Bell Telephone Quarterly

VOLUME XI, 1932

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

PRINTED IN U. S. A.

BELL TELEPHONE QUARTERLY

VOLUME XI, 1932

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BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

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VOL. XI NO. 1

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES AND CANADA; SINGLE COPIES, 50 CENTS

Address all communications to

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

CONTRIBUTORS TO THIS ISSUE

BANCROFT GHERARDI

A brief biographical note regarding Mr. Gherardi appeared in the list of contributors in the *Bell Telephone Quarterly* for January, 1931.

KINGSLAND T. ROOD

Dartmouth College, B.A., 1918. After leaving the Army, entered the Long Lines Commercial Department, American Telephone and Telegraph Company, New York City, as a member of the Commercial Engineer's section, 1920. Transferred in 1921 to the staff of the Long Lines Magazine, which had just started publication; during the next eight years was successfully Assistant Editor, Associate Editor, Managing Editor and Editor. Also assisted in Long Lines publicity work. Publicity Manager, Long Lines Department, 1928–.

STANLEY A. HAVILAND

Cornell University, M.E., 1924. Entered Plant Department, New York Telephone Company, Manhattan Area, same year; later engaging in outside plant engineering, Bronx-Westchester Area. Since transferring in 1929 to American Telephone and Telegraph Company, has been engaged in underground conduit construction matters in the Department of Operation and Engineering.

LAURA M. SMITH

University of Chicago, B.S., 1914; Supervisor, Atlanta Public Schools, 1914–1918; Civilian Relief Worker, American Red Cross, France, 1918–1919; employed by Southern Bell Telephone and Telegraph Company, 1919; member of General Traffic Staff of that company, 1920–1923; for the past eight years, Assistant to Personnel Vice President, American Telephone and Telegraph Company.

ROBERT L. TOMBLEN

A brief biographical note regarding Mr. Tomblen appeared in the list of contributors in the *Bell Telephone Quarterly* for October, 1930.

HERBERT E. SHREEVE

A brief biographical note regarding Mr. Shreeve appeared in the list of contributors in the *Bell Telephone Quarterly* for October, 1930.

Progress Through Research

A paper read at Silver Anniversary Convention of Association of Life Insurance Presidents, December 11, 1931.

I GREATLY appreciate the honor of being asked to speak to the Association of Life Insurance Presidents at their Silver Anniversary Convention. I am not only appreciative of the honor but I am glad to have this opportunity to talk on the subject of progress through research.

I believe that science and its applications have been the major factor in changing the world during the last 150 years. I believe further that from such activities in the future changes will continue in the years to come. If this view is correct, my subject is one of major importance to all and especially to this group of men who direct the investment of such enormous sums of money each year.

From the time of Julius Caesar 2,000 years ago until that of George Washington 150 years ago there was but relatively little change in the lives which people of the civilized world led. People thought much as previous generations had thought. People lived much as previous generations had lived. They lived amidst desperate and unreasoning fears. The life of the average man was well described by Hamlet when he said, "To grunt and sweat under a weary life." Perhaps no better picture of this life has ever been painted than Millet's "Man with the Hoe," with which you are all familiar. A fundamental characteristic of this period, at least as to physical matters, was the general acceptance of the assertions of authority as to the ways of the physical world.

As a result of this general attitude of mind in regard to physical knowledge, an attitude of mind which was enforced by various forms of autocratic authority, but few developments of a physical nature occurred that made any change in the life of man. At the moment I think of only four, the printing press, gun powder, the mariner's compass and the placing of keels on sailing vessels. Methods of production, of transportation and of communication remained practically unchanged. These methods were inadequate to produce sufficient of the necessities and conveniences of life to enable any but the favored few to have a standard of living above the lowest.

I am not saying that during this period there were no thinkers or searchers after truth in regard to matters concerning the physical world. There were a few, but in general the results of their working and searching were promptly lost. About 250 B.C. Aristarchus of Samos even before the time I am speaking of stated that the earth moved around the sun and undertook by methods which were correct in theory but limited by the crude instruments then available to measure the distance from the earth to the moon and to the sun. As a result of his work he was charged by the stoics of that day with impiety.

What he had done was promptly forgotten and his work was unknown to Copernicus who, in the early years of the 16th century, over 1,700 years later, stated again the correct relations between the earth and the moon and the sun. Perhaps fortunately for him he died just as his book was published. He perhaps may be taken as marking the start of the period when among the leaders of thought there began to be a definite rejection of authority as a basis of knowledge and an organized search for facts with regard to nature and for theories to coordinate these facts. The 16th century marked the fundamental work of Gallileo in Italy and of Newton in England, and from their time on a search for truth in the physical sciences was continuous and cumulative.

Probably Copernicus, Newton, Gallileo and the many other great minds who lived during their times and who followed them and whose work greatly extended our knowledge of nature did not have particularly in mind the possibility that this knowledge would be of great utility to man. They were like the explorer who visits new places for the sake of learning things which have not been known before without necessarily any direct utilitarian objective. Their search for knowledge was for the sake of the knowledge itself and not for the use that could be made of it and their guiding principle was that we cannot derive our knowledge of nature by abstract reasoning but that we must examine the facts of nature itself and determine how things happen under various conditions. The vast fund of new information about physical matters which grew up as a result of this scientific research was bound to produce another type of research; that is, the search for ways to utilize the facts of nature for the benefit of mankind and so following the development of scientific research there grew up what may be called industrial research, research made possible by the new scientific knowledge and stimulated by the attitude of mind that things do not always have to be done as they had been done in the past.

Before the beginning of the 19th century traces of industrial research may be found here and there. During the 19th century it became clear to many leaders of thought and of industry that there were better ways of doing things than the way in which they had previously been done and that there were new things that could be done. So that today, in our colleges and universities and in many other laboratories, scientific research is being continuously prosecuted and this research furnishes the basic material for industrial research which is going on in numberless places throughout the civilized world. We need only look about us today to see in almost every field of human endeavor that has to do with physical matters the results of research. When George Washington wished to move from one place to another, like Julius Caesar he could walk, go on horseback or by stage coach and if he wished to travel by water he could go in a row boat or in a sailing vessel. Their travel was slow and surrounded by numberless discomforts. How different the situation is today, with railroads, automobiles, flying machines and sea going vessels driven by powerful machinery, and, if one wishes to go under water, submarines.

In communication George Washington, like Julius Caesar, was subject to the limitations of transportation. It is true that such things as semaphores, heliographs and smoke signals were known and used in a very limited way but they really played no part in world communication. Today, the communication story is entirely different. Not only has the improvement of transportation vastly improved all of the older forms of communication, but entirely new ones, unknown and undreamed of when George Washington died, have been developed. This began about 1830 when in Albany a distinguished American scientist, Joseph Henry, demonstrated the principles of the electric telegraph, which principles were commercially applied by Morse in 1844 between Baltimore and Washington.

This invention immediately provided a means of communication independent of transportation not subject to its limitations and annihilated distance for written messages between points to which the system was extended. Still, however, there was one serious limitation to communication. When two people are near at hand their natural mode of communication is by the spoken word when, as is usually the case, no permanent record is desired. In 1876 Bell, by the invention of the telephone, removed this limitation and made it possible for two people to carry on a conversation even when separated by distances beyond those to which the human voice could carry. Out of the work of these men and by the efforts of a host of others who have followed them there was developed the electrical communication system of today which we all use in our business and social lives and which, so far as communication is concerned, brings all parts of the civilized world closer together than were two counties in the same state in the life of George Washington.

Time does not permit more than a mention of a few of the many other fields in which revolutionary progress has been made—in the field of power, the steam engine, oil engine, gasoline engine, gas engine, in the chemical field, in the electrical motor and generator field and in many others to which research has been intensively applied.

While volumes would be insufficient to describe the research, the development work and the inventions which have produced the results of today in any one of the fields which I have mentioned, perhaps it will not be out of place for me to describe briefly one item of research which has contributed so much to the improvement and extension of the telephone system during the last 15 years.

Up to about 1910 the Bell System was so fully occupied in developing and extending its local and shorter-haul toll services that the question of transcontinental telephone service could not be a pressing one. About that year, however, it became clear to us that the time had come to seek for a solution to this problem, not that we had experienced any commercial demand for such service, but that we believed there would be a substantial use of the service if it were made available. We therefore decided to undertake the investigation. The first question which had to be settled was along what general lines the solution should be sought. Obviously the problem was one which could be approached in several different ways. We might undertake to develop a more powerful transmitter, or a more sensitive receiver, or a more efficient telephone line, or to develop a satisfactory and reliable telephone repeater, which is a piece of apparatus inserted in the line at more or less frequent intervals, by means of which the telephone current is magnified without changing any of its other characteristics.

Each of these methods of approach involved the exploration of territory at that time unknown or but dimly known. The problem was like the location of a satisfactory pass through an extensive mountain range which had never been charted. It is not clear even where to start. Theoretically, of course, it would have been possible to have started research simultaneously on all four of these approaches. Practically, however, it was desirable to avoid this method if it could be done, because not only is such research expensive, but there were only a limited number of men available with the proper training and experience. Therefore, if at the start it was practicable to determine the correct general approach, much time and effort would be saved; and if the proper general approach was chosen, the result would be obtained more quickly than if the research efforts were scattered.

The various possible solutions were therefore carefully reviewed, and it was our judgment that in the light of such knowledge as we had, the solution to the transcontinental telephone problem lay in the direction of the development of a satisfactory telephone repeater. The problem was therefore intensively attacked from this point of view. Today, the answer to the proper method of approach may seem obvious, but that it was not so at the time our research was started is indicated by the fact that in Europe the solution of the problem of telephony over great distances was believed by many to lie along the lines of a more powerful transmitter, and much work was done there to develop such instruments. These have contributed as far as I know nothing to the extension of telephone service.

The solution of the transcontinental telephone problem was not a simple one. It did not alone involve the mere development of a device (the telephone repeater) to be placed here and there in the line. In addition to the development of such a device, the problem involved the development of methods by which this device could be connected in the line and would do its work on a two-way conversation; it involved the adaptation of the lines themselves to telephone repeater operation; it involved modifications in maintenance and operating methods so that telephone repeaters could be successfully used. Each of these was in itself a formidable problem, but all were successfully solved, so that in September, 1914, Mr. Theodore N. Vail—then President of the American Telephone and Telegraph Company—had the satisfaction of speaking the first words that were heard across the Continent. This statement is literally true, because, having satisfied ourselves by experimental work on shorter lines that the system we had developed would operate satisfactorily, the line between New York and San Francisco was never connected through until Mr. Vail's first conversation.

The successful prosecution of a research problem such as this is not the work of any one individual. Hundreds of scientists and engineers contributed in an essential manner to the result, and many prior advances in the art were incorporated in the new devices and methods. Research is essentially cumulative in character. It builds upon the work of others not only within but outside of the organization.

In research work, as in other lines of endeavor, one thing often gives rise to another. Out of the solution of the transcontinental telephone problem, grew many other possibilities. It gave us the means of working long telephone cables, so that today wires in storm-proof telephone cables give service over distances of more than 1,500 miles. The present radio telephone art, including broadcasting, rests upon the developments made for and first used in the transcontinental telephone line. The whole of the talking movie art rests upon these developments, and but for their success a transatlantic telephone cable now within the range of practical engineering would still be a dream.

Research has had an important influence upon the organization of many industries. In the olden days, industry or business was essentially a matter of routines. Year by year, and generation by generation, the business was done in the same general way; and except for a few people at the top of the organization making decisions, the carrying on of the business was practically the executing of established routines. Today, however, in many businesses and industries, a new branch of the organization has grown up. This branch is not concerned with the day-by-day operations of the business; its problems have to do with new devices, new methods, and with new modes of operation. From the beginning of the telephone industry, the chief executives of the Bell System have been strong in their support of this work. Mr. Walter S. Gifford, now President, is one of its keenest advocates.

Research is often thought of as an activity which is carried on in laboratories. Much research *is* carried on in laboratories, but in many cases the subject matter of research is of such a character that it does not lend itself to laboratory treatment. In this connection, I need only mention such research as is primarily statistical in character, research on social questions, and research on business methods.

At this point, two questions may be asked: "Shall we continue to have further important developments in the future?" and "What of it all anyway?"

To the first question, the answer is I believe easy; it is "yes." We have not exhausted the secrets of nature, and we have not ended the opportunities to apply, to the uses of mankind, even those that we do know. If we were to listen to any group of research men talking to one another, we would find that their conversation is not so much about what they have done as about what they are doing and what they are going to do, about things that are not today available, but which they confidently expect will be in the months or the years to come. Their confidence generally rests on a firm basis.

In the Communication field there has been something new offered to the public within the last thirty days. You have perhaps read a little about it in the newspapers. It is known as "switched teletypewriter service." For some time, teletypewriter machines have been in use connected with private lines. By the use of these machines and the private lines, it has been possible to send instantaneously written communications between the machines connected at the ends of the line. By a combination of these machines with the telephone switching art, and suitable adaptations of both the machines and the switchboards, a service has been offered to the public by which a connection may be established between any machine in the System and any other machine, and written messages may then be interchanged in the same way as oral messages are now exchanged over the telephone system. This places the written communication art on the same direct and instantaneous basis as is the telephone art of today.

I cite this merely as an illustration of a thing which was not done a month ago, which is being done today, and which in a few years will no doubt be a commonplace in our day-by-day life.

To the second question—"What of it all, anyway?"—the answer is not so simple, but I believe it is one of encouragement. It seems to me that one of the fundamental troubles in the world prior to the 19th century was that the known methods of production were not capable of producing enough to sustain the peoples of the world at any reasonable standard of living; in other words, that the combined efforts of practically everyone were not sufficient to produce results which would, even when judged by low standards, adequately house, feed and clothe everyone. I am not speaking of any question having to do with the inequalities of distribution, but am speaking of the total amount of production. Today, as a result of scientific progress and of its practical applications through research, this is no longer true. It is possible, by known methods, to produce enough in civilized countries to house, clothe and feed the population at high standards compared with any that formerly existed in the world, and to have enough left over so that the young may devote time to education, so that all may be provided with books which they have learned to read and with other forms of amusement, and so that all may have leisure time for such uses as they wish to make of it.

