisters by patient research and experimentation. Hard-earned advances blaze the trail of telephone progress, each problem successfully solved being a monument to untiring effort.

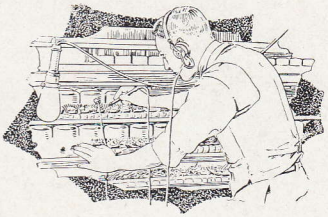
The progress still continues—must continue, for the telephone serves the needs of a growing nation and itself must grow in order to meet the ever-increasing demands upon it. Research in the telephone art never ends. Telephone development is never completed. Each year brings new problems; each problem solved brings progress.

These problems the American Telephone and Telegraph Company is continually engaged in solving for the benefit of the twenty-three operating telephone companies associated with it to form the Bell System.

Bell Telephone Laboratories, Inc., Building, New York City

Bell Telephone Laboratories

The staff of the Bell Telephone Laboratories comprises over 4,200 people of whom more than half are scientists, investigators and technical specialists, who continually carry on research and experimentation in the fields of the two fundamental problems of electrical communication—the electrical transmission of intelligence and the development of the channels for such transmission. Numerous collateral studies relating to the general science and art underlying electrical communication and allied subjects, are also carried on. This research work has been of inestimable value



Testing Cord Circuit Repeating Coils

in extending the scope of electrical communication service and in improving it in economy, efficiency and dependability. The visible results are in the switchboards, cables and wire lines, loading coils, repeater tubes, telephone instruments—in the hundreds of physical details that combine to form the intricate plant necessary for the quick and clear transmission of speech. The invisible results are apparent to telephone users in the constantly improving quality of service. Through the research work carried on for the Bell System, new metal alloys have been discovered, new designs in apparatus have been achieved, the size and consequently the cost of numberless items of equipment has been reduced. Hundreds of millions of dollars have been saved the telephone users of the nation.

Progress of the Telephone Art

In some six decades of telephone research, the telephone engineers have overcome one by one the barriers of speech transmission. From the very beginning the progress of the art has been marked by epoch-making advances due to inventions and improvements in apparatus and equipment. Some of the more notable

Photoelectric Research Laboratory from Which Have Come Developments in Picture Transmission and Television

Twisting Rings on Messenger Strand

achievements in the development of the art have been as follows:

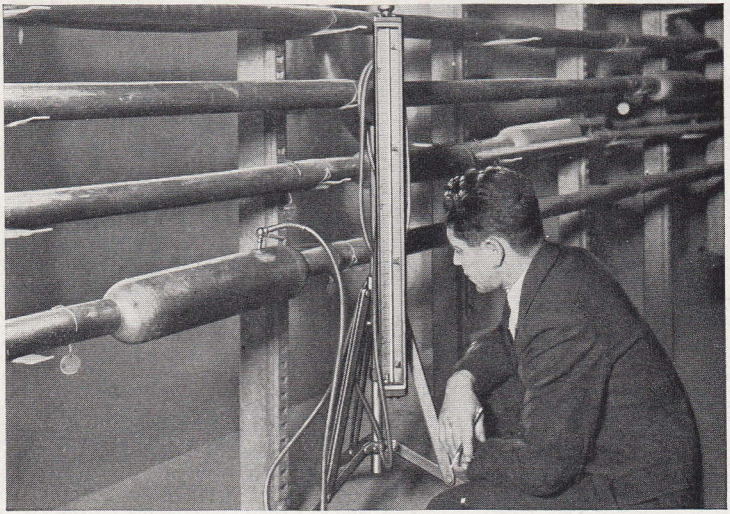
The development of the switchboard, without which no interconnecting group of telephones would be possible, which was the beginning of the telephone exchange system.

The discovery of the process of hardening copper wire and its application to telephone circuits, improving transmission and making long distance open wire telephone circuits possible.

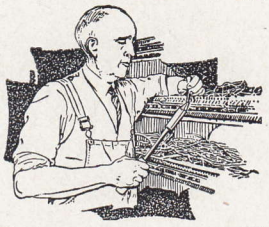
The substitution of a pair of wires for a single wire with ground return, thus very much reducing the disturbances caused by adjacent power circuits or other telephone circuits and greatly improving transmission.

The multiple switchboard, making possible the expansion of the exchange system by providing positions at the switchboard for a large number of operators, each answering the calls on a certain number of subscribers' lines. Because of the duplication of all the subscriber line terminals at each section of the switchboard, each operator is able to connect the calling subscriber with any other subscriber in the same central office.

Successive improvements in the



Testing Gas Pressure in a Telephone Cable in an Underground Cable Vault to Determine the Location of Some Distant Damage to the Sheath of This Intercity Highway



Soldering the Switchboard Connections

design of the telephone instrument, not only increasing its efficiency as a means of communication, but giving it a more attractive appearance. The early "box" telephones were superseded by various types of wall and desk sets, some of which are shown in the illustrations at the tops of the pages in this booklet. Now the convenient and graceful hand telephone is made available, with or without the dial.

The transposition of telephone circuits, thereby minimizing the interference of other telephone circuits and of electric light and power wires.

The development of the underground cable, enabling the removal of pole lines from the main thoroughfares of the large cities, and the aerial cable, reducing the number of cross-arms and the size of the poles.

The phantom circuit, which is made possible by utilizing two physical telephone circuits to create a third independent circuit.

Carrier-current telephony, in which the telephone current is combined with a high-frequency current, transmitting this combination over line wires and at the receiving end removing the high-frequency current and leaving the telephone current, making it possible to transmit simultaneously several telephone currents over a telephone circuit.

The application of the repeater or current amplifier to long distance circuits, further increasing the range

Research in Progress on the Construction of an Experimental Repeater for a Coaxial Line

of long distance telephony; also, its application to overhead and underground cables, making it possible to extend greatly the use of cables in place of open-wire construction and also allowing the use of smaller gauge wire. General improvement in speech transmission was also accomplished.

The range of possible use of cable has been gradually increased until by 1920 conversation was possible through 2,000 miles of cable. Methods have since been developed which will make conversation through 15,000 miles of cable practically as good as a conversation from one

Lineman at Terminal Box

room to another in the same building.

Improvements in the design and in the methods of manufacture of cables for local exchange use have made it possible to increase greatly the number of wires which may be placed within a cable sheath of given size. By employing wires of smaller diameter, the maximum number carried in a single cable has been increased to 1818 pairs.

Improvements in dial telephone apparatus and systems, enabling dial telephones to be used more advantageously in large metropolitan areas as well as in smaller cities and communities.

The discovery of the new magnetic alloys—permalloy and perminvar. The former has revolutionized the submarine telegraph cable art by permitting speeds five times greater than before. It has also made possible a reduction in the sizes and a decrease in the cost of loading coils required for telephone cables and has brought about savings in many other types of telephone apparatus.

Developments in submarine cables including the use of single conductor cables, the telephone amplifiers and terminal telegraph apparatus and the devices for permitting the telephone and telegraph to operate simultaneously, all differing radically from past practice.

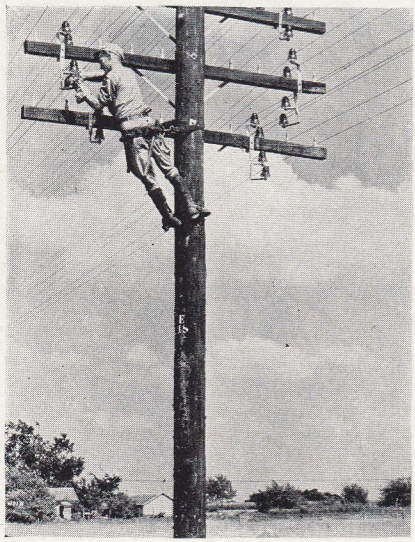
Two Cable Routes Like the One Pictured Above Cross Pennsylvania from East to West Safeguarding Over 1,000 Long Distance Circuits in Four Cables

The Wire Network

Advances in Long Distance Transmission

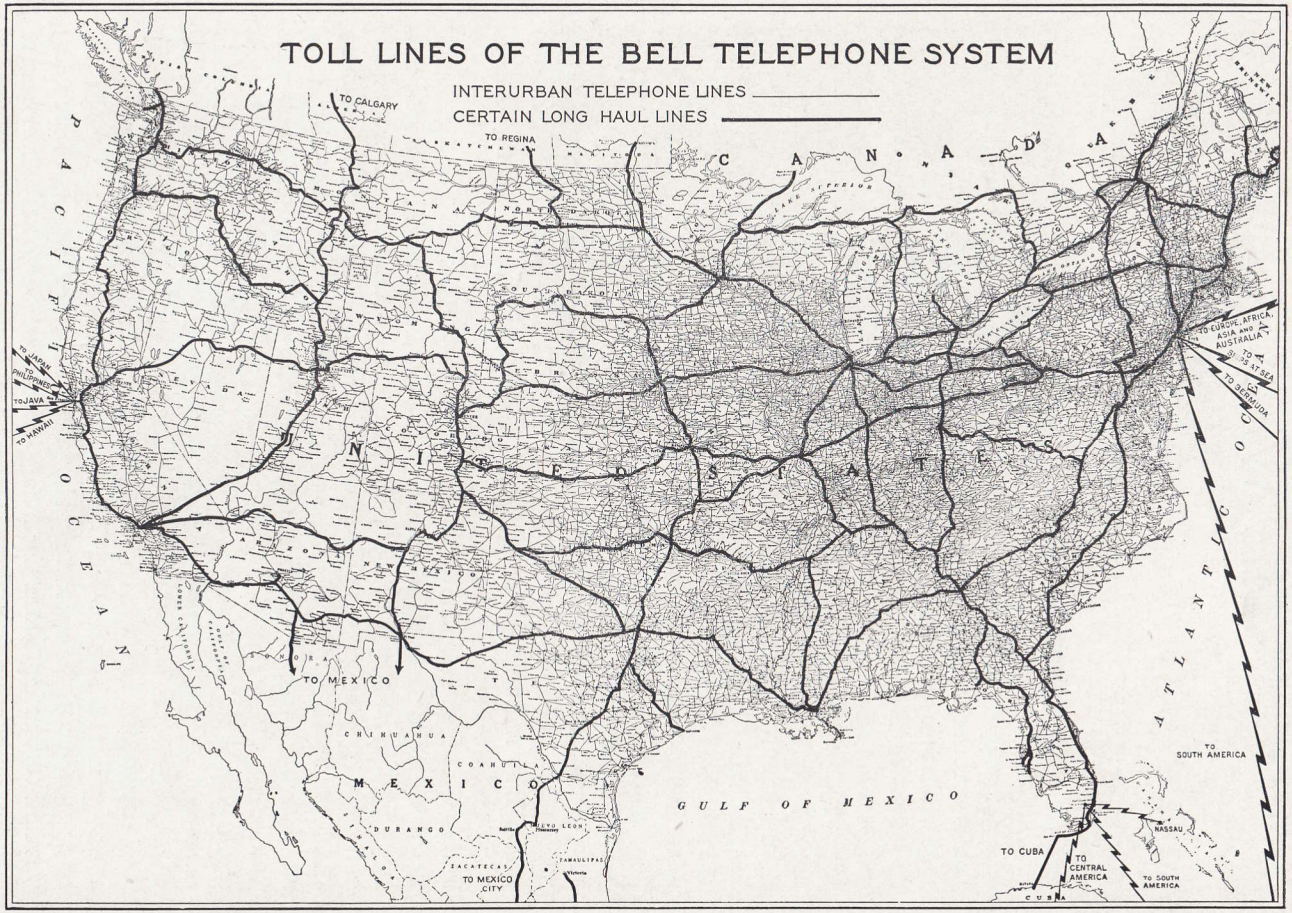
The cumulative effect of improvements and inventions in telephone apparatus and equipment is nowhere shown more strikingly than in the progressive advances in long distance transmission which have been made from time to time.