Our problem today does not appear to be an inability to produce enough; rather, it has to do with how to utilize our present production capacity. It is not the problem of want, it is the problem of plenty. Such problems are not primarily for the engineer, the scientist, or the inventor; they are for those who deal with social, economic, political and financial questions; they are problems concerning human relationships.

The question has sometimes been raised as to whether perhaps some of our difficulties at the present time do not arise from the fact that while in the fields of the physical sciences we have abandoned the old methods of authority and tradition and made rapid advances as the result of a different approach, may it not be that authority and tradition still too much limit the development of social, political, economic and financial relationships. Upon this question, I do not feel competent even to suggest an answer. As bearing upon the answer to this question, however, I might point out that science is impersonal; that scientific research will aid in satisfying the desires of the peoples of the world, however such desires may be crystallized in the minds of the leaders. Science can give us higher standards of living as we may define them; it can give us more leisure for all of us to use or misuse as we may elect; it can give us more comfortable and convenient ways of living and carrying on human relationships; it can give us more effective ways of killing and maiming one another in devastating wars; it can aid in attaining whatever may be the objectives of those who are leading the world. Those who are prosecuting research in scientific and industrial fields and are applying the results do not determine their own objectives; the broad objectives are determined for them by others.

What special relation has research to the Life Insurance Presidents? What do you wish to know about a "risk" before you accept him? How about the acceptance of the risk of investing in or lending money to a business or industry? When a life insurance company is considering an applicant for life insurance, there are certain things which it would like to know about the applicant. Among these are his past history as to health and disease, and his present health. In addition, it wishes to know certain facts which will give some indication of his expectancy of future life, his habits, his home conditions, and other factors. The life insurance people know that one man is a good risk, and another a poor one, although as far as age, health and previous medical history they are similar. Is not the same true of any business? Does not the future health of a business depend not only upon what it has done and what it is doing today but what it is planning to do to meet the future? What is its vision for the future and what plans is it making to adapt itself to that vision? We all know that the general conditions and the surroundings under which business will be done will change; the habits of the people will change; their tastes and desires will change. Will the business in question change and adapt itself to these new conditions? Will it be progressive? Will it do its part in the creating of new conditions under which it can survive? Will it improve its product, improve its methods, develop new products, so that it will not only be among the leaders in its own field; but what is perhaps equally important, will it be able to hold its own in the competition for the customer's dollar in which every industry is competing with every other industry?

More and more as time goes on the answer to these questions will, I believe, depend upon the intelligence and vigor with which research is carried on and the intelligence with which the general management of the business or industry directs this research along the proper lines.

As with peoples, so with industry—"Where there is no vision the people perish."

BANCROFT GHERARDI.

Five Years of Overseas Telephone Service

FIVE years ago this month, the speech bridge with which Bell System scientists and engineers had succeeded in spanning the North Atlantic, was formally dedicated to public service by Mr. Walter S. Gifford, President of the American Telephone and Telegraph Company. On that opening day of January 7, 1927, the territory served by the transatlantic telephone channel was limited to the metropolitan districts of New York and London, embracing some 2,500,000 telephones.

Since then the telephone horizon has been constantly widened. Today it includes 32,829,000 telephones, or about 92 per cent of those in service throughout the world. The area thus served includes most of North America, much of South America, all of Great Britain and Northern Ireland, practically all of Europe from Brittany to the Black Sea, Australia, and a city in Africa. It includes, moreover, the islands of Java and Sumatra in the East Indies, Sicily, the Canary Islands, Bermuda and the Hawaiian archipelago. Seven large passenger liners, while at sea, maintain telephone contact with this great network through the ship-to-shore service. And the limit has by no means been reached.

As the service extensions have followed one another, the volume of messages has steadily gained. Daily transatlantic messages during 1927, the first year of the service, averaged seven. Each succeeding year has witnessed an increase, until during a record week last summer conversations between the United States and Europe averaged more than 100 a day. Total transatlantic messages for the year 1931 show an increase of 21 per cent over the total for 1930.

With these facts in mind, several questions naturally arise. Who uses the transatlantic service? What is it used for?

Has experience proven Mr. Gifford's prediction to Sir Evelyn Murray, Secretary of the General Post Office of Great Britain, during the ceremonies inaugurating the service five years ago, that "it will certainly facilitate business; it will be a social convenience and comfort; and through the closer bond which it establishes it will promote better understanding and strengthen the ties of friendship"?

The answers to these questions can be gleaned from the daily press. For ever since the service was established, its use has been chronicled as news, and the part it has played on important occasions or for important purposes has been widely commented upon. It is from such comments and news accounts, as well as from personal reports of patrons, that the material that follows has been compiled.

Financial

Almost from the day transatlantic telephone service was opened for public use, banks, brokerage houses and financiers have turned to the service as an instant, effective means of communicating between the money centers of Europe and America. A bank talks with its European representative to negotiate certain credits. A brokerage house keeps in close touch with political developments in a foreign capital. An American financier travelling abroad holds daily conferences with his brokers in New York. Almost every ripple that disturbs the financial world is faithfully reproduced in the ebb and flow of overseas telephone service, as the news of the day reveals.

When the "bull market" toppled from its peak in 1929 the transatlantic traffic for the next two or three days jumped to a record. During the period when the debt negotiations were in progress last summer, the interest of American financiers in Germany's economic fate was expressed in the largest week of transatlantic usage up to that time.

Again, when Great Britain announced her abandonment of the gold standard last September, the announcement was followed by the establishment of a new message record for a single business day, when 162 transatlantic conversations took place on September 21.

The announcement last August that French and American bankers had combined in offering a credit to the British Treasury of four hundred million dollars included the statement that the negotiations had been completed largely by transatlantic telephone in the short time of 36 hours.

Going back to 1929 we find news items to the effect that a well known promoter, while travelling abroad, used the telephone daily during a period of intense activity in the stock market to keep in close touch with the situation. His calls were not only numerous but of unusual length. Press reports of the time estimated his expenditure of $25,000 during a single week on telephone conversations with his New York brokers. The reports added that he talked every day to each of a dozen brokers on one call, and that such calls sometimes lasted as long as an hour and a half.

Another important financial figure is said to have talked from the Savoy Hotel in London to New York in a 97 minute conversation.

Many similar reports might be cited, if necessary, to show how men of large affairs have adopted as one of their valued business tools a communications service that was a spectacular accomplishment only five years ago.

The Press

The establishment of overseas service came as a boon to the Press. Many a harassed editor has thankfully reached for his telephone and talked directly to someone on the scene of a news happening 3,000, 5,000, even 10,000 miles away, thereby confirming details, getting direct impressions of eye witnesses, and valuable bits of local color with which to embellish the story he may have received by routine channels. Frequently the editor has been able to talk directly with one of the principals of such a happening and obtain an exclusive interview, through a transatlantic telephone conversation.

When some terrible tragedy occurs, the transatlantic telephone channel is sure to be used by editors in other lands seeking details for their readers. One instance was when the Cleveland hospital explosion horrified the civilized world two years ago. Interest abroad in the event was so intense that several English newspapers telephoned for last-minute information. The London Daily Mail queried the Cleveland News for nearly 25 minutes about the disaster.

Happier episodes of life, too, are often the themes of transatlantic newspaper reporting. When well-known persons, for example, are suspected of making nuptial plans, what better way is there of changing rumor into fact than by inquiring directly of the principals, even though they might be some thousands of miles away? That was the conclusion of a London editor last October when he called a well-known American actress and confirmed the rumor of her engagement to the younger son of a British Peer. Another London newspaper talked directly with the American woman tennis champion for the same purpose, and with a similar result.

Among the interesting interviews secured by the Press over the transatlantic telephone was one last September in which one of President Hoover's secretaries was asked by a European newspaper to confirm or deny a report that the President was considering calling a World Trade Conference. A New York evening paper interviewed Mayor Walker while the latter was abroad, concerning aspects of a city investigation then in progress. Following a receipt by Scotland Yard, last August, of photographs of a notorious criminal, a London evening paper interviewed the Police Commissioner of New York regarding the man and his exploits. Many other transatlantic calls to New York's police commissioner have testified to foreign interest in crime and criminals as well as to the usefulness of the telephone channel that spans the Atlantic. That this channel can play a prominent part in the detection or prevention of crime is of course one aspect of its unique value as a means of international communication.

One piece of transatlantic newspaper reporting deserves more than a brief mention because of its resourcefulness and dramatic character. It has to do with the first arrival of the dirigible, *Graf Zeppelin,* in this country in October, 1928.

Sensing the news value of the event, a German news gathering organization arranged for one of its reporters to make the trip in the *Graf Zeppelin.* He was among the first passengers to disembark at Lakehurst, where he was met by an American representative of the news agency. The American several days previously had hired a room in a roadside refreshment stand, in which the telephone company had installed a telephone for him. He had then filed a call to Berlin to be put through on the airship's arrival.

Followed by the German visitor, he hurried to the stand. Meanwhile, learning from the din of whistles, horns and cheers that the dirigible was in sight, the Lakehurst central office force had started work completing the call to Germany. Within a few minutes the story of the eventful trip was being dictated to Berlin, where five stenographers, working in relays, took it down in short-hand during a forty minute call.

Government Officials

A roster of Government officials who have talked on the overseas telephone within the past five years would include several kings and presidents, prime ministers, high officials of various governmental departments, secretaries and under-secretaries in abundance, according to newspaper reports. It is interesting to recall that many government heads took part in the ceremonies extending overseas service to new countries. One of these occasions, on October 13, 1928, when President Coolidge conversed with King Alphonso of Spain, marked the first time in history when a President of the United States has spoken with a ruling European Monarch by telephone.

When the overseas service was inaugurated between the United States and Austria, in November, 1928, the Secretary of State, Frank B. Kellogg, in Washington, exchanged greetings with Dr. Ignatz Seipel, Chancellor of Austria in Vienna. During the same month Secretary Kellogg took part in ceremonies extending overseas service to Hungary and Czechoslovakia. From Budapest, Count Stephen Bethlen, Premier of Hungary, addressed him while Dr. Eduard Benes, Foreign Minister in Prague, replied to Secretary Kellogg on behalf of Czechoslovakia.

While visiting in the United States, H. R. H. Don Alphonso D'Orleans, first cousin of the Spanish king, his wife and his son, talked from New York with King Alphonso in the Royal Palace at Madrid early in 1929. S. Parker Gilbert, Agent General of Reparations, about the same time, while in Washington to confer with heads of the State Department, talked with his Paris representative concerning the personnel of the Committee of American Experts for the forthcoming Reparations Conference.

When King George V of England made his famous address opening the Naval Arms Conference at London, on January 21, 1930, he spoke into a gold and silver microphone before his great gold chair in the royal gallery of the British House of Lords. His message was estimated to have reached the ears of a hundred million persons listening at radio sets in all parts of the world. A total of 121 radio stations broadcast His Majesty's words in the United States after they had been brought to this country over the transatlantic telephone channels, as well as by transmission through a British experimental short wave channel at Chelmsford. Americans had to rise early to hear the broadcast which began shortly after 6 A.M., New York time, and that same early hour was responsible for a great deal of delicate work on the part of Bell System technical men who were forced to shift frequently from long wave to short wave and back to long wave again.

In November, 1930, King George again spoke to the world at large through an extensive broadcasting hook-up when he opened from London the India Round Table Conference. The Columbia Broadcasting System received his words via the transatlantic telephone channel, as well as those of Premier MacDonald and the Indian representatives who spoke following His Majesty.

The voice of President Hoover has frequently been borne overseas by the Bell System's radio telephone facilities. Three years ago this month, he greeted the King and Queen of the Belgians meeting with governmental dignitaries in Brussels. When telephone service was established between the United States and South America, Mr. Hoover made the ceremonies notable by speaking with the presidents of Uruguay and Chile, seated in their respective capitals, and a day or so later he talked over the new channel with the president of Argentina.

Since that time Mr. Hoover and Secretary of State Stimson have employed the overseas telephone so often to reach U. S. officials abroad and the heads of European governments that, in the words of various newspaper editorials, they have inaugurated a new departure in diplomatic usage. In fact Mr. Stimson last Fall asked for a permanent installation in his office of several "head sets" so that members of his staff might at times listen in to his overseas conversations and make observations and notes as needed.

Last March the late Senator Morrow in London gave Mr. Stimson details concerning the proposed Naval Agreement between France and Italy in a 25 minute conversation.

While Mr. Andrew Mellon, Secretary of the Treasury, was in Europe in June last, he talked frequently with Mr. Hoover regarding the progress of the Franco-American debt moratorium negotiations. "At least twice the telephone operator at the American Embassy here with unaccustomed drama in her voice" says a press dispatch from Paris, "has announced 'The White House calling' and, in between the Presidential talks, Secretary of State Stimson and others in the Department of State have been in telephonic consultation." Secretary of State Stimson joined Mr. Mellon in Europe and while there kept in touch with Washington by overseas telephone.

As a new British Cabinet was being formed with Ramsay MacDonald, British Premier, heading a Coalition Government last August, it was announced that President Hoover had talked with Mr. MacDonald across the Atlantic.

Last October, when Premier Laval of France was preparing to come to America to talk with President Hoover regarding the problem of Inter-Governmental debts, Secretary Stimson talked with the American Ambassador in Paris, regarding the proposed subjects of the conversations. Mr. Stimson also talked to Mr. Prentiss Gilbert, American Consul General at Geneva, regarding the latter's presence at the meetings of the League of Nations Council.

When Premier Laval arrived in the United States last Fall he used the transatlantic telephone almost every day of his visit in America to talk with members of his Ministry in Paris. Shortly after M. Laval arrived, Count Dino Grandi, Foreign Minister of Italy, and his wife also reached these shores for a visit. Both used the overseas service to talk to their homeland, the Count to report to Premier Mussolini, and the Countess to speak to her children who had been left at home.

Even more recently Winston Churchill, British statesman, while in New York, met with an unfortunate automobile accident. As soon as he recovered sufficiently from his injuries he made half a dozen transatlantic calls to friends and relatives in England to reassure them.

Business Uses

That the transatlantic telephone has proven itself a valuable ally to trade and commerce is already well established.

In the early days of the service the Studebaker Corporation was reported to have made a sale of a quantity of its automobiles to an importer in Germany, carrying on negotiations through the transatlantic telephone channel. The General Motors Export Corporation has likewise used the service widely for administrative and sales purposes. Its American headquarters at various times has talked to nearly every one of its units in Europe and South America, and has even conversed with its representatives in Adelaide, Australia. And speaking of automobiles, an American manufacturer of auto horns in Jackson, Mich., some time ago was delivering a sales talk to his prospect in London. To convince the customer of the quality of his product, the Michigan business man brought one of the horns to the telephone and honked it several times as an actual demonstration of what his horn could do.

Up to the minute style news has been obtained from Paris on numerous occasions by American merchants who wished to offer their customers the latest creations from France. On one such occasion 100 buyers were gathered in the showrooms of a New York importing firm while the head of the company sat at a telephone and talked with his son in Paris on fashion's modes of the moment.

Learning of a Glasgow merchant anxious to obtain at once a consignment of high grade flour, the salesman of a Toronto milling company talked by telephone with the dealer and sold him the flour for immediate delivery in Glasgow. A long distance telephone call to the company's mills at Port Colborne, Canada, followed, ordering the rush loading of the flour. Next morning the freighter passed Toronto outward bound for Glasgow, with 23,000 bags of Canadian flour in her hold. Another Toronto milling company executive called his Oslo, Norway, representative and settled a misunderstanding regarding freight rates. In speaking of the occurrence the export manager of the milling company remarked, "We have often spoken to business firms in England but this is the first time we have had occasion to speak to Norway."

Even real estate has changed hands through negotiations conducted by overseas telephone. One such call effected the sale of large and valuable property in New York City. The American real estate broker called the owner of the property at his home in Dresden, Germany. Negotiations had been begun through other means of communication, but time pressed and quick action was necessary. The talk lasted a little more than five minutes and the property, including 12 stores, was disposed of.

A buyer for a large New York firm who has never been out of the United States is a frequent user of the service. Sometimes he talks to half a dozen countries in a single day, buying men's apparel in London, women's clothing in Paris, textiles in Berlin and other varieties of merchandise elsewhere, all the way from Stockholm to the Mediterranean. This man began his career in a small way through buying by telephone in San Francisco, Portland, Ore., and Western Canada.

Precious stones of considerable value have changed ownership after negotiations have been completed by telephone calls across the Atlantic. A New York jewelry firm found that a price increase in rough diamonds was to become effective in the London market almost immediately. With but a few hours leeway a telephone call to a London syndicate enabled the American firm to take advantage of an option at the old price.

Among some of the odd trades effected through the voice channels to Europe was the sale of a blue ribbon wirehaired fox terrier whose owner in Lancashire, England, telephoned to the prospective buyer in Worcester, Mass. A Philadelphia book collector successfully bid for a rare book at an auction in London without leaving his Quaker City office. A call to Europe from Tulsa, Okla., sold 3,000,000 gallons of gasoline. A motor boat company in Algonac, Mich., sold 100 boats valued at approximately $500,000 in London in a few minutes talk via the wire and radio voice link.

And thus is borne out Mr. Gifford's prophesy that "it will certainly facilitate business."

Professional

Professional men and women in all fields of endeavor have learned that telephone service to Europe can be used to good advantage. Doctors, lawyers, preachers, architects and representatives of other professions have held consultations, delivered opinions and obtained needed information by timely use of the wire and ether voice channels. Stars of the stage and the screen have turned to it on many occasions, or have been called up by admirers a matter of 6,000 miles distant.

An American traveling in France a year or so ago was suddenly taken ill. He put in a call to his physician, in New Orleans. When the latter answered the telephone, the patient described his symptoms. The doctor diagnosed the case and gave a verbal prescription.

Two years ago a law suit involving $1,000,000 was settled in part by a fifteen minute conversation between London and New York. The suit involved contracts made by the British fuel administrator during the war. The attorney for the American plaintiff in his call persuaded the defendant to pay approximately $225,000, and stated later that he expected to adjust the entire claim by telephone.

When Sir Joseph Duveen was being sued for saying that the painting "La Belle Ferronniere" was not an original Leonardo da Vinci, he required the evidence of an expert who had done some secret work for the Louvre. To obtain it, permission of the Louvre authorities had to be secured. Through a telephone call to Paris the situation was explained and the expert was permitted to testify.

"Personal" Messages

As far as can be judged from the newspaper reports that have been examined, there has been an almost equal ratio between conversations dealing with business or professional matters and those of a personal nature ever since transatlantic telephone service was inaugurated.

This is not surprising, for the urge to communicate with family or friends is especially strong when an ocean separates, and for convenience, reassurance and personal satisfaction there is no substitute for a telephone conversation. This is particularly the case in the holiday season, as the data for Christmas, 1931, show.

For the fifth year in succession, Christmas Day overseas traffic set a new record. A total of 342 messages, echoing Yuletide wishes, sped to or were received from Europe, Australia, South America, island groups in the Atlantic and Pacific, and ships at sea. This compares with a total of 207 messages for Christmas Day, 1930.

The conversations were as follows: Transatlantic, 182 (including five with Australia); South America, 51; Hawaii, 87; Bermuda, 20; ship-to-shore, 2.

There can be no doubt of the political, economic and social significance of an agency of intimate, personal communication between the old world and the new, between the two Americas, and with far away islands in tropic seas ready to answer a telephone call. Five years of overseas service have already indicated how the nations it serves are certain to rely on it, to an ever increasing extent; for the ability to transmit speech and the desire engendered by the flow of goods and people from one nation to another, act and react upon each other. Prophesy must pause in contemplation of the traffic of thought, the freight of ideas, that will cross the telephone bridge in the coming years. But no prophet is needed for those who have themselves thrilled to the magic of a telephone talk to a distant land, who have heard the answer to an eager question come back with the speed of light over thousands of miles of land and water. One illustration will suffice. It is the story of a Scandinavian in America who was moved to call by telephone his aged mother in Sweden. It was thirty years since he had left his Northland home to journey to America. His mother's parting "Good bye" were the last words he ever expected to hear her speak.

One day he heard of this wonderful telephone service which would enable him to talk all the way back to his boyhood home. He inquired about the charges and was astonished to learn they were well within reach of his pocket book. He promptly filed a call to Stockholm.

His call went through. Breathless with anticipation he waited for his mother's first words. When the trembling, well remembered voice answered across the 4500 miles circuit, his emotions overcame him. He shook with sobs, and for a few seconds was unable to control his voice sufficiently to speak. Quickly mastering himself, however, he went on with the conversation which meant so much to him that two days later he made a trip to the long distance office in New York City just to express his gratitude.

Occasionally those speaking over the overseas telephone channel are aware of a faint noise in the background of the conversation. Sometimes it is static. At other times—who knows?—it may be heart throbs.

K. T. Rood

Some Unusual Conduit Tunnels

IN the course of constructing the underground conduit systems which link together the various telephone communities of the country, it is necessary on occasion to resort to unusual measures in surmounting the natural and man-made obstacles that lie along the selected routes. Most commonly, the problem presents itself in the form of a river or railroad intersecting the line of the proposed conduit and over which there is no structure available for carrying the ducts. Several such undertakings have been completed in the past year or two, perhaps the most interesting of which, from its size, is the crossing constructed under the Harlem River in New York City.

As the usual means of crossing bodies of water in the past has been by submarine cables, it will perhaps be of some value before describing the construction of the Harlem River crossing to consider some of the limitations of the submarine cable.

In routes involving a relatively small number of cables, the steel-armored submarine cable serves adequately in effecting crossings of rivers, bays and similar water barriers. Many of these crossings are of such length that the economic advantages of the submarine cable in this respect favor its selection to the exclusion of any other plan. Ordinarily the cables are simply laid on the bottom. However, where there is likelihood of subsequent dredging operations, the cables may be given additional protection by depositing them in a trench prepared for this purpose. Usually no attempt is made to backfill the trench, this operation being left to the washing action of the water.

However, as the cables increase both in number and importance, the urgency of ensuring against all chance of service interruptions assumes added significance. Particularly is this true where the river traffic is heavy and the depth of channel is restricted. Such streams demand constant attention in order to keep the channel open. This requires the frequent services of dredges which, if they are for one moment handled incautiously when in the proximity of the submarine crossing, can inflict serious damage with their big dippers.

A further disadvantage of the submarine cable when installed in large groups is the difficulty of maintenance in the event of injury. Generally the cables are buried in mud and often become so entangled by the shifting currents that it would be next to impossible to isolate the ailing cable in order to make repairs. Such efforts, if successful, might take days, during which time the pairs included within the sheath, possibly among them important toll circuits, would be out of service.

The conduit of which the Harlem River crossing forms an essential part carries the main toll circuits from New York City to New England as well as a number of trunk circuits tying together various exchanges in the vicinity of New York. Consequently, security in the greatest practicable degree was the feature which demanded first consideration in the design of this crossing. Next in importance was the provision of sufficient flexibility to permit the ready replacement of any cable which might develop conductor trouble as the result of breakdowns within the sheath. With these salient points in mind the best solution seemed to lie in the construction of a tunnel in which ducts to accommodate the crossing cables could be installed.

To accomplish this, a trench was first dredged across the river bottom at a depth such that the topmost part of the structure would be 27 feet below the mean low water level of the river. This is two feet greater than the maximum depth required by the government regulations controlling the Harlem River. At this depth the conduit structure is safe from any possible injury during dredging operations. The trench-ing being completed, the balance of the work consisted in constructing a 614 foot pipe tunnel heavy enough and strong enough so that once the ducts were placed inside they would be protected from dragging anchors or similar hazards.

Timber piles were driven and capped to form supports spaced at 12 foot intervals along the trench. While this work was in progress, 12 foot lengths of 84 inch bell and spigot cast iron pipe, each weighing 10 tons, were being assembled and jointed on barges near the shore to form sections 72 feet long. This pipe of 7 foot inside diameter has a wall thickness of 1¾ inches and is reputed, incidentlly, to be the largest cast iron pipe of its class ever produced. A strongback in the form of a riveted steel truss was lowered to the top of a 72 foot section and bound to it with the aid of curved wooden saddles and wire rope cables. A floating derrick was used to pick up the entire unit and lower it into place upon curved cast iron saddles spiked to the cap of every alternate support. After directing the junction of each successive section, divers released the strongback and completed the calking of the leaded joints between sections.

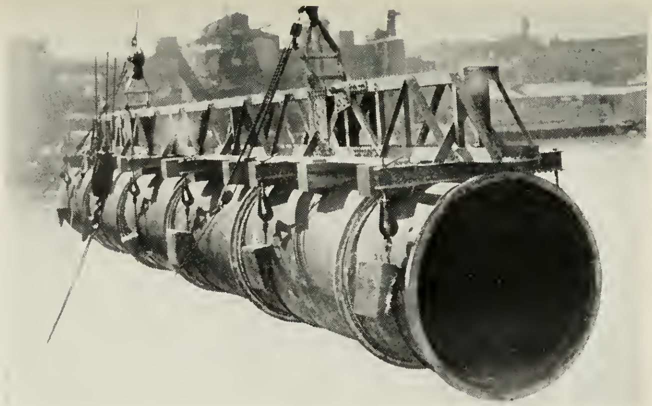
At a point roughly 75 feet out from each of the terminating manholes the pipe began to slope upward toward the manholes at the rate of 4.29 feet in 10 feet. To accomplish this change in grade four curved segments were prejoined by means of lugs and coupling rods and so braced from within that the complete unit could be handled much in the manner of the straight sections. This curve was designed to provide a radius consistent with that obtainable with the standard clay conduit normally used in constructing bends in conduit lines.

At intervals along the top of the pipe were placed precast saddles of concrete curved to fit the contour of the pipe. These saddles served to add stability and weight against the current of the river, but were intended primarily to act as bulkheads against which side forms for the pouring of concrete could be placed. The space between the forms was filled with concrete deposited through a tube under water to provide a thickness of 18 inches on the sides and 24 inches at both the top and bottom of the pipe.

After the pipe was pumped dry the tunnel underwent a period of inspection to check for settlement and possible development of leaks. Following this the conduit crews entered the pipe, constructed a narrow gauge track for the movement of materials and began the work of installing the multiple vitrified clay and wrought iron pipe conduits. The headroom in the tunnel was such that 3 foot lengths of clay conduit could be used in place of the 12 and 18 inch lengths usually employed in constructing crossings having a smaller diameter pipe.

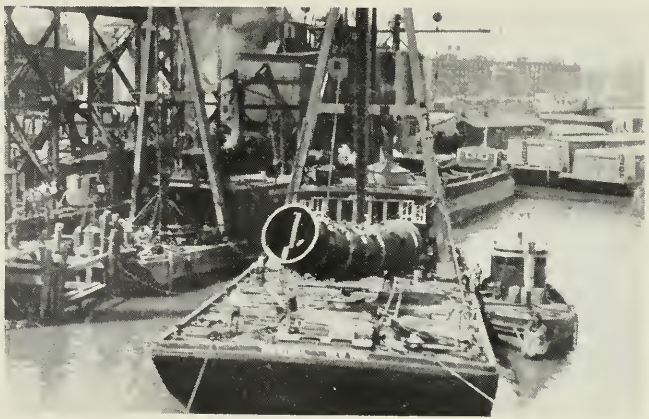
An undertaking of this nature being, of course, somewhat of a departure from the usual telephone construction, the normal procedure governing the decision as to the number of ducts to be installed as related to growth was subject to modification. Economic and practical limitations warranted a period of planning greatly in excess of that usually considered proper for the ordinary types of underground construction. This resulted in the installation of ducts sufficient to completely fill the pipe—206 ducts in all. In consideration of the depth at which the ducts are submerged in the river bed and under the protection of 1¾ inches of cast iron and from 18 to 24 inches of solid concrete, it is felt that these cables will be free from the hazards that ordinarily beset the submarine crossing.