In 1881 the Boston-Providence line, 45 miles long, was opened; in 1884 the New York-Boston line, 235 miles; in 1892 the New York-Chicago line, 900 miles; in 1911 the New York-Denver line, 2,100 miles, and in 1915 the New York-San Francisco line, 3,400 miles. In 1920 regular commercial radio telephone service was established between Santa Catalina Island, about 30 miles out in the Pacific Ocean, and the mainland near Los Angeles, California, at the latter point making junction with the local and long distance wires of the Bell System throughout the United States. In 1921 came the opening of the Key West-Havana submarine telephone cables, bringing all the principal places in the United States into communication with Havana and other important places in Cuba. In 1923, submarine telephone cable was laid connecting Santa Catalina Island with the mainland, superseding the radio telephone service.



Expert Maintenance Insures High-Quality Wire Service

In 1925, after seven years of construction work, a storm-proof cable 861 miles in length, connecting New York and Chicago, was finished and put into service, and in 1926 was extended to St. Louis. The 850 mile extension of the New York-St. Louis all-cable line to Dallas was opened for service in January, 1933. By means of this addition to the cable network, a direct New York-Dallas circuit about 1,850 miles long was established. Seventy-five per cent of the cities in the United States of 50,000 or more inhabitants are con-


TOLL LINES OF THE BELL TELEPHONE SYSTEM
INTERURBAN TELEPHONE LINES
CERTAIN LONG HAUL LINES
TO CALGARY
TO REGINA
C A N A D A
TO JAPAN PHILIPPINES
TO JAVA
TO HAWAII
TO EUROPE, AFRICA, ASIA AND AUSTRALIA
TO ST. PIERRE
TO BERMUDA
TO MEXICO
CHIHUAHUA
COAHUILA
M E X I C O
DURANGO
NUEVO LEON
TAMAULIPAS
ZACATECAS
TO MEXICO CITY
GULF OF MEXICO
TO SOUTH AMERICA
NASSAU
TO CUBA
TO CENTRAL AMERICA
TO SOUTH AMERICA
CUBA

The "Trouble Shooter" Ready for Service

nected with the toll cable network of the Bell System.

To the original Transcontinental Telephone Line, opened in 1915, have been added three other routes for coast-to-coast service. A southern route by way of El Paso and Los Angeles was completed in 1923 and in 1927 a northern Transcontinental Line was completed and opened to public service, which west of Chicago passes through Minneapolis, Fargo, Bismarck, on to Seattle. The fourth Transcontinental Line by way of Kansas City, Albuquerque and Los Angeles has since been constructed to supplement the central and southern routes.

In 1927 service between points in the United States and the principal cities of Mexico was inaugurated by the ceremonies in which the Presidents of the two Republics exchanged greetings over a circuit connecting Washington, D. C., and Mexico City.

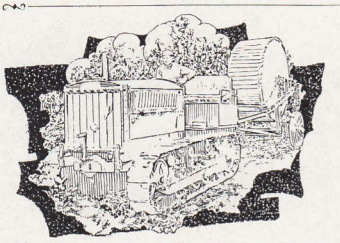
The Bell System's Underground System

Of the Bell System's 80,000,000 miles of wire, nearly 53,000,000 miles are enclosed in lead-covered cables in underground conduits, including about 6,600,000 miles of toll wire. More than 70 per cent of the exchange wire of the Bell System is in underground cables. The exchange and toll underground cables are laid in more than 633,000,000 duct feet of conduits.

Each Day Over 2½ Million Toll and Long Distance Conversations Take Place in America

First Underground Experiments

The Bell engineers early discovered that the problem of speaking through long cables or over great distances could not be solved by increasing the power of the telephone instruments. The fact that one mile of underground cable cuts down the transmission as much as



Tractor Hauling Cable Reels

about thirty miles of high-grade, open-wire toll lines threatened to check permanently the growth of the telephone system. In 1881 the Bell engineers began to apply themselves to the special study of overhead and underground cables and the improvement of telephone lines. In 1882 experimental cables were laid for a short distance along a railroad track in Massachusetts.

Within a year or so after that, the first underground cables for commercial use were laid in Boston and Brooklyn, but subscribers using the cable could not talk satisfactorily farther than to the suburbs.

By January 1, 1886, there were only 3,417 miles of wire underground in the Bell System out of a total wire mileage of 155,791. This underground mileage could be contained in less than one mile of modern 1818-pair cable.

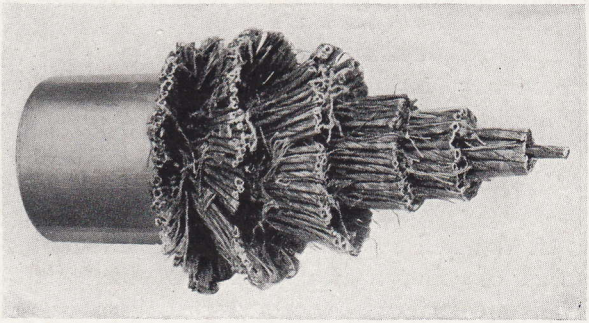
In 1887 the successful introduction of twisted pair conductors paved the way for the extensive use of cables.

In 1902 the application of the loading coil, together with other improvements, permitted the installation of a "loaded cable" between New York and Newark, N. J.

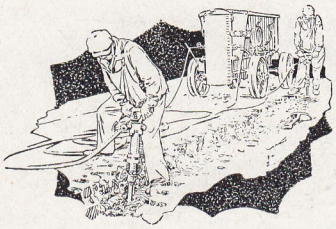
In 1905 a loaded cable twenty miles long extended from New York in the direction of Philadelphia.

In 1906 an underground cable ninety miles long was successfully operated between New York and Philadelphia.

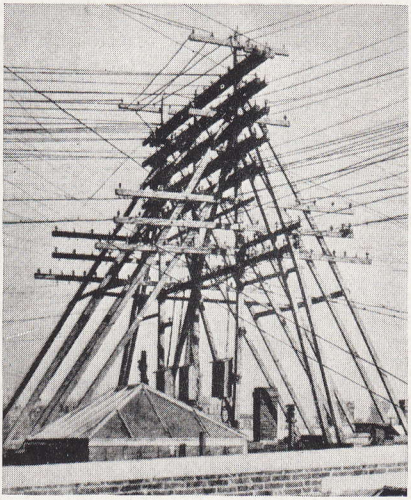
Early in 1909 a sleet storm swept the Atlantic seaboard, paralyzing communication and isolating the capital at the time of President Taft's inauguration. The next morning the Chief Engineer of the Bell System received from Theodore N. Vail, who was then President of the American Telephone and Telegraph Company, a note beginning with these words: "Put those wires

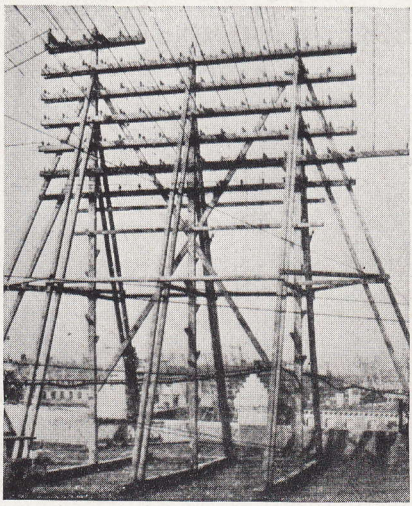


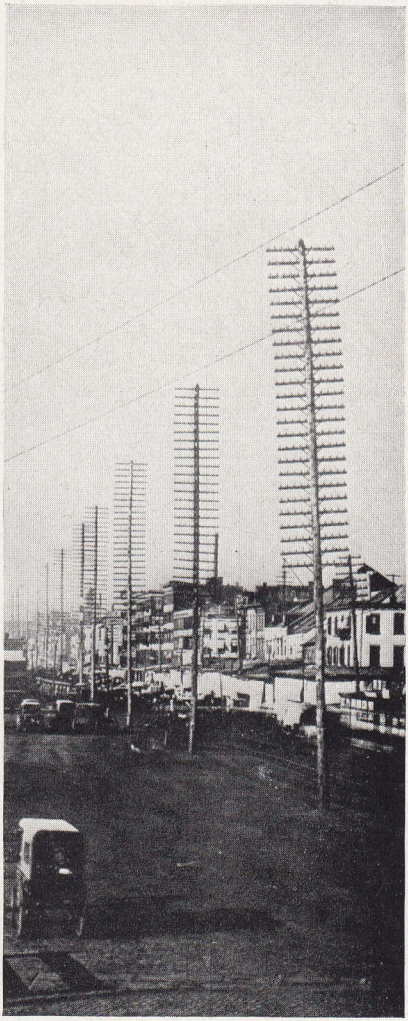
Section of an Aerial Telephone Cable Fanned Out to Show the Telephone Circuits



Breaking Pavement With Air Drill







The Roof-Tops of Boston (left) and the Sidewalks of New York (right) Typified the Problem of Every Community in the 'Nineties Before Telephone Engineers Learned How to Put Groups of Wires Underground

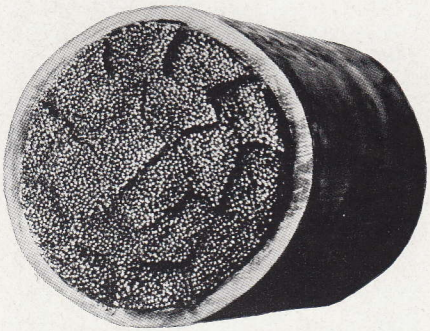
Splicing Underground Cable

underground. I know that the present state of the art of telephony does not make such wire-burying possible. But experiment—." The Bell engineers did experiment and by 1911 they had designed an underground cable, capable of giving satisfactory conversation between Boston and Washington. The cable was built and the Washington-New York section placed in service in 1912. The following year it was extended to Boston, a total distance of 455 miles, which was several times the length of any other underground line in the world at that time.