In addition to waterways, conduit routes sometimes intersect man-made barriers that are almost as formidable as rivers, and which are best negotiated by tunneling operations. Contrasted with the water crossing and the handicaps invariably attendant upon marine construction, crossing under a railroad would appear such a commonplace undertaking as to be of but passing interest. On the contrary, however, the plan adopted in the recent construction of a crossing of this type developed into a project of more than ordinary interest as an innovation in telephone construction.

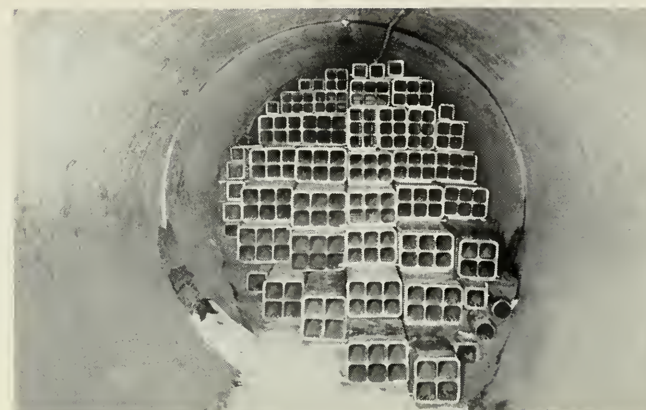


1. Close-up of Pipe—Method of Supporting Prejoined Sections for Harlem River Crossing.

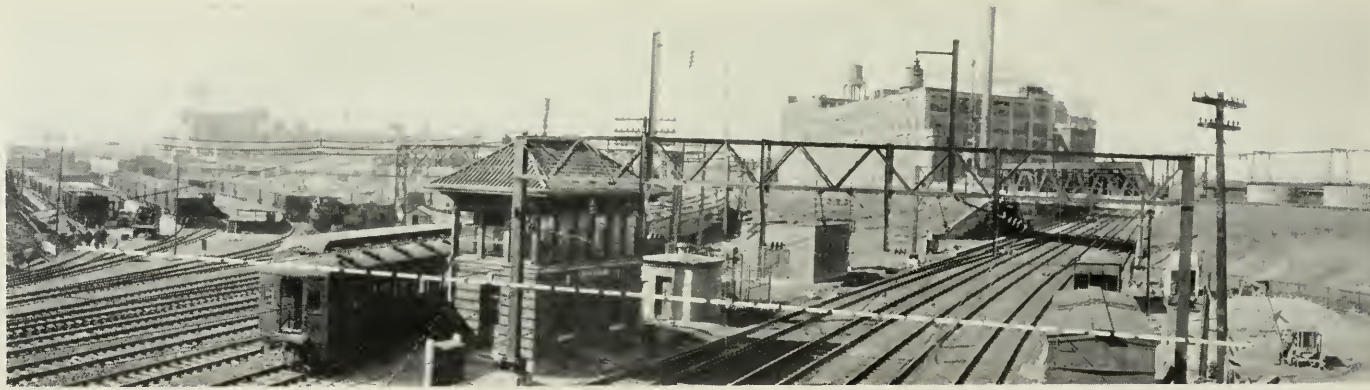
2. Lowering 72-foot Prejoined Section.



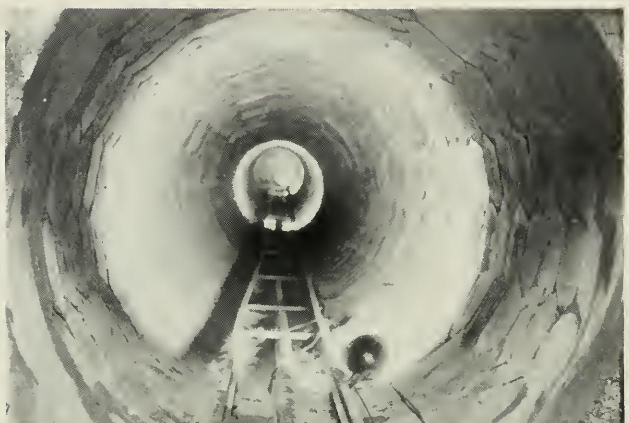
3. Curved Section used at Shore Approach.



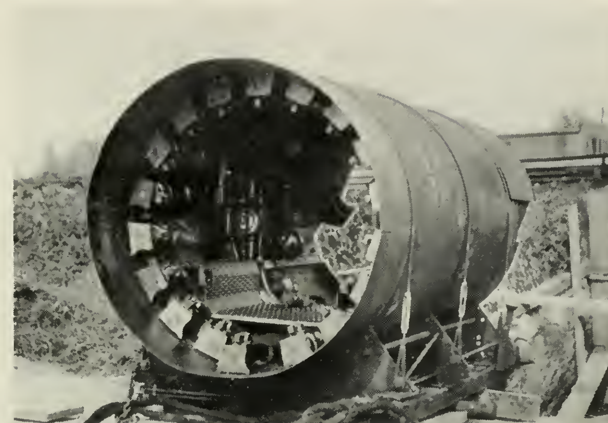
4. Duct Arrangement in 7-foot Pipe.



5. General View of Line of Tunnel under Railroad.



6. Interior View of Tunnel.



7. Rear View of Shield Showing Position of Jacks and Operating Mechanism.

Construction under railroads, while not involving all the difficulties presented by navigable streams nevertheless offers opportunities for the exercise of considerable ingenuity in making the job safer for the workman and more secure against untoward developments. Rights-of-way of narrow width may sometimes be traversed by means of jacking operations whereby individual pipe ducts are driven under the tracks without disturbing the track structure. Where greater width is involved, the uncertainty of control over the direction the pipe may take in passing through the soil precludes the use of the jacking method to any great extent. Obviously, to employ this method of jacking individual pipes would be impracticable where a large number of ducts is required for the crossing.

A variation of the above operation is seen in the method of jacking sections of larger diameter pipe and thereafter installing conduit to complete the crossing. This plan has been employed with considerable success in the construction of culverts and tunnels for mains under embankments. Since a workman is stationed at the front of the pipe to excavate the earth, it is possible with this method to exercise some control over the direction the pipe is taking, and thus much greater accuracy is obtained than when jacking small bore pipe. Without intermediate openings, however, this scheme is apparently impracticable for lengths much over 100 feet or for diameters over 42 inches. The enormous pressures required to overcome the additional earth friction encountered beyond these limits is more than the relatively thin pipe walls will stand without collapsing.

In view of the foregoing, until recently the recourse followed in carrying large numbers of ducts across wide rights-of-way has been by means of an open cut under the tracks. The cost of such work is high, involving as it does much heavy shoring, difficulty of disposing of spoil and the possible need of subsequent operations to correct for settlement. In addition, it is necessary for the railroad companies to reduce the speed of trains crossing the site and to keep watchmen continuously on duty during the operations.

Tunneling shields for the construction of subterranean passages are not new but with the development of a small bore device to be operated by an ordinary portable compressor came the first opportunity for the use of a tunneling shield in telephone work. Such a device was used in carrying 60 ducts of a conduit system under 15 tracks of a Reading Railroad yard in Philadelphia. This tunnel is 230 feet long and 4 feet inside diameter and is lined with hexagonal faced interlocking blocks of concrete 5 inches thick.

The shield employed in constructing the tunnel is cylindrical, 10 feet 5½ inches long and 4 feet 10 inches outside diameter. It is constructed of cast steel ¾ inch thick except for the tail, 14 inches long and ⅛ inch thick, in which the block lining of the tunnel is built up. Around the inside circumference of the shield is a series of 18 hydraulic jacks actuated indirectly by air pressure from a compressor above ground.

Eighteen blocks compose one complete ring of lining but because of their hexagonal shape nine alternate segments are always half a block ahead of the other nine. In operation one bank of nine jacks bears against these alternate blocks while the remaining nine jacks are retracted. In the spaces thus left are placed nine more blocks. As each block is placed one of the retracted jacks is brought to bear against it, holding it firmly in place. When all blocks in this ring have been set the high pressure oil is turned into the jacks and their action shoves the shield ahead half the width of a block or 4 inches.

As the jacking operation continues, earth is excavated at the front of the shield and is transferred to a conveyor belt. From the conveyor belt it falls into a car on narrow gauge tracks which carries it out to the opening of the tunnel. The same car is used to bring in another supply of blocks on its return trip. Getting the car out to the portal, dumping it and getting it back to the conveyor is the limiting factor in the construction, for the operation of the shield is practically continuous. Except when waiting for the car, the only time the shield stops moving is during the short interval when the blocks are being placed in the lining ring.

The tunnel is started by excavating a pit to the depth required by the proposed grade. The shield is lowered into place on a steel cradle resting on a concrete mat, the cradle being carefully set to line and grade. The first ring of blocks or starting ring is precast and set in place inside the tail of the machine. The jacking then progresses as described above. When the objective is reached the shield is excavated and the lining wall is completed with a ring similar to the starting ring. Conduit is then placed inside the tunnel to complete the crossing.

The advantages of this method of crossing a railroad are immediately apparent. Four of the tracks under which the tunnel passed are main line tracks over which express traffic is quite heavy, yet there was no break in schedules. Watchmen were not needed, for the men in the shield worked in perfect safety. Since the lining is erected within the tail of the shield where the skin thickness is but ⅛ inch, there is negligible loss of ground as the shield passes and no settlement of ground surfaces or structures. Furthermore, and this is by no means the least of the attractive features of this method, the cost was much less than would have been possible under the most favorable circumstances involving an open cut.

Stanley A. Haviland.

Opportunities for Women in the Bell System

FEW people realize the variety of occupations open to women in the telephone business. To be sure, telephone workers are found everywhere throughout the United States. In this country, one person in every hundred families, on the average, is engaged in some branch of the telephone industry. Despite this fact the public generally is still inclined to think of telephone employees as comprising two groups in the main: men who construct the lines and women who operate the switchboards.

An article on "Telephone Man Power" in the BELL TELEPHONE QUARTERLY for April, 1930, has already described some of the varied types of work done by the men and women of the Bell System. It is the purpose of the present article to indicate in rather more detail the opportunities open specifically to women in the telephone industry.

The first woman telephone operator, employed as an "experiment" two and a half years after the invention of the telephone, doubtless did not realize that she was opening a new and important vocational field to women. Within less than ten years after her entry, women had for the most part supplanted the original "boy operators" in practically every central office in the country. By 1890, when the total number of Bell telephone exchanges was slightly over 750 and the number of telephones had increased to 225,000, there were approximately 3000 women employed in what is now known as the Bell System to meet the growing demand for telephone service. Women were no longer an experiment in the industry; they had found a new and interesting occupational niche. The number entering grew larger year by year, until in 1902 the number of women equalled the number of men employed. Since that time the proportion of women in the Bell System has further increased until at present they comprise about 62 per cent of the total employee group of men and women.

The employment of women in the Bell System has increased at a considerably more rapid rate than the employment of women in the industries of the country as a whole. At present, the Bell System affords work for practically 3 per cent of the total gainfully employed female population, excluding those engaged in agriculture, and domestic and personal service.

Of greater interest than the large number of women employed, however, is the gradual increase in the variety of opportunities afforded them, at present, in practically all lines of Bell System work.

Early Opportunities

There was practically no choice of occupation within the telephone industry for the young woman who entered it fifty years ago. Nor was there a definite "next step" to take when she had mastered the intricacies of the switchboard and was able to meet in a satisfactory manner the demands of the subscribers. In most cases she remained an operator, deriving her chief satisfaction, according to the testimony of many of these pioneers, from the gratitude of the subscribers and a sense of her usefulness to the community. It was not until the beginning of the Twentieth Century, when the present central office organization and the systematic training of operators began to be general, that a perceptible broadening in opportunities for women occurred in the industry.

A summary of the early experiences of a group of 100 of the women who came into the telephone business between 1879 and 1900, shows that 91 began as operators, 4 combined operating with clerical work or bookkeeping, and 5 entered as clerks. Even as late as 1900, when the total number of women employed in the telephone industry in this country was 22,000, less than 10 per cent of these were to be found outside the operating force. Interesting opportunities for women outside the operator's job were, however, not entirely lacking in the early days of the industry. The gradual widening of the field of service for women which has characterized Bell System employment practices in more recent years was apparent even before the turn of the century.

In the late Eighties a few women were employed for straight clerical or bookkeeping duties wherever the growth of the business made this advisable. There were women cashiers, in 1899, in several Bell companies. At a somewhat later date, women were employed in the accounting department of other companies, and throughout the Bell System women were beginning to be responsible for the employment of operators and the handling of certain phases of commercial work. Despite these encouraging signs of progress, however, it is not until after the turn of the century that a definite and persistent trend toward broader opportunities for women can be observed. This significant increase in the kinds of opportunities for Bell System women doubtless was hastened by the creditable way in which these women pioneers adapted themselves to whatever responsibilities the day's work might include. It was stimulated by the rapid growth of the business itself, and made possible by a progressive management which recognized at a comparatively early date the importance of woman's contribution.

As a result of all these factors, the young woman entering the business today has a wide range of occupations from which to choose. Given the necessary qualifications and training, she has open to her, moreover, a definite line of progress leading eventually into a position of real responsibility, regardless of the avenue or department through which she may enter the business.

Present Opportunities for the Operator

Although women are contributing, today, to practically every phase of Bell System work, the operator's job is the avenue through which the majority enter the industry.

A recent study of the operator's job, its requirements and its future, has brought out some interesting facts. The high degree of tact and skill required of her have remained undiminished during the years that have elapsed since the first woman entered the business, but the outlook for the operator has changed completely. The young woman entering the business, today, not only has a wide variety of operating jobs open to her when she enters, she also has a definite line of progress ahead of her which may eventually take her up to the chief operator's job in the central office, or into something equally interesting, perhaps in another department of the company.

If she becomes a local operator, she may be either an "A" operator who answers the subscriber's signal, or a "B" operator who completes calls received from other offices. Or she may be assigned to special operating duties, such as information operator, sender-monitor operator, intercepting operator, varifying operator, trouble operator, or special service operator in a dial office.