The Cable Sheath

Up to 1912, the sheaths of cables used in the Bell System contained about three per cent of tin alloyed with lead. Back in 1907, development work was undertaken to discover a new alloy that would prove at least as satisfactory as the lead-tin alloy and less expensive. After laboratory experiments and field trials extending over several years and covering a wide range of alloys, a new alloy was adopted, consisting of about one per cent of antimony alloyed with lead, and this alloy is now used for both underground and aerial cables.

Cable development illustrates concretely the value of the research work carried on by Bell System engineers. In 1888 the standard



This Cable 2⅝ Inches in Diameter Contains 3,636 Wires

cable was capable of accommodating only 50 pairs of wires and cost between $150 and $160 per pair-mile to install, including the cost of ducts. Through constant experimentation, means have been found of increasing the number of wires and in 1928 the first cable 2⅝" in diameter containing 1818 pairs of No. 26 gauge wire was manufactured. As contrasted with the 50-pair cable of 1888, the cost of this latest cable installed is in the order of $10 per pair-mile. The type of cable which is used on the New York-Dallas long distance route has a capacity of about 250 telephone circuits, while 500 telegraph messages may be sent simultaneously.

The Radio Voice Network

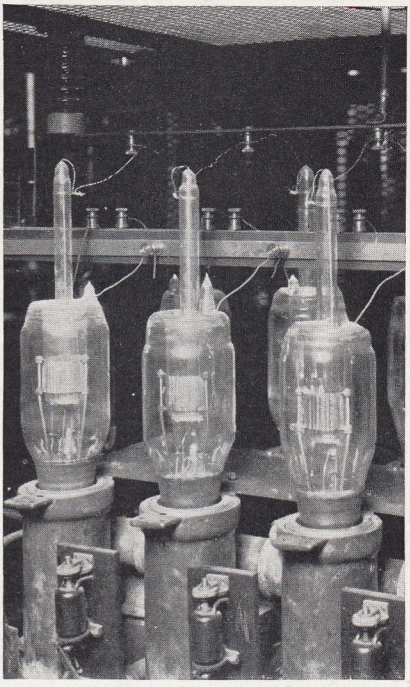
Radio Telephony

Thorough research and extended experience demonstrate that the field of the wireless telephone is in maintaining communication between ship and shore, from ship to ship, or for talking from the ground to moving aircraft, or from airplane to airplane, or as an extension of the wire system bridging strips of desert or bodies of water, where it is impracticable to employ wires.

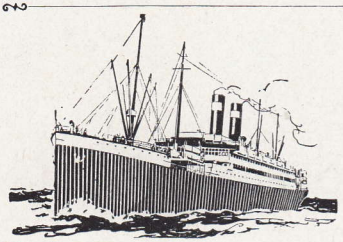
Before the advent of the three-electrode vacuum tube, attempts to communicate by radio telephony were discouraging. In 1912 Bell System engineers began development of the tube as a long distance wire telephone amplifier or repeater. So satisfactory were the results that work was immediately begun on much larger tubes, to be applied to radio telephony.

The first successful demonstration of radio telephony, employing vacuum tubes, took place in 1915 when speech was transmitted from Montauk Point, Long Island, to Wilmington, Delaware, a distance of 250 miles. Later in the year, messages from Montauk Point were received at Jekyl Island, off the Georgia coast, 900 miles away. Messages from New York, carried by land lines, were automatically relayed to the radio equipment at the Long Island station and received in Delaware and Georgia—the first experimental use of radio as a supplement to wire telephony.

The World War saw the revolutionizing of most methods of warfare and it also revolutionized communications for many military and naval purposes. As a means of establishing quick communication



Banks of Huge Water-cooled Vacuum Tubes Are Required for a Transoceanic Radio Talk



Ship-to-Shore Telephone Service

with airplanes and between naval vessels, such as units in a submarine-chaser flotilla, the wireless telephone proved particularly useful.

During ship-to-shore radio experiments in 1920 two-way telephone communication was maintained for several months between several cities and two ships, the messages going by wire between these cities and the Bell System's experimental radio station at Deal Beach, N. J., and thence to the ships by radio.

In 1929 a regular service was instituted between shore telephones of the Bell System and the *S. S. Leviathan*, and today about a score of large ocean liners have the facilities for regular telephone communication with the land.

In 1934 a ship-to-shore radio telephone service was initiated for small boats operating within 300 or 400 miles of Boston Harbor. Harbor radio telephone stations have also been constructed at New York, San Francisco, Los Angeles and Seattle, to offer a similar service to boats operating in those harbors.

Radio Broadcasting

The year 1921 saw the advent of radio broadcasting on a scale which attracted hundreds of thousands of listeners. Broadcast programs, at first, comprised those given only in the radio station "studios." As radio audiences increased in size, however, it became evident that greater diversity of programs would increase their popular interest.

Beginning in 1922 interesting events were made available for broadcasting by the installation, at the location of the programs, of microphone transmitters, including those used by expert announcers, which were in turn connected with the broadcasting studio by telephone lines, often hundreds of miles long and especially adapted for the purpose.

The long distance telephone lines also made possible the simultaneous radiation of one program from several widely scattered broadcasting stations. One of the first events of national importance to be thus given to the public was President Coolidge's first message to Congress on December 6, 1923, which was simultaneously broadcast by six radio stations, in New York, Washington, Providence, Kansas City, St. Louis and Dallas.

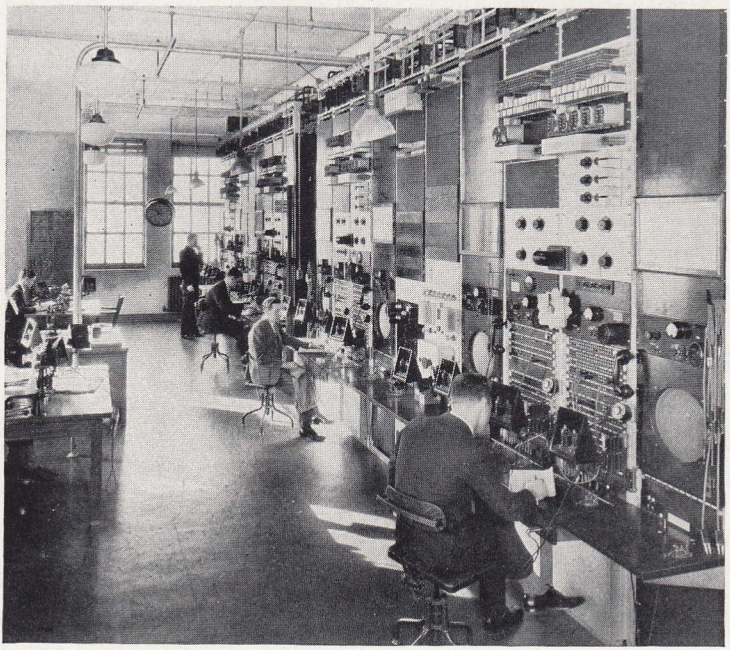
The Problem of Music

There is, however, a vast difference between the transmission of speech and the satisfactory trans-

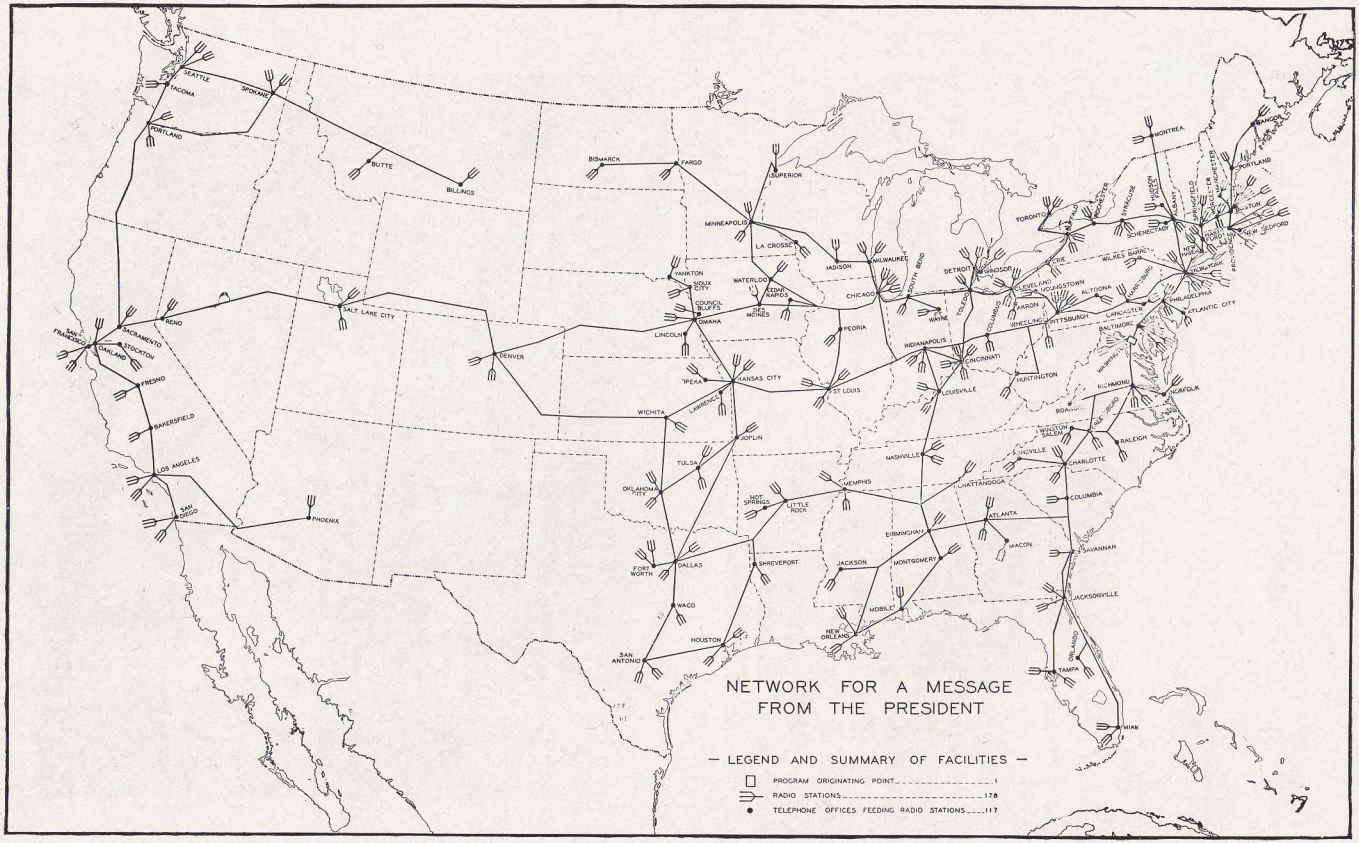
The Microphone for Broadcasting

mission of music over wires, because of the difference in tone range. Since musical programs are principally available in the country's amusement and artistic centers, it was necessary so to arrange the long distance circuits that they could adequately transmit these programs to the broadcasting stations before such programs could be shared by groups or networks of stations.

To provide a wire system that could transmit the wide range of frequencies inherent in music, it was necessary to equip cable circuits with special loading coils approximately every half mile. Special broadcasting wires were built into new cables. Special amplifying or repeater apparatus was needed every 50 miles on these cable circuits and every 200 miles on the open wire circuits. These provisions had to be made so that the character and strength of the electrical waves would be faithfully preserved during their long journeys

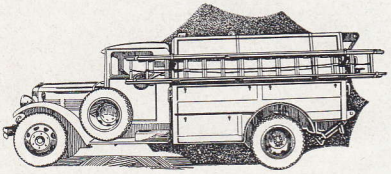


A Section of One of the Telephone Company's Control Offices for Broadcasting Network Service Where Programs Are Supervised and Safeguarded



Special Wire Hook-Up of Broadcasting Stations in Connection with Delivery of a Message to the People Direct from the White House

Heavy Telephone Construction Truck

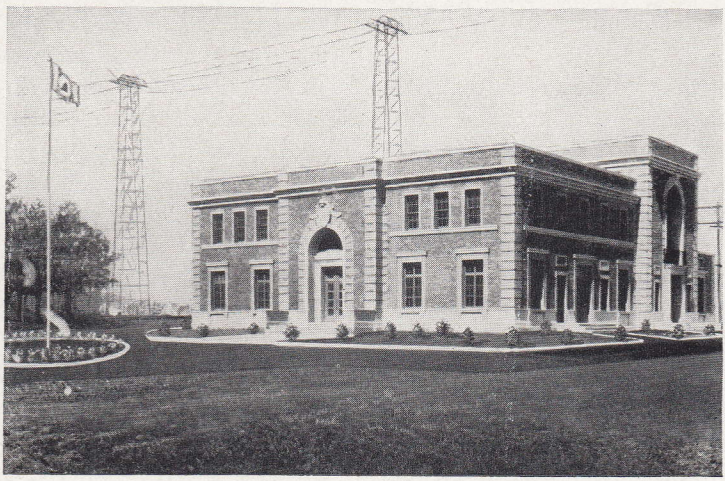


from the microphone to the broadcasting stations, in order that radio receiving sets could convert these waves back into music and speech that would not sound distorted or unnatural when amplified by loud speakers. The system of special telephone circuits thus set aside for broadcasting purposes comprises a total of 50,000 miles of wire known as "program transmission routes" which are regularly used for chain broadcasting, and an additional 50,000 miles of wire which are used on many occasions. About one-half of the mileage is in open wire and the remainder in cable.

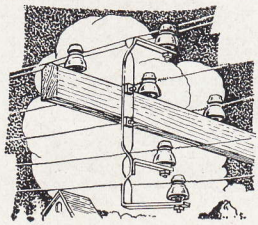
Because of the availability of this network of broadcasting facilities, it is possible for a great many stations to be grouped for the broadcasting of special events of national interest, as when more than 175 stations have been joined together to make a presidential broadcast available to a nation-wide audience.

Overseas Telephone Service

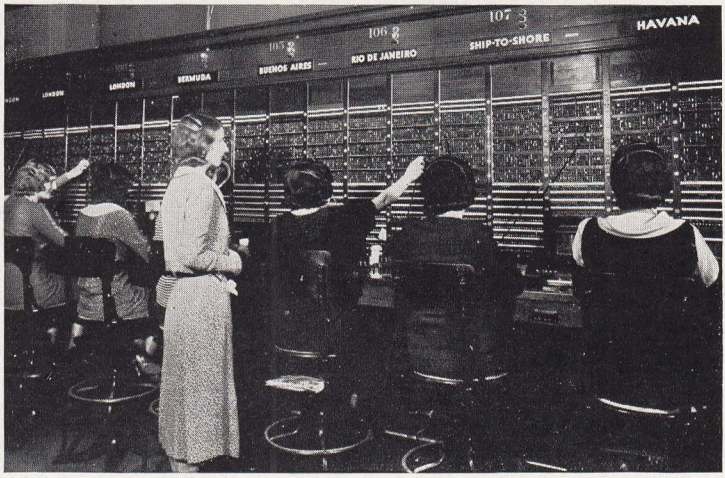
Experimental transoceanic telephony by radio was first achieved in October, 1915, when speech was carried by electric waves from the Arlington station, near Washington, D. C., across the Atlantic to the Eiffel Tower, Paris, and also across the American continent and the



Transmitting Station of Overseas Radio Telephone Service, Lawrenceville, N. J.



Transposition Brackets on Long Open Lines



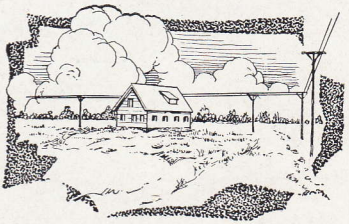
Operating the Transoceanic Switchboard at Long Distance Headquarters in New York City

Pacific to Honolulu, Hawaiian Islands. The airline distance from Arlington to Honolulu is nearly 5,000 miles.

While the World War delayed development of overseas service, on January 14, 1923, the Bell System carried out a successful demonstration of one-way transoceanic radiotelephony when a group of telephone officials in New York talked for two hours by wire and radio to a group of scientists and engineers assembled in London for the test. On March 7, 1926, for the first time in the history of communications, groups of people both in America and England conversed together by wire and radio during a test of two-way transatlantic telephony.

The goal of this long experimentation was commercial service between America and England through the combined use of wire telephony and radio. On January 7, 1927, President W. S. Gifford of the American Telephone and Telegraph Company formally opened commercial service between New York and London.

The scope of the service was thereafter gradually extended on both sides of the Atlantic, the hours of service were lengthened and the charges reduced. The demand for the service increased to such an extent that it became necessary to supplement the



Radio Receiving Station, Houlton, Me.

original long wave radio circuit and several short wave circuits were added.

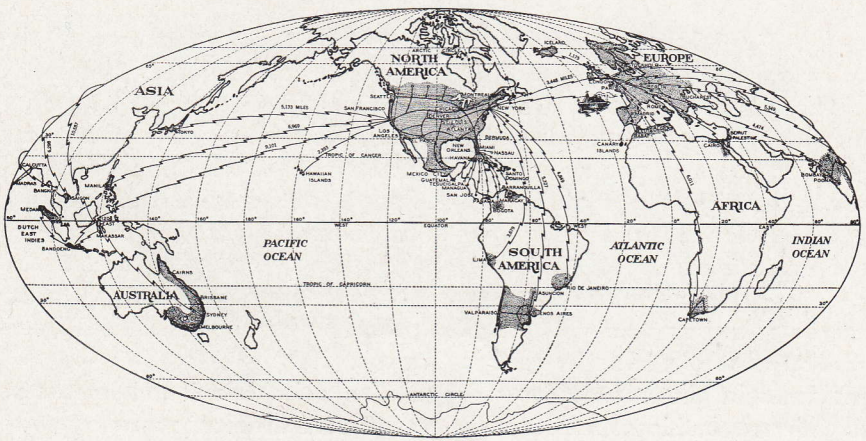
In 1930 radio telephone service was established for the first time between North America and South America. In the same year service was extended to Australia by way of the transatlantic circuit and a radio circuit between Great Britain and Australia.

The following year important island groups in distant seas—Bermuda, Java, Sumatra, and the Canary Islands—were included in the widening horizon of American callers and a new radio center near San Francisco began the conquest of the Pacific by adding Hawaii.

During 1932 two major sections of the African continent—Egypt and South Africa—were reached as well as Siam in Asia. Another new radio telephone center was constructed near Miami, Florida, to provide service with the Bahamas, and countries bordering the Caribbean.

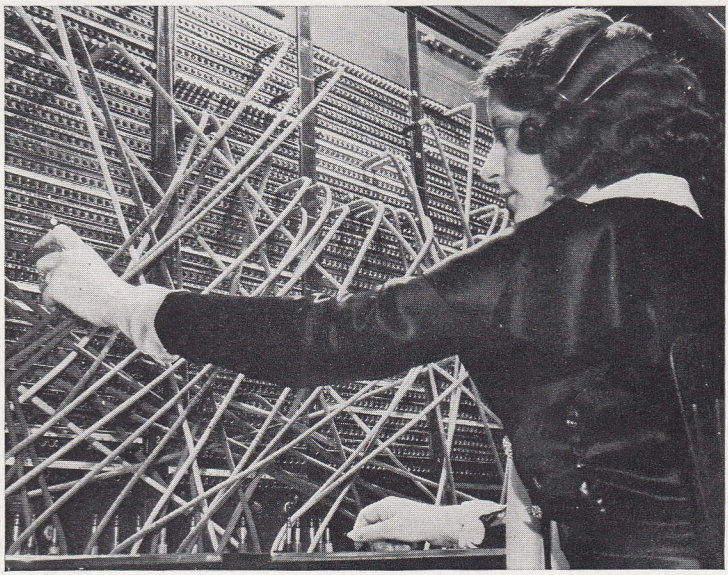
Among countries brought within the reach of American telephone users in the following years were the Canal Zone and the Philippines, India, Palestine and Japan.

From any part of the United States telephone connections can now be established with a total of 32,100,000 telephones, or about 93 per cent of all the telephones in service in the world.



Overseas Telephone Connections of the Bell System

The Central Office



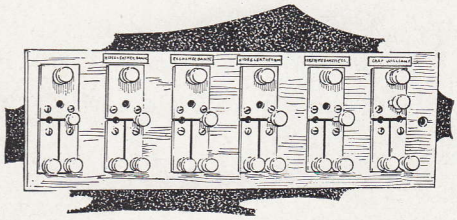
"Hold the Line, Please" Is Today the Request of the Operator on Almost Every Long Distance Call

The Telephone Central Office

The telephones first placed in the hands of the public were leased in pairs. The lessee put up his own telephone wire to connect his telephone with that of a friend or neighbor, or ran the line between his home and his place of business. At first, there was no way whereby he could talk by telephone with the other individuals in the community who, like himself, had leased a pair of the early instruments.

It was the development of the telephone switchboard that made possible the interconnection of individuals and of communities, and thus broadened the telephone's usefulness to the public. What gives the telephone its great value today is the fact that it can be connected any time with any one of some 17,350,000 other telephones in the United States alone.