Or perhaps this young woman, upon completion of the required training may become a toll or long distance operator. In the toll office she may be either an "inward" or an "outward" operator. Or she may be assigned to one of the special operating positions, such as information operator, rate and route operator, or ticket distributing operator.

Whether a young woman enters a toll or a local office, she usually has an opportunity to combine several classes of operating, thereby broadening her experience and increasing her chances of finding the work to which she is best adapted. In both toll and local offices there is ample opportunity for advancement, the normal line of progress in a typical central office being as follows: student, junior operator, operator, supervisor, evening or night chief operator, and chief operator. In the larger offices there are other steps which the young woman who hopes to become a chief operator some day may take. She may, for example, after acquiring the necessary background as a supervisor, become a central office instructor or an assistant chief operator. Or, after having demonstrated her leadership and interest in personnel matters, she may become personnel assistant to the chief operator with responsibility for recreational activities, health, and the general welfare of the operating force.

Employment and the Dial System

Occasionally one hears the fear expressed that the introduction of dial telephones is seriously threatening the future of the women already engaged in telephone work; also that it will limit the opportunities for women in the years ahead.

Such a view is contrary to the facts. The Bell System's dial conversion program, adopted because of the complexity of the operating conditions which have been brought about by the country's growth and by the public's service demands, is of necessity a long view program, formulated after a multitude of factors have been considered and integrated. This program calls for the introduction of the dial system for handling local calls in less than 1000 of the System's 6000 telephone exchanges, and this will not be accomplished for at least ten years.

Conversions to the dial system require a long period of technical preparation and this makes possible the carefully formulated technique of "personnel engineering" that distinguishes the Bell System as an employer. Thus, the operating forces in the large cities where the change from manual to dial operating is gradually being made, can be employed in the toll offices or in the remaining manual offices, and used to offset the normal turnover, as employees leave the service to marry or for other reasons. In some localities any need for additional operators prior to conversion to the dial system can be met largely by employing ex-employees and others who desire only temporary work and are taken on with that understanding.

When the program of conversion to the dial system is completed ten years from now, there will actually be more operators with the telephone companies than at present. Some will be employed at the many manual switchboards that will be retained in places where the dial system is not to be installed. Others will operate the toll and long distance boards. Some will be information operators. A large number will always be needed to supplement the dial service by helping persons who have trouble in dialing, by handling calls to nearby points, especially around large cities, and by rendering general assistance to telephone users.

So far as future requirements for operators are concerned, the present viewpoint would indicate that the trend in the number of operators required will equal, if not exceed, the trend in the growth of population.

Opportunities at Private Switchboards

In addition to the varied opportunities in the central offices of the telephone companies, there is an allied field of occupation that is far larger than is generally realized—the operation of private switchboards on the premises of business concerns. Opportunities in this field for trained telephone operators have multiplied at a rapid rate during the past few years, particularly in the larger cities where the communication needs of business are constant and varied. New York City alone has 35,000 of these "private branch exchanges," and it is estimated that in the United States there are about 145,000 young women employed to operate the private switchboards of telephone subscribers. The high degree of technical skill required today and the important nature of the business served by many private switchboards make this work of unusual interest to the young woman who has acquired telephone operating experience.

The Broadening of the Field for Women

There has been much the same gradual broadening of opportunity for women in all other phases of Bell System work that has been observed in connection with central office employment, particularly during the past ten or fifteen years. The growth of the business has opened up additional opportunities in the older types of telephone work. At the same time the increasing scope of telephone activity has opened up new opportunities for women as well as for men.

The Traffic Department

In the Traffic Departments of the telephone companies this broadening of the field for women occurred first in the actual work of giving telephone service. The women who were first made chief operators demonstrated, at an early date, their ability to handle in a satisfactory manner the many complex service and human problems the new position entailed and, thus, paved the way for women to occupy positions of responsibility in this and all other lines of telephone work.

The next broadening of the field for women developed in connection with the employing and training of operators. From the beginning, women were eminently successful in these lines of work, and, today, the young woman who has the necessary experience and training may find in the company's employment department such opportunities as, interviewer, application supervisor, and, eventually, employment supervisor.

In the work of training operators, a woman may become, in turn, instructor, assistant training supervisor, and training supervisor.

Opportunities for women in the Traffic Department developed next in personnel work. Matrons and personnel workers were installed at a fairly early date in many rest rooms to look after the comfort and well-being of the operators. They also gave the necessary supervision to the off-duty activities of the operators which were usually of a social nature.

In more recent years there has come a marked increase in women's responsibility for practically every phase of personnel work. On district, division, and general staffs, women are, at present, supervising the health and nutrition courses and guiding the social and recreational activities of operating and clerical forces. They are also participating widely in the administration of the benefit plan, employee representation, the thrift program, and other important personnel work.

There has been a similar broadening of opportunity for women in the Traffic Department in connection with the planning and supervision of operators' quarters and of company dining service. In this field several women are finding interesting work as assistant to the traffic employment supervisor in connection with the furnishing and decorating of company sitting rooms, and as supervisor of dining service on district and division staffs.

A somewhat newer field for women than any of those previously mentioned is that of traffic engineering. In a few of the Bell telephone companies, women are working as engineering assistants on such matters as force adjustment, trunk order work, and the preparation of tandem trunk estimates. Women are assisting, too, in the preparation of dial equipment traffic orders and the making of special dial traffic studies.

As private branch exchange instructors and supervisors, women are responsible for instructing operators and maintaining helpful relations with private branch exchange subscribers. In some cities a woman is responsible for training and directing those who give the actual supervision to this important feature of telephone service.

The Commercial Department

Progress of women in the Commercial Department of operating companies has been largely from routine clerical and stenographic work, or jobs as cashiers and tellers—which women held at a fairly early date—to such important positions as chief clerk, office manager, observer, instructor, directory production supervisor, commercial representative and, even, in some cases, commercial manager in charge of an entire office or group of offices.

In such positions as these, women not only have large responsibilities in directing the routine work of the office and handling the usual business transactions, but they are playing an important part in promoting good public relations and customer good will and co-operation. One of the most recent of these positions for women is that of commercial representative which women are filling in several of the telephone companies. In this capacity they are interpreting service matters to the public by telephone and through personal contact. These commercial representatives are opening up a new field of opportunity for women which promises to become increasingly important as time goes on.

The Accounting and Financial Departments

There has been a noticeable increase in openings for women in the Accounting Department of the operating companies during the past decade. A tendency may be observed in many of the companies to appoint women to staff positions of importance when they have demonstrated their aptitude for the tasks to which they were first assigned in the department. Some of the newer positions which women are holding in the Accounting Department are: librarian, secretary-staff assistant, statistical assistant, and results clerk.

Women have been employed over a considerable period of time in Financial Departments of operating companies where the growth in business and the consequent multiplication of jobs of a clerical nature have given employment to increasingly large numbers of women. Here, the paymaster's office, the stock bureau, and the bank records and bond divisions, each has its force of women clerks, stenographers, and supervisors.

In more recent years, women in this department have filled such responsible positions as assistant paymaster, supervisor of preferred stock accounts, supervisor of Bell Telephone Securities Company Accounts, and assistant to the transfer clerk. In one of the companies, a woman has recently risen to the position of general cashier with responsibility for pay rolls, stock transfers, bank correspondence, cash estimates, and similar important matters.

The Engineering Department

Positions for women in the Engineering Department of operating companies, like those in most other departments, developed first along routine clerical and stenographic lines. In more recent years, however, a few women have found employment as engineering assistants. It is easy to understand why engineering jobs for women have been late in developing, for most of the work to which women would be assigned as engineering assistants requires formal technical training in addition to a telephone background. The interesting beginning that has been made by women in a few of the companies indicates, however, that there is a limited number of opportunities along this line for those who have the required bent and training.

The Plant Department

Women are employed in the Plant Department of all operating companies though, generally, in smaller numbers and less varied tasks than in most of the other departments. Their work here consists, for the most part, of clerical and stenographic duties, though some opportunity exists for promotion to the position of chief clerk in district, division, or general offices.

Perhaps the most interesting job for women in this department is that of repair clerk to whom customers report, by telephone, service troubles requiring the attention of the line and station maintenance forces.

Women are also employed as assignment clerks in this department, and the efficiency with which this phase of plant work is carried out has an important cost and service bearing on plant engineering, and construction and installation jobs.

Other Positions

This brief description of what women are doing in Bell System operating companies does not include many important jobs which individuals have been able to develop from relatively small beginnings with the encouragement of their supervisors. Such positions are found in several departments and in practically all companies. In some cases women have attained positions which enable them to make their influence felt along personnel lines in all departments of their respective companies. One of these women, for example, is assistant benefit secretary in her company; another is general supervisor of the health course and related activities, while a third has recently been made assistant to the personnel vice president. There is a woman public relations representative in one company, a supervisor of educational activities in another, and the position of office manager is held by women in several cases.

Nor does this summary attempt to point out the importance of the work of women secretaries in the Bell System, or the contribution of women librarians, many of whom are combining important research with the administration of general or departmental libraries.

Women are finding interesting opportunities, also, on company magazine staffs as associate editors, feature writers, and staff artists. In addition, women physicians and nurses are found in most Bell System companies.

Such opportunities as these, while interesting and encouraging, are not generally open to the average young woman entering the business as an operator. For practically all of the openings previously mentioned, however, operating experience is desirable preparation, if not an actual requirement.

The Western Electric Company

In the Western Electric Company which manufactures telephone equipment for the Bell System, the employment of women dates back to the earliest days of the business. A few women entered this new type of factory work soon after its inauguration and were assigned to such relatively simple tasks as winding coils, braiding cords, insulating magnet wire, and inspecting and assembling apparatus. The skill and aptitude of these pioneers soon made a permanent place for women in this branch of the industry. Shortly thereafter, many women were trained in the use of the micrometer, the Wheatstone bridge, and the slide rule, and assigned to operations requiring a higher degree of skill and proficiency.

The growth of the business also created opportunities for large numbers of women along stenographic and clerical lines, and the number thus employed steadily increased.

With the development of the business and the adoption of new machinery, new processes, and improved safety measures, has come the same gradual broadening of opportunity for women in this organization which has been observed in other parts of the Bell System. Some of these women who entered in routine clerical or factory work were, as a result of their increased proficiency and broader knowledge of the job, placed in charge of groups and sections where large numbers of women were employed. Others were fitted into jobs requiring ability along certain definite lines.

In the Western Electric Company there are, at the present time, women chemists who analyze various materials and chemicals used in the manufacture of the company's products; women engaged in important research along various lines; women heads of training departments; women accountants, draftswomen, physicians, nurses, and dietitians. The current trend seems to be toward even greater diversification of opportunities for women in this important unit of the Bell System.

The Bell Telephone Laboratories

In the Bell Telephone Laboratories there is a relatively large number of women engaged in stenographic and general clerical work and in the operation of various office appliances. Women in this organization are also distributed among a wide variety of less traditional occupations. Some are draftswomen; others are members of technical staffs where some are mathematicians and others librarians; while still others are supervisors, shop mechanics, or technical assistants to engineers and scientists.

One woman in this organization, who entered as a stenographer a few years ago, recently qualified as a practicing patent attorney and is now assistant general patent attorney for the company. Another, also entering as a stenographer, is working side by side with one of the company's foremost scientists in the making of studies which are of paramount importance to the industry.

The American Telephone and Telegraph Company

No survey of woman's contribution to Bell System achievements is complete without reference to the work that women are doing in the General Departments of the American Telephone and Telegraph Company at 195 Broadway, New York City. Here women comprise nearly 50 per cent of the total Headquarters group, and their responsibilities range from those of messenger and junior clerk to supervisor of an entire division, secretary or staff assistant to an official, statistician, or engineer.

The department employing the largest number of women at Headquarters is the Operation and Engineering Department with 375 women workers. Next, in the number of women employed, come the Treasury Department with 224, the Development and Research Department with 193, and the Comptroller's Department which has 150 women employees. The Benefit and Medical Department, the General Service, the

Legal and other departments, although smaller afford opportunities equally varied and interesting.

Many of the positions open to women at Headquarters are of a routine clerical and stenographic type, as is the case in any large organization. There is, however, a variety of important supervisory positions held by women in connection with such work which calls for initiative and entails considerable responsibility. Some of the women in those positions are chief clerks and cashiers who supervise large forces of clerical workers, handle payrolls and expense accounting, and direct messenger service. Others supervise stenographic, mail, and file bureaus with large forces to be directed. Still others have charge of the various department records and accounts. One of these women, for example, has complete responsibility for the work of the transcription room in one of the larger departments where her duties include employing and training new employees and supervising a large stenographic force. Other women, as floor clerks, direct the messenger force, handle personal checks and vouchers, arrange for conferences, compile various reports, and supervise the ordering and up-keep of office supplies and equipment.

The personnel and general service requirements of the twelve hundred women employed at Headquarters constitute another field in which women play an important rôle. In her capacity as supervisor of recreation, one woman is responsible for directing the recreational activities, cultural and athletic, of women at Headquarters. Another supervises personnel and administrative matters of the company medical office, where other women, as doctors and nurses, help to look after the general health of employees.

In the Treasury Department of the company, where the regular work requires the employment of a large force of clerical workers, a woman personnel representative is responsible for the employment and counseling of the women workers in the department and for the compilation of special personnel studies.

Much of the work done by women in certain departments of the American Telephone and Telegraph Company requires special ability and training as, for instance, that done by draftswomen and computers who work out engineering formulas, and that done by women accountants and statisticians. In such capacities as these, the responsibilities carried by women range from those of drafting room clerk to the supervisor of graphics; from individual computer to the supervisor in charge of groups of computers and special studies; and from clerical assistants in the Comptroller's and the Treasury Departments to junior and assistant statisticians.

Equally interesting and highly specialized is the work of the fifty-two women in the Headquarters organization engaged in engineering duties, some of whom have the title of engineer. Some of the women in this group conduct studies for the improvement of operating methods, devise such methods, supervise their trial and judge their worth. Another plans many types of studies of an analytical nature relating to message use and the effect of rate changes on revenues, develops rate schedules to meet specific situations, and prepares studies on rate theory.