The switchboard and apparatus associated with it together comprise a central office. The lines, instru-

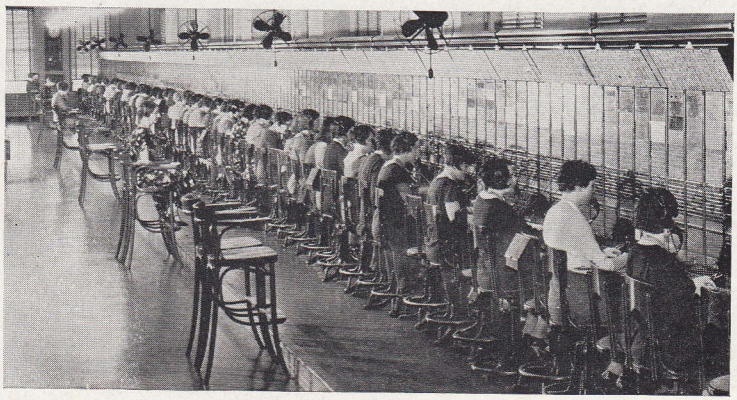


First Switchboard, Boston, 1877

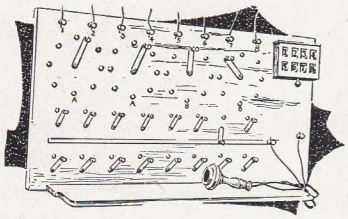
ments, and other facilities by which the telephones of a community are given service, are called collectively a telephone exchange. In small communities an exchange may include only one central office, while in larger communities it may contain many of these offices, in which case the community is known as a multi-office exchange. Central offices are connected by telephone lines called trunk lines. The lines that connect exchanges are called toll lines.

A widely used method of making telephone connections utilizes switchboards operated by women, who are called operators. Because the work of establishing the connections and disconnections is done by hand, switchboards of this type are called manual switchboards. When this work is done mechanically, the telephones are equipped with dials and the central offices serving such telephones are called dial system central offices.

Manual switchboards are divided into two kinds, depending upon the manner in which power is supplied for the talking circuits, and the method of signalling the operator. In one type of switchboard the power is supplied from a central plant that is located at the central office. These are called common battery switchboards and the subscriber signals the operator by removing the receiver

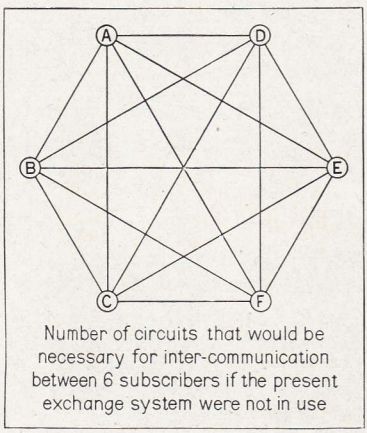


The Dial Central Office Also Uses Operators as Shown by this Long Switchboard Required for Two Dial Offices in a Business District



Switchboard at New Haven, 1878

from the hook. In magneto switchboards, on the other hand, the talking current is supplied by batteries installed on the subscriber's premises, and the subscriber signals the operator by turning a small crank on a magneto generator. Magneto switchboards are used only in some of the smaller communities. In the larger communities both common battery manual and dial system central office equipment is used.



Number of circuits that would be necessary for inter-communication between 6 subscribers if the present exchange system were not in use

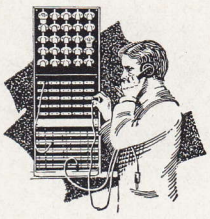
What the Switchboard Does

Three segregated pairs of telephones give three talking lines. Unite three pairs of telephones by means of a central office switchboard and an intercommunicating system is formed which permits establishing 15 different communications where only three were possible before. An exchange system with 10,500 telephone lines gives 55,119,750 paths of communication. Putting it the other way around, if it were physically possible to connect 10,500 telephones, without a central office switchboard, so that communication would be possible from each telephone to every other telephone in the group, it would require 55,119,750 talking circuits—that is, there would have to be 5,250 circuits multiplied 10,499 times.

Dial Equipment

Exhaustive investigation and experiments by Bell System engineers and others over a long period of years resulted in the production of types of dial operated central offices which meet satisfactorily even the most exacting service conditions. For some years the Bell System has been gradually introducing the dial system where warranted by economic and service conditions. At the beginning of 1936 more than 6,600,000 Bell owned telephones were operated from dial system central offices—about forty-eight per cent of the total.

With the dial system the subscriber, after taking the receiver



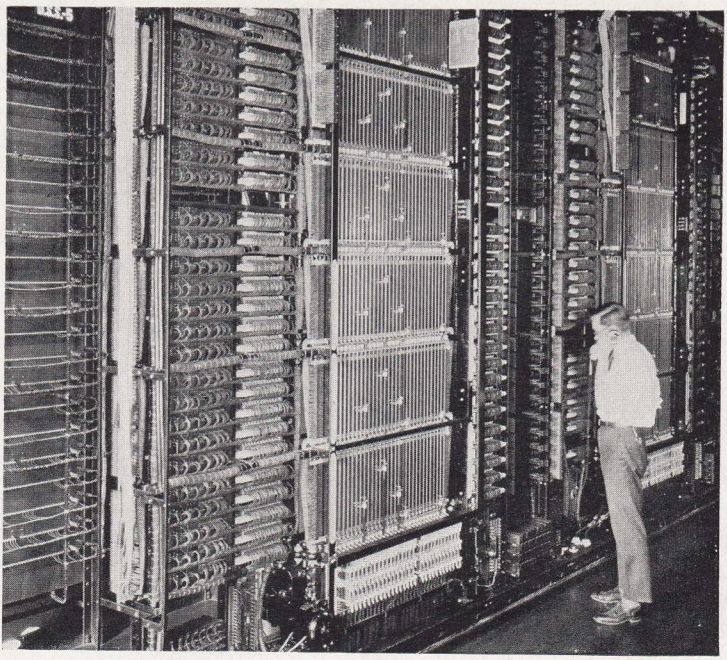
Universal Board
Used in 1879

from the hook, instead of giving the number wanted to an operator at the switchboard, "dials" it by means of the dial at the telephone instrument. The dial central office is not operated entirely automatically, but uses many operators for special purposes. Also, more men are required for maintenance of the equipment than in a manual office.

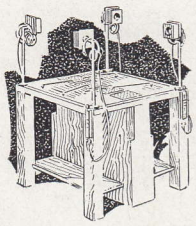
Dial service is more accurate than manual and is somewhat faster; it also provides complete operating facilities for unusual volumes of business in times of emergency or in normally light traffic periods when manual operating forces are on a skeleton basis.

Early Switchboards

The first telephone switchboard was installed in the office of E. T.



These Frames Contain a Very Small Fraction of the Equipment Required for a Single Dial Central Office



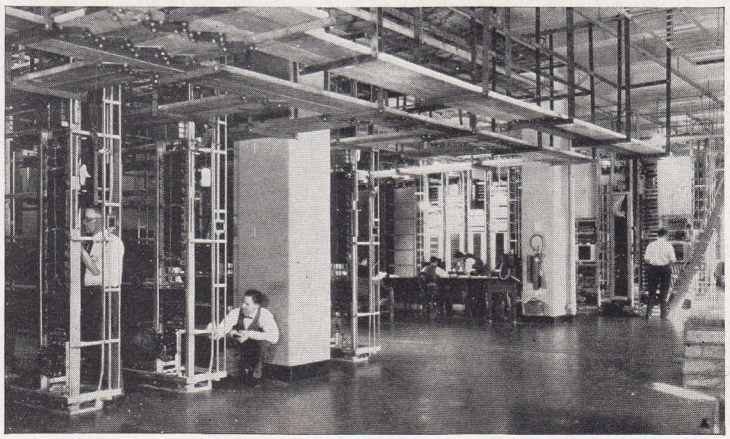
The "Law" Board
Used in 1880

Holmes, in Boston, in May, 1877, and connected four banks and a manufacturing concern. It served as a telephone system by day and as a burglar alarm system at night.

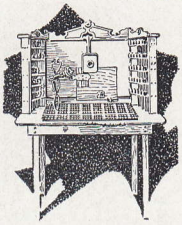
In the fall of 1877 the first real telephone exchange was established at Bridgeport, Conn. This exchange was operated for mutual benefit and not for profit.

On January 28, 1878, the first switchboard for commercial telephone exchange use was installed at New Haven, Conn., with 21 subscribers. Three days later a similar board was installed at Meriden, Conn. Among the other exchanges established in 1878 were San Francisco, Calif., on February 17; Albany, N. Y., on March 18; Wilmington, Del., in April; St. Louis, Mo., May 1; Chicago, Ill., on June 26; Detroit, Mich., on August 15; and Philadelphia, Pa., on November 14. The following year saw the establishment of exchanges in nearly all of the remaining states and territories, but Florida, West Virginia, Utah, and Dakota territory had no exchange until the middle of 1880 or shortly thereafter.

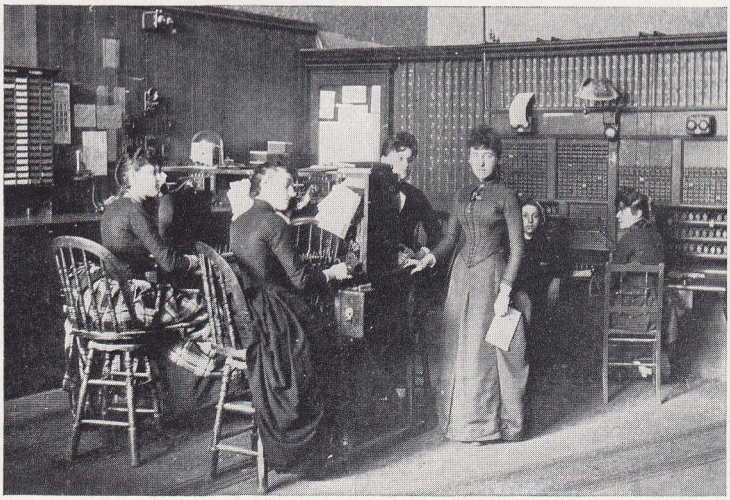
As the demand for telephone service grew, it became necessary to increase the size and capacity of the switchboards. Switchboards of various designs served their purpose for a while, being discarded for later designs embodying new ideas and com-



Expert Installation and Maintenance Make Possible the Precision Operation of Dial Equipment 24 Hours per Day



Gilliland Board
Used in 1880



A Central Office of 1884

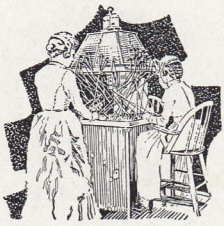
bining greater speed and capacity, until the efforts of the telephone engineers culminated in the manual switchboards and those associated with dial equipment developed for use in large exchanges.

The first multiple switchboard was installed in Chicago in January, 1879.

Differing in size and capacity from their big brothers of the large cities are thousands of other switchboards serving the smaller cities and towns and the rural communities. Each of these switchboards is located in a central office and is the center of an exchange group of telephone subscribers. There are more than six thousand seven hundred central offices in the Bell System all linked together by trunk, toll and long distance lines into one great system of intercommunication covering the country.

The Multiple Switchboard

The "multiple" switchboard gets its name from the fact that each subscriber line that terminates at the switchboard is duplicated or "multipled" on every section of the board. A switchboard equipped to serve 6,000 subscriber lines and consisting of 20 sections has 20 times 6,000 or 120,000 points of



Pyramid Board
Used in 1882

connection. By this arrangement each switchboard operator in answer to a call from any of the subscribers whose lines are assigned to her can connect that subscriber line with any one of the 5,999 other subscriber lines that terminate at the switchboard.

The multiple switchboard is built in sections and is composed of myriad parts of the finest workmanship. Switchboards of the largest type have more than two million tiny soldered parts, 15,000 electrical signal lights, and wire enough to span the continent, more than 4,000 miles of it.

Terminal Room Apparatus

In the large commercial centers the telephone wires have been placed in underground cables which pass from their subways into what is called the cable vault of the central office building, and from there to the terminal room. Here are assembled the items of central office equipment, without which the multiple switchboard could not perform its functions.

Scarcely less intricate than the switchboard itself are the main and intermediate distributing frames. The function of these frames is to bring the telephone wires, entering the central office, to their proper places on the switchboard and to make it possible to change the location of the lines on the switchboard whenever necessary.

At the main distributing frame the telephone circuits first pass from the cables to the "protectors," which are effective devices for warding off lightning discharges and stray currents arising from accidental contact with light and power wires and from other electrical sources. The wires then pass to the intermediate frame where they are so distributed that any line may be connected with

Switchman Adjusting Relays on a Sender in a Dial Panel Office

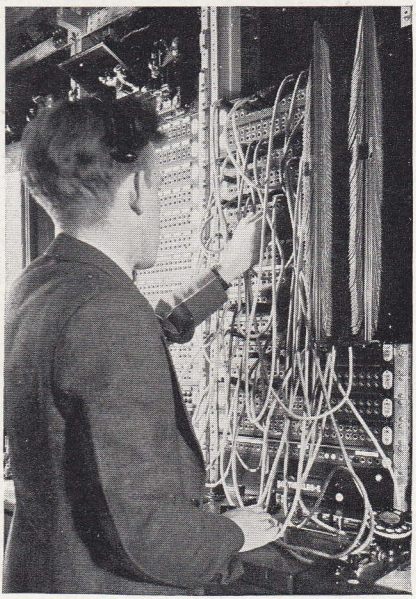
Boy Operators Employed in 1879

any position on the switchboard.

From the intermediate frame the switchboard wires reach the "line and cutoff relay rack," where electrically controlled switches in the form of relays operate the lamp signals that show on the switchboard when subscribers lift or replace their telephone receivers.

Wire Chief's Equipment

The testing apparatus under the supervision of the "wire chief," that is so important in detecting and locating "wire trouble," is also a part of terminal room equipment. Every report of such line trouble that is made by a subscriber or an operator is quickly checked by the supervisory force of the operating room, and then goes to the wire chief for expert diagnosis by his staff who then proceed to remedy the trouble indicated. The wire chief has equipment that enables him to be connected with any subscriber line to test its condition. Because of his routine tests of all exchange equipment, he is frequently able to detect trouble and have it remedied before the subscriber is aware that such trouble has existed. His test board is a marvel of ingenuity and efficiency.



Testboard Where Technical Experts Analyze Telephone Circuit Troubles

The Power Plant

In the Terminal Room or in larger offices in a separate room is the power plant where dynamos charge the storage batteries and provide electricity to carry the voice over the wires. Also located here are the ringing machines which operate the subscribers' bells and provide various other signals. Here, too, are the power switchboard, the battery fuse panel, and other control equipment. Adjacent to it is a room containing the storage batteries.

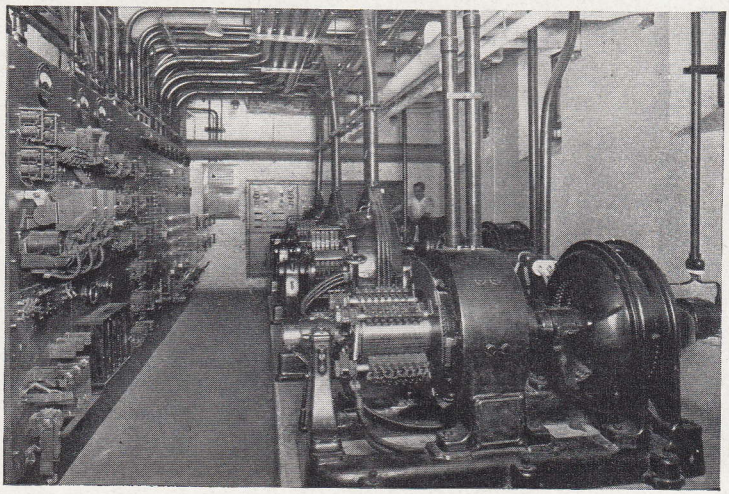
Operators at Information Desk

A source of direct or continuous current is necessary for talking, while an alternating current is used for the bell signals. The current strength required to operate the talking circuits, though small for each circuit, in the aggregate for the many circuits in the larger offices amounts to several hundreds, or even thousands, of amperes furnished by machines constituting many horse-power.

The Traffic Curve

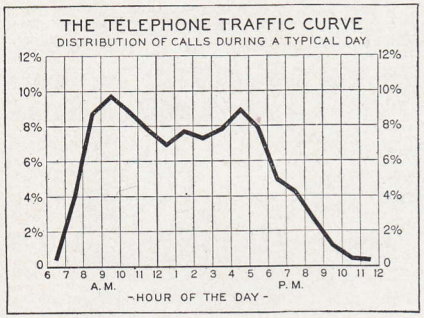
The tide of traffic rises and falls with the business and social activities of the community which each particular exchange serves. In general, it follows a certain uniform curve in the large communities, which is known as the "traffic curve."

In a typical city the highest traffic point, or "peak of the load," is reached between 9 and 11 o'clock a.m. That is when business begins to get into full swing—the stores and offices open and telephone exchanges in the business sections of the city handle the maximum traffic load. The traffic then drops gradually until the lunch hour between 12 and 1 o'clock and rises again until it reaches another peak, not as high as the morning peak, between 4 and 5 o'clock. In the shopping districts calls reach the highest point between 3 and 4 o'clock p.m., and in



Central Office Power Plant

Operator's Set in 1880, Weight 6 lbs.



Telephone Traffic Curves Reflect the Activities of the Community

residential sections there are two high points, one around 9 o'clock in the morning when the housewife is placing her order with the butcher, baker, etc., and the other about 7 p.m., when evening engagements are made. After that the traffic dwindles away, till midnight finds the switchboard practically idle.

But the traffic curve may without warning give a most spectacular illustration of how sensitive it is to the public pulse. A big fire or accident will send thousands of anxious people to the telephone and the traffic curve will shoot upward. A rainy day that drives people off the streets or the interruption of transportation service increases the number of telephone calls very noticeably.

It is a fundamental of Bell System service that careful estimates of probable traffic are made in advance, and both manual and dial central office equipment is engineered with a view to providing adequate facilities for satisfactory handling of the anticipated traffic. Where manual switchboards are in use a careful adjustment of the operators' schedules, in line with the volume of traffic indicated, is made to insure that, at any given time of day, an adequate operating force is provided.

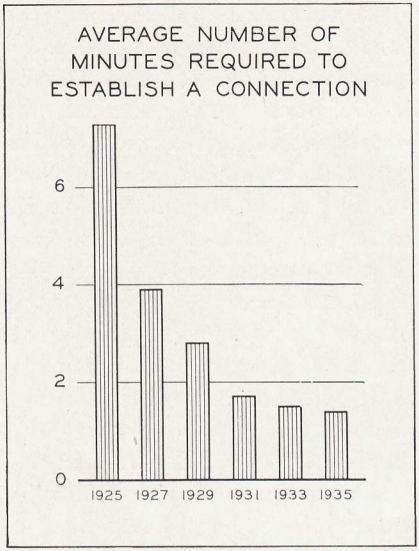
Training Operators

The work of the telephone operator is of such importance in maintaining efficient and dependable service that it cannot be undertaken in a hit or miss fashion. It is a work that can be done properly only by one who is especially trained for it. Under the guidance of instructors who were themselves once operators, the student operator is taught the best way of doing the things she will be called upon to do when she really goes to work. She becomes a telephone employee, however, the moment she begins her work in the training course and her pay begins at once.

The prospective operator learns, by handling practice calls, the proper methods of operating switch-

Operator's Set Today. Weight 17 oz.

boards in real central offices. She is taught to think quickly, to keep cool in emergencies, to make her head guide her hands. Early in her telephone career she begins to absorb unconsciously the spirit of service that has become traditional among the men and women of the Bell System. When her preliminary training is completed, she is assigned to a switchboard where actual service is being given. Here, as at a great loom, is woven the warp and woof of the business and social life of her community and, indeed, of the nation. Her position at the switchboard becomes, in effect, the center of the nation-wide communication system.



Over 90% of Long Distance Calls Are Now Completed by the Operator While the Customer Holds the Line

Working Conditions

Throughout the Bell System everything practicable is done for the health, comfort and convenience of the telephone operators. Rest rooms are provided where operators and other women employees may spend their leisure time when off duty. At the larger central offices there are completely equipped dining rooms where meals are obtainable at very low cost to the employees.

The Importance of "Information"

Because of the constant addition of new subscribers and changes in listings of existing subscribers, information operators are provided to advise telephone users as to new or changed numbers which do not appear in the current telephone directory. The information operator's records are kept up to date daily.

Public Welcomed at Central Offices

Subscribers and others are always welcome at the central offices of the Bell System, where the intricate

Central Office Apparatus Kept in Condition by Experts

Lists of Telephone Numbers Used by "Information" Are Brought Up-to-date Daily

apparatus is gladly explained and full information given regarding the many details of telephone service. Public school classes and technical students find much to interest them in the operating and terminal rooms. All Bell companies court the widest public familiarity with the methods and equipment in use.

An inspection of a central office will amply repay the visitor, in interest and in instruction. Here one sees a mechanism which is marvelously intricate in construction, yet marvelously simple in operation. Miles of wire thread their way through the back of the switchboard, each to its proper place—a veritable maze of circuits at which the visitor stands in wonder. Yet the operators—the "Weavers of Speech" who sit at this huge loom—go about their duties with an apparent ease, an absence of confusion, that is hardly less a miracle than the perfection of the machine at which they work.

Here one receives something more than an accurate understanding of telephone apparatus and telephone operating methods. One comes away from a central office with a deeper appreciation of the telephone itself —his own telephone. It is no longer simply a piece of mechanism, but a part of a greater machine into which thousands of men and women have put their own personalities and made it an instrumentality of nation-wide, universal service.

Print and Vision By Wire

Operators at a Teletypewriter Switchboard

Teletypewriter Service

The teletypewriter is a means of transmitting written conversation just as the telephone is a means of transmitting vocal conversation. This form of communication service uses machines which, in many respects, are similar to typewriters. By means of keyboards electrical impulses are transmitted over a line, the character of these impulses being such as to cause the direct reproduction of messages in typed form on one or a number of similar machines, which may be in offices across the street or across the continent.