In the field of theoretical engineering women are likewise making substantial contributions. One of these is engaged in the analysis of earth currents and their relation to radio transmission. Another solves special problems, individually assigned, or works in collaboration with other engineers on such problems as wave propagation and phase distortion. Both of these women have contributed articles to the Bell System Technical Journal, and one of them holds three patents.

There are many other interesting opportunities for women in this organization, in research, in supervision of special activities such as the health and nutrition courses, and in other special services, many of which are System-wide in their influence, but the examples previously given will serve to show that, at Headquarters, as in the field, women are participating widely in practically every phase of Bell System work.

This general survey of woman's part in Bell System work illustrates, to some extent, how the horizon of the telephone industry is widening, year by year, and how the field of service open to the woman telephone employee is widening with it.

The importance of the contribution which women have made to the development of the telephone industry can never be truly estimated. Suffice it to say that from the earliest days of the business until the present time, women have played a vital part in making possible an indispensable public service, and in so doing, have found the satisfaction which comes from participation in a worthwhile enterprise.

Laura M. Smith

Changes in the Composition of the American Population

IT is obvious that all classes of people are not equally important as present and prospective users of telephone service. For instance, children can be almost entirely eliminated from consideration as telephone subscribers; native whites constitute a better market than negroes or the foreign born, while social and economic differences also have an important bearing upon telephone usage. Thus, the composition and characteristics of the population are of more interest to the telephone industry than mere numbers. Returns of the Federal Census of 1930, when compared with those of the 1920 Census, indicate that during the last decade many significant changes have been taking place in the composition of the population, among which the outstanding features were the general tendency towards decidedly smaller families, the aging of the population, the movement from farms to cities, the restriction of foreign immigration, the improved standards of living, and more widespread education.

Before proceeding to an analysis of the census material now available regarding the composition of the population, it seems pertinent to consider briefly one phase of the recorded increase in numbers during the past ten-year period. (It might be noted at this point that various aspects of the numerical growth in population between 1920 and 1930 have already been discussed in this QUARTERLY, in the issues of October, 1930 and April, 1931.) Between 1920 and 1930, a gain of 17,000,000 was reported for the population of the United States, whereas under the most favorable interpretation of the available vital statistics there was an excess of births over deaths of only 11,000,000 and net immigration, based on official figures, amounted to only about 2,700,000, with the possibility that this figure might be increased to 3,000,000 if allowance be made for illegal entrants. Thus, at least 3,000,000 of the growth remains unexplained.

The portion of the reported increase in population from 1920 to 1930 which is unaccounted for by either natural increase or immigration can probably be most logically explained by the greater thoroughness of the recent enumeration as compared with the 1920 census. This view was expressed in an earlier discussion of census returns[1] in which the following statement appeared:

"A variety of factors indicate that the 1930 census may have been taken with greater efficiency than those of 1920, 1910, and 1900, all of which were apparently made on about the same basis. . . . Although no definite correction of any excess of the reported decade increase over actual growth can be made until the detailed tables on age, sex, and nativity are available, it is probable that the elimination of the excess would reduce the average annual increase to about the same level as was experienced between 1910 and 1920."

This detailed information is now available and its analysis offers evidence that the increased efficiency of the 1930 census resulted in an excess in the reported population increase over actual growth ranging from at least 2,300,000 up to a possible maximum of 5,400,000, with the most probable figure lying somewhere between 3,000,000 and 4,000,000.

Age statistics, by sex and nativity, indicate important discrepancies between comparable groups in 1920 and 1930. For instance, there were more native white females of native parentage in each five-year age group between 10 and 24 in 1930 than there were in the corresponding groups from 0 to 14 in 1920. Since there could have been no accretions to this class through immigration, this inconsistency implies either a negative death rate or a difference in the degree of efficiency with which the two census counts were taken. This evidence of greater efficiency in 1930 is especially convincing since similar

[1] Bell Telephone Quarterly, October, 1930, page 275.

inconsistencies occur too frequently among both whites and colored, male and female, to be accounted for by misstatements of ages on the part of those enumerated. In fact, when adequate allowance is made for deaths, this type of discrepancy between the 1920 and 1930 enumerations appears in almost every age group in all nativity classes.

No exact mortality rates are available for the entire unselected age groups and classes of population, but if the death rates given in the United States Life Tables for the original registration area of 1910 are applied to the 1920 population, the apparent excess of the recorded population increase over the actual growth during the decade 1920–1930 would amount to about 5,400,000. Even if all the people experienced the same improvement in mortality as did the policyholders of the Metropolitan Life Insurance Company between 1910 and 1925, which seems very unlikely, this figure would be at least 2,300,000. A consideration of all the available evidence indicates that the probable difference between the two census counts, due to the better enumeration in 1930, amounts to about 3,500,000, which may be distributed among the principal nativity groups according to the following rough figures: 2,000,000 to 2,200,000 native whites, 800,000 to 900,000 negroes, and the balance in the foreign born, and colored classes other than negroes.

The assumption of the approximate figure of 3,500,000 as the measure of the superiority of the 1930 enumeration leaves 13,500,000 as the true population growth in the United States between 1920 and 1930, a figure which not only is entirely consistent with the detailed statistical data, but also is in closer accord with the marked decline in the rate of natural increase which has been characteristic of the past decade.

Age Composition

This retardation of the rate of growth, perhaps the most significant recent trend in respect of population, has been due, in large measure, to a declining birth rate; but it may also have been influenced by the aging of the population. This latter development has tended to offset the effect upon population numbers of the improvement in mortality experience resulting from modern sanitation and advancing medical science.

Comparative age group data for 1930 and 1920 indicate that the average age of the population is increasing and suggest the probability of a further decline in the rate of natural increase as the proportion of the total population now in the age groups favorable to high birth rates and low death rates becomes less and less. This change will not only reduce the overall birth rate in the future, but will also increase the overall death rate; for as the average age advances there will be proportionately more people in the age groups where death rates are high than is now the case.

PERCENTAGE DISTRIBUTION OF POPULATION IN THE UNITED STATES, BY AGE, COLOR, AND NATIVITY, 1930 AND 1920

Age Group	All Classes		Native White		Foreign Born White		Negro	
	1930	1920	1930	1920	1930	1920	1930	1920
Under 5......	9.3	10.9	10.4	12.7	0.2	0.3	10.3	10.9
5–14........	20.1	20.9	22.3	23.3	2.0	3.6	22.0	23.9
15–24........	18.3	17.7	19.4	18.6	7.4	10.7	20.6	20.5
25–34........	15.4	16.2	15.1	15.2	16.9	22.6	16.3	15.4
35–44........	14.0	13.4	12.6	11.8	24.9	23.1	13.3	12.7
45–54........	10.6	9.9	9.3	8.7	21.6	18.0	9.6	9.1
55–64.......	6.8	6.2	6.1	5.5	14.5	11.8	4.6	4.1
65–74........	3.8	3.3	3.4	2.9	8.8	6.6	2.2	2.2
75 and over...	1.7	1.5	1.4	1.3	3.7	3.3	1.1	1.2
Total....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The tendency of the past decade toward lower birth rates has decreased the proportion of children in the total population so rapidly that there were actually 130,000 fewer children under 5 years of age in 1930 than there were 10 years previously; children in the 0 to 9 age group comprised 19.6 per cent of the total population in 1930, as contrasted with 21.7 per cent in 1920. The reduction in the number of births is further emphasized by the drop in the number of children under 5 years old per 1,000 women aged 15 to 44 from 468 in 1920 to 392 in 1930, or per 1,000 married women from 543 to 438.

While the number of young children is declining, the number of aged people is increasing. There are now more than 6,700,000 persons in the country who have reached or passed the age of 65, and they constitute 5.4 per cent of the population, as contrasted with 4.7 per cent in 1920. These figures suggest why problems connected with old age are becoming more important. Moreover, it appears probable that this tendency toward an increase of older and a decrease of younger persons will become more pronounced with each passing decade. This prospect is regarded by some people as indicating that the rate of growth of the American population will rapidly decline to a very low level.

Racial Composition

The population of the country not only is tending towards stabilization in numbers, but also is becoming more homogeneous in character. The latest census recorded an increase of 14,600,000 native born whites during the decade; while the foreign born whites gained only 100,000, and now constitute 12 per cent of the total white population instead of 14 per cent as in 1920. The percentage of negroes has also declined, from 9.9 per cent to 9.7 per cent.

Although negroes declined in proportion to the total population, they had a recorded numerical increase of over 1,400,000 between 1920 and 1930. Two-thirds of this gain took place in the North, while the South failed even to hold its natural increase, indicating clearly the effect of continued migration of negroes from the South to other parts of the country. In fact, four southern states—Georgia, Kentucky, South Carolina, and

Virginia—showed a net loss in negro population. If, as indicated elsewhere in this article, the actual negro gain in numbers was considerably less than the apparent increase, particularly in southern territory, it is possible that the entire growth took place in northern states.

The foreign born element in the total population is declining in importance from two causes. On the one hand, the immigration laws enacted during the past decade strictly limit the number of aliens to be admitted into the country each year and also, by means of the "national origin" plan of distributing the total quota, favor those countries whose nationals are most readily assimilated into our population. On the other hand, the majority of our alien population migrated to America 20 to 30 years ago, and the aging of this group is causing a rise in its total death rate and, concurrently, is mainly responsible for a decline in the number of births. The 1930 census shows 1,400,000 fewer children under 10 years of age of foreign or mixed parentage than did the 1920 census. It is probable that the 1920–1930 decade will be the last to show a gain in the number of foreign born whites in this country, and that education and intermarriage with the native born will tend to lessen further their importance as a more or less distinctive group in our population.

Educational Composition

There was an increase in school attendance of nearly 5,500,000 during the past decade; and the percentage of children in school rose from 64.3 to 69.9. While this improvement in school attendance was general for children of all ages from 5 to 20 and in each nativity class, being especially marked among the foreign born, it was most pronounced among those attending secondary schools and colleges. The increasing tendency toward higher education is also indicated by the fact that in 1930 more than 1,000,000 persons 21 years and over were seeking advanced training, which was three times the corresponding number in 1920. This increased school attendance has undoubtedly contributed appreciably to the improvement in literacy.

The number of illiterates in the population 10 years of age and over in 1930 was nearly 4,300,000, or 4.3 per cent as compared with 6.0 per cent in 1920. The bulk of these illiterates were among the foreign born whites (1,300,000, or 9.9 per cent of their total), negroes (1,500,000, or 16.3 per cent) and other colored races (360,000, or 25 per cent). In the North and West, the percentage of illiteracy was 2.7, and in the South, 8.2. In general, illiteracy was lower in urban territory than in rural, especially among negroes; while in rural areas it was greater in the farm than in the non-farm population.

The total number of illiterates in the United States was 650,000 lower in 1930 than in 1920. During the decade, however, deaths among those who were illiterate in 1920 amounted to about 1,000,000 and the illiterates 10 to 19 years of age were 160,000 less numerous in 1930 than in 1920, resulting in a total shrinkage from these causes which was over 500,000 greater than the overall reduction reflected by the census. Moreover, these figures take no account of the improvement in literacy which must have occurred in view of the more general education of all classes during the past decade; on the contrary, they even seem to indicate that a considerable number of people forgot how to read and write between 1920 and 1930. Such an interpretation is, of course, unreasonable. It is more likely that the discrepancy of 500,000 is additional evidence of the greater efficiency of the 1930 enumeration and that the 1920 count would have shown a correspondingly greater number of illiterates had it been taken with the same degree of completeness as that of 1930. This presumption derives additional support from the report of the U. S. Bureau of Education showing that considerable progress has been made in industrial and commercial training and that increased attention has been devoted to adult education.

Further indication of a better count in 1930 is found in the fact that, although every state in the Union showed less illiteracy in 1930 than in 1920, certain areas within states appeared to increase in illiteracy. There were more than 500 counties, or 17 per cent of the total number, in which the reported percentage of illiteracy seemed to have gained; and over 300 counties in which the reported proportion of illiterate negroes was higher in 1930 than at the time of the previous census. Since in most of these counties the total population growth was insufficient to indicate any inward migration and since the proportion of illiterates would normally have been reduced through the effect of literate children passing their tenth birthday combined with deaths among the adult illiterates, it is most probable that many of these counties which apparently lost ground in their degree of literacy actually represent areas where the efficiency of the recent census was particularly effective. Supplementary evidence from other sources indicates that the superiority of the 1930 enumeration was most marked in southern rural territory and in the larger northern cities.

Rural and Urban Composition

Probably no factors have a more pronounced influence upon the characteristics and rate of growth of the population than do those arising out of the comparative degree of rural and urban living. In general, country life is much more favorable to a high rate of natural increase than is residence in cities. On the one hand, rural birth rates are higher. According to the 1930 census, the number of children under 5 years old per 1,000 married women in the United States was 370 in urban territory and 530 in rural areas (both these ratios are lower than the corresponding figures in 1920 by 100); furthermore, the rural ratio, when sub-divided, shows 492 for the rural nonfarm and 565 for the farm population. On the other hand, life tables giving rates of survivorship by sexes among the urban and rural population show decidedly lower mortality rates in the country than in the cities.

The past ten years have been characterized by a great increase in the proportion of the population living in the cities. Numerically, the urban dwellers increased by 14,600,000 and now form 56 per cent of the total population, while the rural population gained 2,400,000. Although the farm population of the country decreased by 1,200,000, or nearly 4 per cent, in the last decade, the number of non-farm rural dwellers increased by 3,600,000, or 18 per cent. This latter number evidently includes not only the growing body of city workers who prefer to reside in the country, but also many farm laborers who want the advantages of more desirable living conditions in nearby small towns.

Of the 8,500,000 persons reported as "gainfully employed" in 1930 who reside in non-farm rural territory, about 2,500,000 are engaged in manufacturing and mechanical industries, primarily urban occupations, while 900,000 are connected with agriculture. On the other hand, 1,500,000 of the 10,600,000 workers living on farms are engaged in activities other than agriculture. The phenomenon of several million workers living in rural territory some distance from their regular occupations (in addition there are 450,000 engaged in agriculture who reside in urban communities) emphasizes the influence of the automobile and good roads in facilitating travel and in making possible the greater mobility and flexibility in the distribution of population.