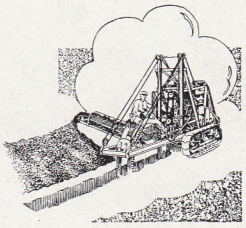
There are two types of teletypewriter. One reproduces messages on standard size pages; the other types on a narrow paper tape.

Teletypewriters are extensively used by the large press associations for transmitting much of their news traffic over Bell System circuits. The rapidity of the service makes it especially useful in connection with stock exchange report traffic.

Brokers, too, are large users of teletypewriter service for the speedy transmission of short statements, requests for prices and other market information between their offices.

The teletypewriter has proved of great value, also, in the administration and control of large business enterprises with plants, warehouses, branches and offices at widely separated points. Orders, specifications, inquiries, reports, price changes and other messages in which speed and accuracy are essential are rapidly transmitted by teletypewriter among the various branches of large steel, oil, manufacturing and other companies.

The United States Department of Commerce uses teletypewriter circuits for the transmission of weather reports along the air routes throughout the country connecting more



Preparing to Put Cable Underground

than 100 airports. Commercial aviation companies are also users of the service, which effectively promotes safety in flying by furnishing departing aviators with up-to-the-minute information as to weather conditions that will be encountered. In many cases the information thus transmitted to the airport is relayed to aviators in flight by radio telephone.

The teletypewriter is also rendering invaluable service to the police as a means of sending out alarms for escaping criminals, descriptions of missing persons and of stolen property and the like. In these days when the automobile has facilitated quick escape, electrical communication is especially necessary for the interception of fugitives from justice. Teletypewriter installations connecting police headquarters with outlying precincts, or linking up the police stations of neighboring towns throughout a county or a state, provide the means for sending alarms to all the connected points simultaneously and obviate calling each place in turn. State-wide teletypewriter systems serve the police of many states. New York City, Boston, Chicago, Washington and numerous other cities have also availed themselves of this means of combating crime. Many of these

Teletypewriter Messages from the Federal Bureau of Investigation, Washington, D. C., Outdistance the Speediest of Criminals

The Telephone Installer

systems in adjacent states are interconnected, and all are coordinated with the various local police radio systems.

Teletypewriter Centrals

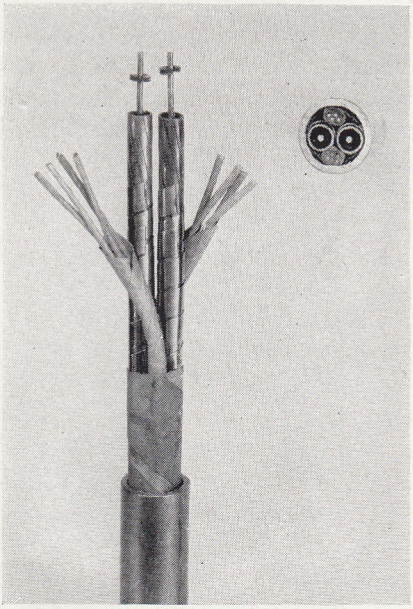
The varied ways just mentioned of applying teletypewriters to the needs of business and government repeat the early history of voice communication, since they involve the private use of wires for connecting fixed points, as was the case with the early telephones. The introduction of the first commercial telephone switchboard in 1878 opened up the possibility of an interconnecting service. A similar stage in teletypewriter usage was reached in 1931 through the development of a switchboard permitting the interconnection of teletypewriter circuits. This made possible the establishment of central offices and the institution of a general teletypewriter service whereby users can, upon request, be connected through the switchboard with other users for the interchange of typewritten messages, just as telephone service permits the interchange of the spoken word.

Pictures by Wire

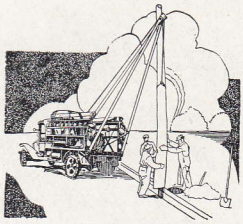
A method for the transmission of pictures over telephone lines developed by Bell engineers was first demonstrated in 1924 and today is in daily use between newspapers located in the larger cities of the country, permitting the transmission of photographs of important events coincident with news accounts.

Television Demonstrated

The first public demonstration by wire and wireless of television or "distant seeing" as developed by the technical staff of the Bell Sys-



New Coaxial Cables Capable of Transmitting a Frequency Band about a Million Cycles in Width

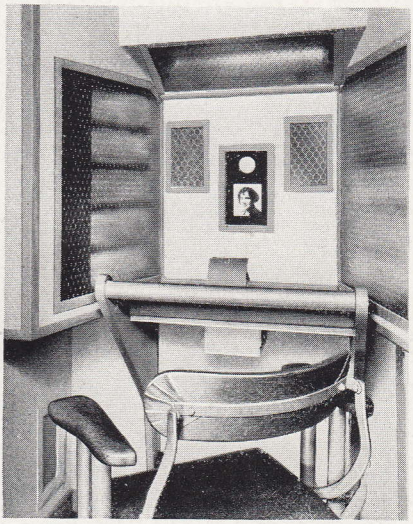


Raising Poles With Derrick

tem, took place on April 7, 1927. Participating in the demonstration at Washington, D.C., and New York were notable gatherings of leaders in the fields of science, industry and public affairs. Those who talked from the Bell Laboratories in New York were able to see plainly the features of those in Washington with whom they conversed over the long distance circuits of the Bell System. By means of a larger screen and loud speakers all those present at New York were able to see the speakers at the National Capital and to hear the conversations over the wire.

This television demonstration between Washington, D. C., and New York over the telephone circuits of the Bell System was followed by a demontration of television by radio in which the audience at the Bell Laboratories in New York saw the artists visualized on the screen and heard a varied program from the radio experimental station of the Laboratories at Whippany, N. J. In 1929 television in color was demonstrated at the Bell Telephone Laboratories in New York.

During the following year two-way television was demonstrated over a circuit connecting the Bell Telephone Laboratories with the headquarters of the American Tele-



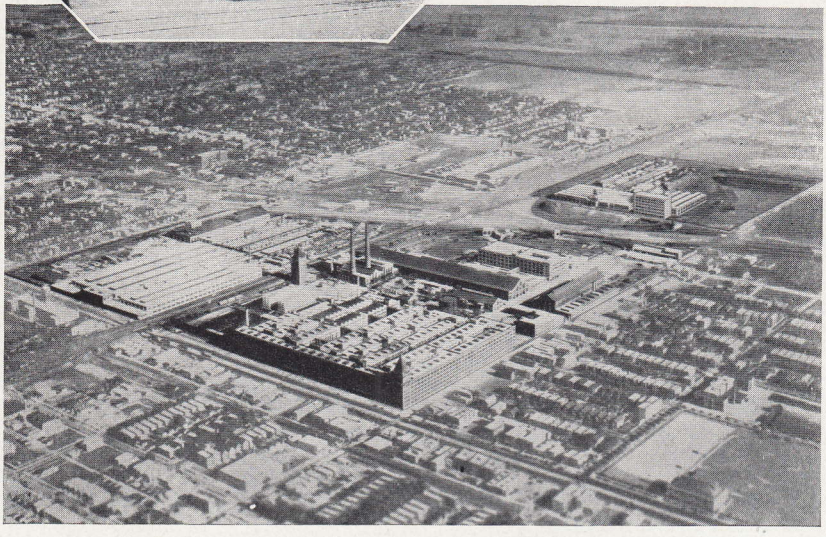
Booth Used in Two-Way Television Demonstration

phone and Telegraph Company. Persons in booths two miles apart were enabled to see moving images of each other while they conversed.

By 1936 the development in the Bell Laboratories of a coaxial cable capable of transmitting more than 200 telephone conversations or a single television program (if future developments create a demand for television circuits) had progressed sufficiently so that an experimental installation between New York and Philadelphia could be undertaken to determine more completely the capabilities of this new system under actual field conditions.

The Telephone Workshop

The Western Electric Plant in 1877



The Hawthorne Works of the Western Electric Company in Chicago

Standardization in Manufacturing

When telephone apparatus has been perfected in the Bell Laboratories, the specifications go to the Western Electric Company, which is both the manufacturing and purchasing organization of the Bell System. Its function is to furnish apparatus and equipment of uniform standard as the regional companies may require it. It is also the System's purchasing agent and buys for the companies such supplies as it does not manufacture, the scale of its operations resulting in large savings to the telephone companies. It operates warehouses which supply not only day-to-day needs but main-

Inspecting Multiple Bank Springs

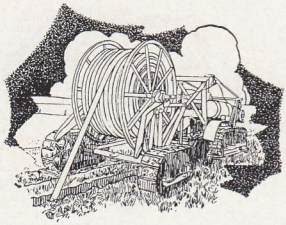
tain reserve stocks that are immediately available to the companies when storm, fire, flood or earthquake make their quick replacement vital in the public interest.

The value of such a policy of standardization is often given dramatic emphasis by an emergency. This was strikingly demonstrated a few years ago when the worst sleet storm ever experienced in the Middle West ravaged the Mississippi Valley, disrupting communication services in a belt 150 miles wide, from Texas almost to the Great Lakes.

Thousands of poles were broken. Thousands of miles of telephone wire, snapped by the weight of clinging sleet, were out of service, breaking the network of communication lines that not only served the people within the territory affected, but that reached out to hundreds of other cities to the East and to the West, even from coast to coast.

To restore the service that was of such vital importance to the nation was a gigantic task, far beyond the man power of the local telephone forces. As a result of Bell System standardization, however, it was possible to mobilize the resources of the System in men and materials and overcome the effects of the storm with a speed that to many observers seemed miraculous. From the Southeast, from New York, from Pennsylvania and Ohio, from the Northwest, the repair trucks immediately started rolling toward the stricken areas. Almost before the storm had subsided, the local repair men, who had gone on duty at the first report of trouble, found groups of their fellows, whom they had never seen before, working side by side with them in the restoration of service. And while men were being mustered, the numerous warehouses of the Western Electric Company had started shipments of tools, wire, poles, crossarms, and other needed material. It was because of standardized material, and standardized methods of using it, that such an emergency could be met at once.

The fact that the United States requires a nation-wide, unified telephone service is what makes standardization of apparatus, and a dependable source of supply, so essential. The facilities in places thousands of miles apart, and the facilities connecting these places, must be designed for harmonious operation together if the spoken message is to be delivered satisfactorily. Furthermore, the American public is mobile. It travels extensively,



Laying Tape-armored Cable in Trench

Forming Cables for Dial Equipment

changes residence frequently. It expects uniformity of service, for the telephone is universal.

First Telephone Workshop

Until 1878 all the Bell telephones had been made by Thomas A. Watson in the little electrical shop in Boston, where the first telephone was constructed.