In general, the migration from farms to cities has been due in part to reduced labor requirements in agriculture and in part to the opportunities for improved economic status. This type of movement now constitutes the principal portion of all internal migration and it may be expected to continue in appreciable volume as agricultural efficiency improves further and foreign immigration remains at a low level.

Occupational Composition

The occupational make-up of the population very markedly affects the number of children born, as birth rates vary greatly between different occupations. Farmers and miners have larger families than workers engaged in sedentary activities, while between these extremes are the handworkers in industry and commerce. In general, it may be stated that the wives of manual laborers have more children than do those of the white collar workers and that economic success appears to be unfavorable to the raising of large or even fair-sized families. In view of these basic conditions, the census returns show certain changes during the decade in the increase and distribution of workers by industries which appear strikingly significant.

The 1930 census showed a total of nearly 49,000,000 persons over 10 years old who are normally gainfully employed, as compared with less than 42,000,000 in 1920. A complete breakdown of all these workers into groups comparable with 1920 data is not possible at present, since the available classification is by industry groups rather than according to occupations. However, comparable figures are available for the largest two industrial groups; they show that the number of workers in each group declined between 1920 and 1930: in agriculture by nearly 500,000, or 4.3 per cent, and in manufacturing by about 200,000, or 2.1 per cent. A greatly increased efficiency in farming operations has been effected by the wide introduction of more scientific farm practices and the widespread use of motor-driven machinery, with the result that fewer workers have been able to produce all the required supply of agricultural commodities. Similarly, a reduction in the number of wage earners engaged in manufacturing has resulted from technological improvements in industry. And, as further developments are realized in labor-saving appliances, there will doubtless be additional declines in the number of workers required in these broad fields.

The greater productivity of machine labor has brought about an increase in wages and a higher standard of living. The general improvement in living conditions is reflected in the much larger number of workers engaged in the service industries. Women workers in particular in these activities have gained in number; over 3,000,000 of them are employed in domestic and personal service, while nearly 1,800,000 are engaged in activities classified as professional service, exceeding the number of men in the professional classes by 100,000. In fact, the increased importance of women in industry in general is worthy of special attention.

Among the 49,000,000 gainfully occupied workers enumerated in the 1930 census, nearly 11,000,000 were women. This number represents an increase of 2,200,000, or 26 per cent, over the previous census, whereas male workers increased by only 15 per cent. The significance of these figures becomes apparent when it is noted that the increase in women workers during the preceding decade from 1910 to 1920, when women took the places of many thousands of men withdrawn from industry, was only 6 per cent, as compared with 10 per cent for males. Thus, female workers not only increased between 1920 and 1930 more rapidly than during any like period, but they increased more rapidly than male workers. This is significant as indicating the status women are assuming in our occupational life.

The decline since 1920 in the actual percentage of males 10 years old and over who were reported as gainfully occupied is due only in very small part to a change in the age composition of the working population. In fact, it can be almost entirely explained by the increased school attendance and by more general and earlier retirement from active work.

Size of Family

The combined and cumulative effect of the several foregoing changes in the composition of the population tending to reduce the rate of natural increase has been reflected to a marked degree in the average size of family and consequently in the number of families. There were nearly 30,000,000 families in the United States on April 1, 1930, an increase since the 1920 census of about 5,600,000, or 23 per cent. Thus, the number of families grew more rapidly than the population, due to the decline in average size of the individual family from 4.341 persons in 1920 to 4.095 in 1930, the equivalent of about one-quarter of a person per family.

Among other things, the family figures indicate a return during the decade to living conditions more normal than those of the beginning of 1920. Since that date, there has been an appreciable increase in families, and a consequent reduction in the average size, through the spreading out into separate living quarters of families who had been forced to double up with others during the housing shortage prevalent in the early part of the decade. The building boom of the mid-decade years relieved that congestion and permitted a distribution of families to normal living accommodations (a condition existing at the date of the census in April, 1930).

More important factors in causing the decline in the size of family, however, have been the rapid urbanization of the population, which has brought a large part of the people into the cities, and the curtailment in the average number of children per family, which is one of the most striking tendencies in American life. As the standard of living has been raised, there has been the apparently axiomatic decrease in the size of the family. When it is noted that the number of adults per family only dropped from 2.57 in 1920 to 2.51 in 1930, while the number of children per family declined from 1.77 to 1.59 during this period, it is evident that the reduction in birth rates was largely responsible for the smaller sized family.

Conclusion

From a market standpoint, the most significant conclusion to be drawn from a study of the recent changes in the composition of the American population and the current trends of growth is that, in the future, the number of consumers will increase with considerably less rapidity than in the past. At the same time, the characteristics and the requirements of the consuming market will change, for, due to the lower birth rate, the relative number of young people is decreasing and that of old people is increasing. In short, in view of the influence of such tendencies as those discussed above, it is indisputable that the characteristics of the American consuming market is in process of profound modification in many directions.

R. L. Tomblen

Eighth Plenary Meeting of the International Advisory Committee on Long Distance Telephony

THE year 1931 has probably seen the establishment of an unprecedentedly large number of new "lows" in the field of industrial activity. All the more interest therefore attaches to the fact that during this period the telephone business of Europe has grown in certain respects. This is particularly true of Anglo-European toll business. The following table compares the toll calls between England and France and England and Germany for the first three-quarters of 1931 with the corresponding intervals for 1930. The values for 1930 were greater in turn than those for 1929.

1930	*Anglo-French Paid Minutes*	*Anglo-German Paid Minutes*
1st Quarter	590562	343089
2d "	625883	330709
3d "	552192	321919
1931		
1st Quarter	625722	329769
2d "	667709	345657
3d "	672820	393313

Such figures indicate very clearly the increased popularity of international telephony in Europe and this growth in popularity is, of course, in large measure the result of a steadily improving service.

The work of the International Advisory Committee (the C. C. I.) has greatly facilitated the realisation of these improvements. As was explained in an earlier article this international organisation, comprised of technical and operating experts from well-nigh all of the telephone administrations of Europe together with a good representation from the New

World, has been entrusted with the study of important telephone problems and the recommendation of improved methods for coping with them. Although these recommendations are in no sense binding on the participating administrations, they are quite generally adopted and the rapid strides that international telephony has made in Europe in recent years are in no small measure due to the efficient work of the C. C. I.

Once each year the studies of the various sections of the C. C. I. are submitted to review at a Plenary Assembly. During this review studies are either formulated into definite practices and officially recommended or else returned to the various Committees for further consideration. New questions are also proposed and adopted for study.

The Eighth Plenary Meeting of the C. C. I. was held in Paris between the dates of September 14th and September 21st, 1931, inclusive.

In accordance with custom the Presiding Officer was chosen from among the officials of the Administration acting as host. In this instance M. Lange, Directeur Generale de l'Exploitation Telephonique of France was unanimously selected.

The Vice-Presidents elected to deal respectively with questions of Protection, Transmission, Traffic and Commercial were:

Dr. Breisig . . . . Germany
Mr. Muri . . . . Switzerland
Sir Thomas Purves . . . . Great Britain

Of the 36 Administrations or National operating groups adhering to the C. C. I. 24 were represented at the Eighth Plenary Assembly, and in addition there were present representatives of the International Telegraph Union of Berne and delegates from various electro-technical groups such as the Union Internationale des Chemins de Fer, Union Internationale des Producteurs et Distributeurs d'Energie Electrique, Union Internationale de Radiodiffusion, etc.

Matters of General Organisation

During the past year there has been a considerable increase in the membership of the C. C. I. This includes two new operating Companies in the Argentine (which is already represented by five separate Companies) the Telephone Administration of the Dutch East Indies, the Chile Telephone Company, the Telephone Administration of the Union of South Africa, the Republic of Uruguay (represented by two Companies) and Roumania (represented by the Societatea Anonima Romana de Telefoane). It is understood that an agreement has been reached among the seven Argentine Companies as to the proportional share of the payments to be made by each toward the Budget of the C. C. I. and that an alternate plan has been worked out to provide for the appointment of a Chef de Delegation to represent the group at the various C. C. I. Meetings.

The Budget

During the Paris meetings the Plenary Assembly examined the suggestion made by one of the Administrations that the basis of apportioning the expenses of the C. C. I. would be more equitable if based upon population rather than upon the schedule used by the International Telegraph Bureau of Berne. This suggestion was discussed at the Plenary Assembly and there developed a considerable difference of opinion, and finally, it was decided to leave the matter to the choice of each Administration; that is, each may elect to make its contribution either on the basis of the Berne Bureau schedule or on a classification based upon population, such choice to be made prior to the issue of the call for funds, so that the necessary notices can be promptly sent out.

At this point a word might be said regarding the operating expenses of the C. C. I.

During the past year about $23,600 was expended while the budget for 1932 indicates a slight reduction to about $23,200. In view of the important character of the work which the C. C.

I. is accomplishing these figures seem very moderate It is, furthermore, anticipated that from now on, with co-operation between the various telephone Administrations firmly established, the operating costs of the C. C. I. will tend to diminish. A feature tending to offset the diminishing costs due to the greater efficiency of the machine as a whole is the increasing amount of work placed on the separate committees due to the ever-growing number of questions requiring to be studied. It was with the idea of reducing the amount of work required to be studied in Committee meetings that the delegation from the American Telephone and Telegraph Company suggested at the Paris Plenary Assembly a method whereby it is expected that the work entrusted to the various Commissions will be simplified.

Questions Studied by the C. C. I.

The proposal is to divide the questions undertaken by each of the Committees into two distinct categories, A and B:

"A" questions regarding which it is important to have international agreement and uniformity of practice, either within the Continent of Europe or for the world as a whole.

"B" questions primarily of an informative character concerning which the distribution of information by the C. C. I. is helpful in assisting telephone development, but concerning which it is not vital that there should be uniformity of practice among the different nations. In the case of some of these questions, uniformity of practice would not be practicable because the desirable arrangements depend largely upon local conditions.

The above proposal was examined by the Chief Delegates and approved by them and by the Plenary Assembly.

Under the proposed arrangement, questions of Class "B" will be handled more informally, perhaps entirely by correspondence, thereby reducing the amount of work to be handled at the actual Committee meetings.

To take up in detail in the present article any of the questions now under study by the various Commissions of the C. C. I. would lead to many ramifications. In general, these questions cover broadly the subjects of Protection, Transmission, and Traffic and Commercial. Under the heading of Protection there were about a dozen questions reported on at Paris; under Transmission and its component elements there were nearly 40 questions, and under Operation, somewhat more than a dozen. Some of these questions deal, of course, with the international transmission of broadcasting programs. The transmission of such programs across national boundaries is becoming more and more popular, and one cannot help but hope that these glimpses of the life of other countries will bear useful fruit, particularly in cementing the friendship of nation for nation.

In connection with the general question of telephone transmission, it is interesting to note that the English and European technicians working from premises largely independent of our work have arrived at similar conclusions to ourselves in regard to the importance of considering all of the factors which influence the ability of subscribers to carry on a telephone conversation. In other words, the importance of effective transmission is fully realised by the C. C. I. and a study of all of the important elements of this problem is included in the list of questions before the various Technical Committees.

Date of Next C. C. I. Meeting

Up to the present the Plenary Assembly Meetings of the C. C. I. have been held each year, but this is not specified in the regulations, and the time and place of future meetings is arranged by the Chief Delegates in consultation with the General Secretary. An exchange of views on this matter took place at the Paris Meeting.

Following an invitation extended by Mr. Hernandez Barroso of Spain, it was agreed that the next Plenary Meeting which, however, would deal only with questions of traffic and commercial matters, should be held at Madrid during September, 1932, and that this meeting should be preceded by a meeting of the Rapporteurs of the Sixth and Seventh Commissions. No decision was made in regard to the date or meeting place of the Technical Commissions C. Rs One to Five inclusive, an agreement in regard to which will be arrived at at a later date by the Chief Rapporteurs of the various Commissions in consultation with the General Secretary. It is probable that these meetings will be held simultaneously during the year 1932 at some point in Europe convenient to the various Administrations directly interested.

H. E. Shreeve

Notes on Recent Occurrences

NEW TELETYPEWRITER SERVICE

A COMMUNICATION service which offers the flexibility of telephone service in the transmission of the written word was made available November 21, when the Bell System announced the inauguration of teletypewriter switching service.

The teletypewriter transmits typewritten messages electrically over wires, so that whatever is typed at one end of a circuit appears, practically at the same instant, at the distant end, also in typewritten form. Teletypewriters have been in extensive use for some years in connection with private wire service contracted for by large business concerns having branch offices, banks, brokers, press associations, police departments, air transport lines and others.

In order to provide the new service, teletypewriter exchanges are being established at various points throughout the country so that a subscriber to the service may transmit written messages directly to any other subscriber, anywhere, at any time. This new service is a "two-way" service, permitting inquiry and reply to be made immediately on the same connection.

OVERSEAS TELEPHONE SERVICE FURTHER EXTENDED

Roumania

ON November 9 transatlantic telephone service was extended to include all of Roumania. The service was inaugurated by conversations between officials of the State Department and ministers of the Roumanian government. It embraces all Bell and Bell-connecting telephones in the United States, Canada, Mexico and Cuba. Conversations are handled over the radio channels between New York and London now connecting North America with practically all of Western Europe. The charge for a three-minute conversation between New York and any point in Roumania is $39 with $13 for each additional minute. Roumania has some 50,000 telephones, operated by the Societatea Anonima Romana de Telefoane, a subsidiary of the International Telephone and Telegraph Corporation. About a fourth of these are in Bucharest, which is partly served by automatic exchanges. The country, whose principal industries are agriculture and stock-raising, has a population of about 17,700,000.