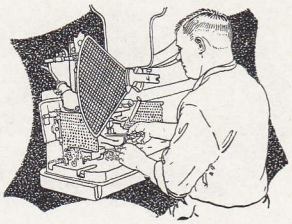
When this limited source of equipment supply became inadequate, licenses were granted to four other electrical concerns to use the Bell patents in the manufacture of telephone apparatus. Besides these companies, in 1869, Enos M. Barton and Elisha Gray had formed a partnership which, in 1872, became the Western Electric Manufacturing Company, the predecessor of the Western Electric Company.

Birth of the Western Electric Co.

In 1881 a consolidation of all these companies was effected and the Western Electric Company was organized. In 1882 the Western Electric Company became the headquarters for Bell telephones, apparatus and equipment. In that capacity it conducts extensive manufacturing activities.

The Bell telephone workshop, keeping pace with the growth of the Bell System, has itself expanded tremendously. It now embraces three principal plants, the Hawthorne Works at Chicago, the Kearny Works in New Jersey, and the Point Breeze Works at Baltimore, Maryland. The Queensboro Works, a smaller plant located in Brooklyn, New York City, is devoted principally to making telephone booths.

In addition, the Western Electric Company maintains 29 distributing warehouses in the principal cities of the United States. Through these it furnishes the equipment to the telephone companies. In still another department, a force of men scattered through the country is engaged in



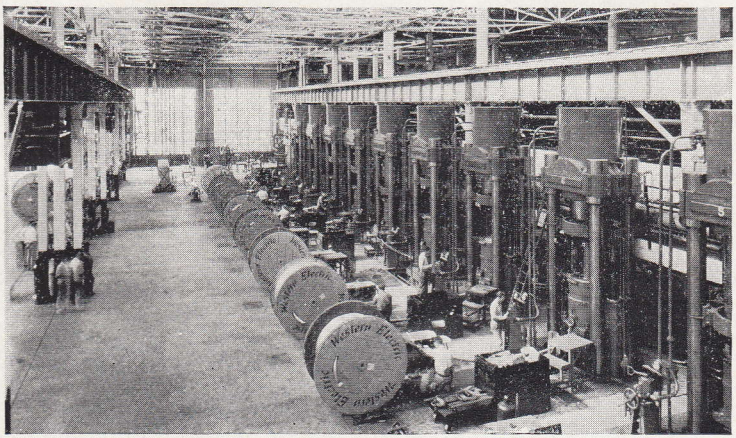
Safety Device Protecting Worker

installing central office and associated equipment for the companies of the Bell System.

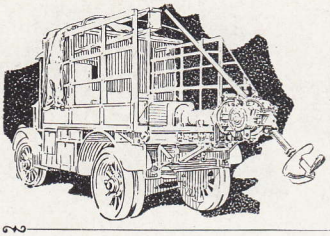
The Western Electric Company owns the stock of the Teletype Corporation which manufactures at its plant in Chicago all kinds of printing telegraph equipment. It also owns Electrical Research Products Inc. This company, as its name implies, provides a means for the commercial development, of inventions of the Bell Telephone Laboratories and the Western Electric Company, having application in fields outside the telephone industry. Notable among these is the equipment for the recording and reproducing of sound motion pictures, of which the Western Electric Company is the principal manufacturer. Another company, the Nassau Smelting and Refining Company, is equipped to carry on in the most economical manner the reclamation of scrap metals resulting from manufacturing operations and materials removed from Bell System plant.

The Hawthorne Works at Chicago covers approximately 203 acres and has about 89 acres of floor space. It is laid out according to the most modern ideas of city building.

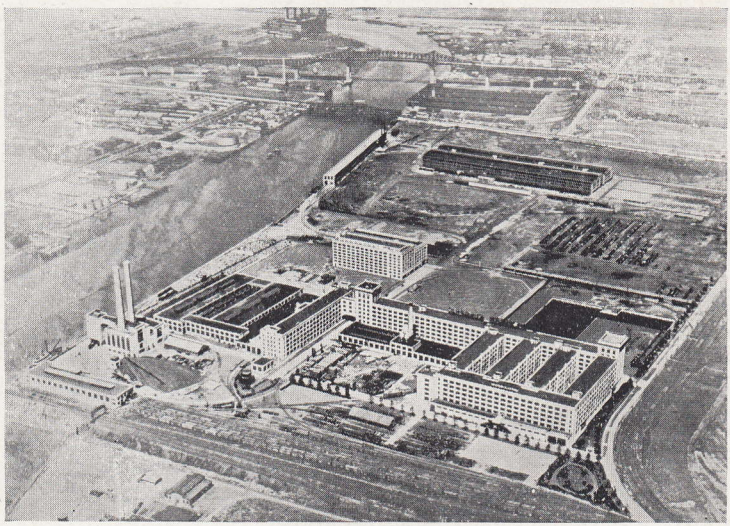
The streets of the telephone city radiate from the big water tower in the center, which looms above the other buildings. It has a railway system of its own and among all



Lead Press Room Where Sheath Is Placed on Cables



The Earth-boring Machine



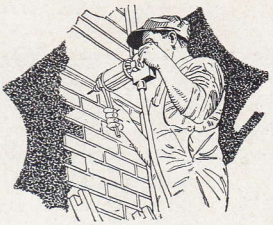
The Western Electric Company Plant at Kearny, N. J.

the big buildings trains are moving away finished products or bringing raw material. Within the city's gates are an electric plant, an independent water supply, several restaurants for employees, a hospital, a library and lecture rooms where employees of the company can take special courses—all these, in addition to the huge factory buildings where the telephone apparatus is made. Nor is this a city of toil alone, for it provides for recreation hours, baseball diamonds, tennis courts, a gymnasium, and an athletic field.

Two Other Industrial Cities

The Kearny Works was started in 1923 to provide telephone products in sufficient quantity to meet the growing demands of the Bell System. From swampy meadow land fronting on the Passaic River have sprung great cable manufacturing shops and multi-story telephone shops. The Kearny Works now has floor space almost as extensive as that of the Hawthorne Works.

The original land has been increased by the acquisition of adjacent property with modern buildings.



Operating Electric Drill

Early in 1929 the Western Electric Company purchased a tract of land in Baltimore and began the erection of a plant there for the manufacture of telephone cable, apparatus and wire. A bulkhead was constructed and a large area, previously useless, was reclaimed from swamp and water, giving this new industrial city plenty of space for future growth. The first buildings were placed in operation within a year. The plant's location is at Point Breeze on the waterfront in Baltimore's extensive harbor.

Mines and Forests Furnish Raw Materials

To keep these workshops supplied with raw material, men are toiling in our own country in the forests of the Northwest and in the iron, copper and lead mines and in steel works; in the mica mines of India; in the platinum mines of Canada, South America and the Ural Mountains in eastern Russia; and in the forests and jungles of far-off India, Africa and South America.

In making your telephone, as many as thirty-four different kinds of raw materials are used, gathered literally from the four corners of the earth. Of the precious metals, platinum, gold and silver are required, and of the baser metals, copper, zinc, iron and steel, tin, lead, aluminum, nickel and brass. Rubber, mica, silk, cotton, asphalt, shellac, paper and carbon in the form of coal enter into the manufacture of the marvelous instrument that transmits and receives the human voice, regardless of distance.

In a single year the shops transform into finished telephone apparatus enormous quantities of material. It is difficult to imagine the labor, the transportation, and the outlay required to bring to the doors of the shops all of these raw and fabricated materials.

Western Electric Quality

While the Western Electric Company manufactures other communication equipment, its principal activity is the making of the standard Bell telephone apparatus, and the excellence of its product is recognized everywhere.

A TELEPHONE CHRONOLOGY

1876 First telephone patent issued to Alexander Graham Bell.
First complete sentence transmitted by telephone.
First conversation by overhead line, 2 miles—Boston to Cambridge.

1880 30,900 telephones in the United States, all Bell owned.

1881 Conversation by overhead line, 45 miles—Boston to Providence.
Conversation by underground cable, ¼ mile.

1884 Conversation by overhead line (hard-drawn copper), 235 miles—Boston to New York.

1890 211,500 telephones, all Bell owned.

1892 Conversation by overhead line, 900 miles—New York to Chicago.

1900 677,000 telephones owned by or connecting with Bell System.

1902 First conversation by long-distance underground cable, 10 miles—New York to Newark.

1906 Conversation by underground cable, 90 miles—New York to Philadelphia.

1910 5,883,000 telephones owned by or connecting with the Bell System.

1911 Conversation by overhead line, 2,100 miles—New York to Denver.

1913 Conversation by overhead line, 2,600 miles—New York to Salt Lake City.
Conversation by underground cable, 455 miles—Boston to Washington.

1915 First conversation by transcontinental line, 3,650 miles—Boston to San Francisco.
Speech transmitted for the first time by radio telephone from Arlington, Va., across the continent to San Francisco, to Hawaii, and across the Atlantic to Paris.

1920 12,602,000 telephones owned by or connecting with Bell System.

1921 Conversation by deep sea cable, 115 miles—Key West, Fla., to Havana, Cuba. First conversation between Havana, Cuba, and Catalina Island by submarine cable, overhead and underground lines and radio telephone—distance 5,500 miles.
Extension of Boston-Philadelphia cable to Pittsburgh—total distance 621 miles.

1922 Ship-to-shore conversation by wire and wireless between Bell telephones in homes and offices and the *S. S. America* 400 miles at sea in the Atlantic.

1923 Successful demonstration of transoceanic radio telephony from a Bell telephone in New York City to a group of scientists and journalists in New Southgate, England.
First broadcasting of a presidential message to Congress, December 6.
Completion of Southern transcontinental line.

1924 First public demonstration of picture transmission over telephone circuits—New York and Cleveland.

1925 Completion of the New York-Chicago telephone cable—overhead—underground.
16,720,000 telephones interconnected in the United States.

1926 Successful test of two-way transatlantic radio telephony.
Completion of extension of New York-Chicago, all-cable telephone line to St. Louis.

1927 Transoceanic telephone service inaugurated between New York and London.
Northern transcontinental telephone line formally opened.
First public demonstration of television by wire and radio.
Telephone service opened between the United States and Mexico.

1928 Transoceanic telephone service extended to principal countries of Western Europe.

1929 Ship-to-shore telephone service established.

1930 Transoceanic telephone service opened to South America and Australia.
Two-way television demonstrated by Bell engineers.
20,098,000 telephones interconnected in the United States.

1931 Teletypewriter exchange service inaugurated.
Fourth telephone cable to Cuba opened.
Transoceanic service extended to Java, Sumatra, Bermuda, Hawaii, Canary Islands.

1932 Transoceanic service extended to South Africa, Egypt, Siam and the Bahamas.

1933 A telephonic system for high quality transmission and reproduction of orchestral music demonstrated by Bell System engineers.
Transoceanic service extended to the Philippines, Canal Zone, and Central American countries and to Palestine, and India in Asia.

1934 Transoceanic service extended to Japan.

1935 First telephone conversation around the world.

1936 93% of world's telephones within reach of any Bell System telephone.

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