Sumatra

On November 12 telephone service was opened to the island of Sumatra in the Dutch East Indies. The circuit to Sumatra, like that to Java to which service was opened last April, is in operation during the business day. The charge for a call between New York and any point in Sumatra is $49.50 for the first three minutes and $16.50 for each additional minute. Three radio circuits, linked by wires, are required to establish the telephone connection between the United States and Sumatra. Calls to the island travel over the regular transatlantic radio telephone circuits to London, thence by wire to Amsterdam and from there by radio to Bandoeng in Java. Another short wave radio telephone circuit links Bandoeng with Medan in Sumatra. The service connects all telephones of the island with the United States, Canada, Cuba and Mexico.

Brazil

The Bell System's radio telephone service to Rio de Janeiro, Brazil, was opened on December 18. Brazil is the fourth South American nation to be brought within reach of United States telephones, service to Argentina, Chile and Uruguay having been in operation since April, 1930.

The Brazilian service is available to all Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico. At the southern end it embraces all telephones in the states of Sao Paulo and Rio de Janeiro, and in the southeastern part of Menas Geraes. The Brazilian network involved in this new extension has some 104,000 telephones serving a population estimated at 9,500,000.

The connection to Brazil is established over a short wave radio telephone channel 4,800 miles long between the transoceanic stations of the American Telephone and Telegraph Company at Lawrenceville and Netcong, N. J., and stations operated by the International Telephone and Telegraph Corporation near Rio de Janeiro. These stations connect with the lines of the Brazilian Telephone Company.

The cost of a call between New York and Rio de Janeiro is $30 for the first three minutes and $10 for each additional minute.

Bermuda

Telephone service by radio to Bermuda was opened on December 21. The service is available to all Bell System and Bell-connecting telephones in the United States, Canada, Cuba and Mexico.

The channel is operated on short wave, using wave lengths in the vicinity of 30 and 60 meters. It is in service daily from 9 a.m. to 9 p.m., New York time. The cost of a call between New York and Bermuda is $15 for the first three minutes and $5 for each additional minute.

Hawaii

Hawaii and the North American mainland were linked by regular telephone service on December 23, marking the first step in the extension of Bell System overseas telephone service to the Far East. The new service interconnects all Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico with those in the principal islands of the archipelago.

The voice path across the Pacific is over a short wave radio channel between stations near San Francisco and on the island of Oahu. It is in operation during the greater part of the business day.

Through the headquarters of the Mutual Telephone Company of Hawaii in Honolulu the service embraces all telephones in that company, those on other islands being linked by an inter-island short wave radio system.

The cost of a call between San Francisco and Honolulu is $21 for the first three minutes and $7 for each additional minute. Calls involving other points are subject to additional charges proportional to the distance. The charge for a New-York-Honolulu conversation is $30 and $10.

The extension of service to Hawaii recalls the fact that sixteen years ago a young engineer of the American Telephone and Telegraph Company with an experimental radio receiving set heard the voices of telephone engineers coming through the ether from Arlington, Virginia. During the same tests, listeners on the Eiffel Tower, in Paris, caught a few words and finally a connected sentence, also transmitted from Arlington. These early experiments paved the way to the establishment, in 1927, of regular transatlantic telephone service with Europe.

SHIP–SHORE SERVICE TO S. S. *MONARCH OF BERMUDA*

SHIP–SHORE telephone service was opened to the new S. S. *Monarch of Bermuda* when she left New York on November 28 on her first voyage to Bermuda.

The telephone channel from the United States to the ship is through the ship-shore radio telephone stations of the American Telephone and Telegraph Company on the New Jersey coast. Through these the passengers are able to reach any Bell System or Bell-connecting telephone in the United States, Canada, Cuba and Mexico. The charges for a call between the ship and points along the Atlantic seaboard is $9 for the first three minutes and $3 for each additional minute.

TRAFFIC EMPLOYMENT AND PERSONNEL RELATIONS CONFERENCE

A BELL System regional Traffic Employment and Personnel Relations Conference was recently held near Chicago. The conference was a joint meeting of the traffic men of the areas included and the personnel representatives of the respective companies; together with some of the personnel men from the operating departments of the American Telephone and Telegraph Company.

Long range fundamentals and current problems of traffic employment and personnel relations were discussed, including a consideration of wage and working conditions matters, handling of force surpluses, stabilization of employment, relation between personnel work and some of the major policies of the business and employee representation. The discussions were principally informal, although a few short papers served as a basis for considering some of the subjects. Similar regional conferences had been held previously near San Francisco and Philadelphia. In all a total of approximately 135 men were in attendance.

EQUIPMENT AND BUILDING CONFERENCE

A BELL System Equipment and Building Conference was held at Virginia Beach, Virginia, November 17 to 20, attended by representatives of the various Associated Companies, the Bell Telephone Company of Canada, the Long Lines Department of the American Telephone and Telegraph Company, the Western Electric Company, the Bell Telephone Laboratories, and the firm of Voorhees, Gmelin and Walker, architects. There were also present a number of representatives from the General Departments of the American Telephone and Telegraph Company.

Following the opening of the conference by J. B. Rees, Equipment and Building Engineer of the American Telephone and Telegraph Company, who acted as Chairman, and a brief greeting by Vice President Bancroft Gherardi of the same company, the conference was addressed by W. H. Harrison, Plant Engineer, of the American Telephone and Telegraph Company, in a review of operating results and the construction program. Papers were presented on the subjects of Small Exchanges, Dial Conversions, Building Activities and Station Matters, prepared to a large extent by representatives of the Associated Companies.

The purpose of the conference was to discuss those items that seem to require particular attention at this time rather than to cover the whole range of equipment and building activities. Great interest was shown in the papers and especially in the discussions. It was the expressed view of the conference that the importance of a fuller and truer appreciation of the duties and responsibilities of the equipment and building engineers had been deeply impressed upon the members.

TREASURY DEPARTMENT TRAINING CONFERENCES

A SERIES of training conferences of supervisory employees has been conducted in the Treasury Department of the American Telephone and Telegraph Company during the past year. Organization, administration, principles of supervision, training and the general development of employees were included in the topics discussed and analyzed under the direction of a conference leader.

Among those participating were eight Assistant Treasurers of Associated Companies, 11 of their supervisory employees and 56 members of the American Telephone and Telegraph Company Treasury Department.

Plans have been made to continue similar conferences this winter.

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

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VOL. XI NO. 2

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES AND CANADA; SINGLE COPIES, 50 CENTS

Address all communications to

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

CONTRIBUTORS TO THIS ISSUE

H. D. ARNOLD

Wesleyan University, Ph.B., 1906; M.S., 1907; D.Sc., 1930; University of Chicago, Ph.D., 1911. Entering the Engineering Department of the Western Electric Company the same year, he was assigned to the development of the vacuum tube for the repeater system. He perfected the three element tube for use at high power levels for which he was awarded the John Fritz Medal in 1928. He is now Director of Research of Bell Telephone Laboratories.

RALPH BOWN

Cornell University, M.E., 1913, M.M.E., 1915, Ph.D., 1917. Captain Signal Corps, U. S. Army, 1917–1919; Department of Development and Research, American Telephone and Telegraph Company, 1919–. Mr. Bown has been in charge of work relating to radio transmission development problems. He is a Past President of the Institute of Radio Engineers.

HERBERT E. IVES

University of Pennsylvania, B.S., 1905; Johns Hopkins, Ph.D., 1909. Following his discharge from the United States Air Service, he entered the Engineering Department of the Western Electric Company and engaged in investigations of photo-electric cells and their possible uses in communication. He was entrusted with the general development of picture transmission over wires and the Bell System's development program on television of which, as Electro-Optical Research Director of Bell Telephone Laboratories, he is now in charge.

FRANK B. JEWETT

Throop Polytechnic Institute, A.B., 1898 (now California Institute of Technology); University of Chicago, Ph.D., 1902. Several honorary degrees. Instructor in Physics and Electrical Engineering, Massachusetts Institute of Technology, 1902–1904. Transmission and Protection Engineer, American Telephone and Telegraph Company, 1904–1912; Assistant Chief Engineer, Chief Engineer, Vice President, Western Electric Company, 1912–1925; Vice President, American Telephone and Telegraph Company in charge of Development and Research Department and President, Bell Telephone Laboratories, 1925–.

ARTHUR WILSON PAGE

Harvard, B.A., 1905. After graduation engaged in editorial work with the publishing firm of Doubleday, Page and Co., Garden City, N. Y., of which he was Vice President from 1913 to 1927. During this period he was also editor of the *World's Work* except for a time during the war when he was engaged in the Army Intelligence Service in France. In 1927 he was elected Vice President of the American Telephone and Telegraph Company, of which he became a Director in 1931.

ROBERTSON T. BARRETT

A brief biographical note regarding Mr. Barrett appeared in the list of contributors in the *Bell Telephone Quarterly* for January, 1930.

BANCROFT GHERARDI

A brief biographical note regarding Mr. Gherardi appeared in the list of contributors in the *Bell Telephone Quarterly* for January, 1931.

Lectures in the Lowell Institute by Bell System Representatives

ON January 5, 1932, a series of seven lectures by representatives of the Bell Telephone System was begun in the Lowell Institute, of Boston, Massachusetts, the general title of the series being "The Application of Science in Electrical Communication."

These lectures, in the order of their presentation, were as follows:

January 5—"An Introduction to Research in the Communication Field," by H. D. Arnold, Ph.D., Sc.D., Director of Research, Bell Telephone Laboratories.

January 8—"Research in Speech and Hearing," by Harvey Fletcher, Ph.D., Acoustical Research Director, Bell Telephone Laboratories.

January 12—"Transoceanic Radio Telephony," by Ralph Bown, Ph.D., Department of Development and Research, American Telephone and Telegraph Company.

January 15—"Picture Transmission and Television," by Herbert E. Ives, Ph.D., Sc.D., Electro-Optical Research Director, Bell Telephone Laboratories.

January 19—"Talking Motion Pictures and Other By-Products of Communication Research," by John E. Otterson, President, Electrical Research Products, Inc.

January 22—"Utilizing the Results of Fundamental Research in the Communication Field," by Frank B. Jewett, Ph.D., D.Sc., Vice President, American Telephone and Telegraph Company, President, Bell Telephone Laboratories.

January 26—"Social Aspects of Communication Development," by Arthur W. Page, A.B., Vice President, American Telephone and Telegraph Company.

Five of the seven lectures are published in this issue of the BELL TELEPHONE QUARTERLY, in the order of their presentation, with reproductions of most of the lantern-slides that were used as illustrations. It is unfortunately necessary to omit the second and fifth lecture in the series because they contain frequent references to illustrations and exhibits that cannot conveniently be reproduced.

EDITOR

An Introduction to Research in the Communication Field

A lecture delivered at the Lowell Institute, Boston, Massachusetts on January 5, 1932

TO have ideas and to share them—that makes civilization. Of course the ideas must be good ones if the civilization is to be worth while. Society recognizes this when it entrusts to Education the stupendous task of teaching us how to think and what to think about. But sharing is really the kernel of the matter. For civilization is not a solitary affair; no individual becomes civilized by and for himself alone. Civilization is a community affair and grows and spreads only as fast and as far as people can come to a common understanding. It is the business of communication to provide facilities to broaden and speed this concourse of thought and feeling. In any business it is the duty of research to carry forward its ideals and provide always better means of achieving them. Thus in communication, research seeks as its ultimate goal to break down the barriers of time, distance and expense which prevent the quick and easy meeting of our minds.

Perhaps you think this ideal too ambitious and far-reaching for practical folk to consider. We think not; for in idealism, in ambition and in practicality the modern research mind recognizes no limitations. This is especially true where a group is joined together in the common effort to understand and master all of some problem, from its deepest roots to its farthest branches. Just such an effort is joined in our research in communication. If at times we seem to go too deep or aim too high I would suggest that from the points to which we have ventured out we can perhaps see more clearly the value of what is in the depths and on the heights. We make no apology for following where our vision leads, for after all that is Research.

In offering you an introduction to research in communication you can readily see I am attempting no simple task. The problems dealt with are numerous and complex. Fortunately, the succeeding lectures will bring to you a clearer insight of how some of these problems are handled in detail, how they materialize in useful forms, and why it is all worth while. For my part I shall try to give you a general idea of what we have to do, and how we go about doing it in this business of Research.

II

Let us consider first what it is that communication is called upon to accomplish. When I talk to you face to face you hear me and see me. These two processes are the most important in the communication of ideas; we have grown up with them from the childhood of the race; and we would like to feel that some time we shall be able at will and instantly to effectively project our ears and our eyes to any place in the world. We feel the need of a great deal more than the mere transportation of words. The mind is much too complex to find anything like complete expression in language. Our thoughts move too quickly and lose their full force before we can formulate them in speech or writing. But we must remember that after all words are rather recent acquisitions of the human race. We used our voices long before we had developed the rules of grammar, and even before we had much of a vocabulary. It is natural, therefore, that a great deal of the spontaneous contact between our minds has come to depend upon the intonations of our voices. We all know how completely the meaning of a sentence may be changed by the tone in which it is spoken. To be thoroughly satisfactory therefore a communication system must transport much more than mere words—it must transport the voice itself with all its shades of emotion and personality. And ultimately it should transport vision as well. For the mind reveals itself through the expression of the face, the gleam of the eye, the motion of the body, as truly as through the voice. Indeed these modes of expression, which are so elementary and spontaneous, are often more clearly indicative of the mind than mere words can possibly be. The judge and jury always wish to see the witness and hear him speak; they are not content with a written record.

III

Now there is already in existence a communication system which, for very short distances, does all these desirable things, —the marvelous system that is within our own bodies. Nature solved tremendous problems in connecting our minds to the external world through our ears and eyes. Just how cunningly she used the materials and forces which she had at her disposal is becoming more apparent to us year by year. For example, consider what happens when we hear. We know that sound waves come through the air and shake the diaphragms of our ears in exact accordance with the motion of their source, whether that is the voice of a speaker or a musical instrument. Then comes about a marvelous transformation. The mechanical motion of our ear drum sets up a complicated train of mechanical and chemical changes and, as a result, up the nerves to the brain go a series of electrical pulses which carry every detail which previously existed in the motion of the air and the vibration of the ear drum. The earliest electrical telephone!

How do we know this is so? At Princeton University, Wever and Bray recently discovered that when they connected a vacuum tube amplifier and loud speaker directly to the nerves leading from the ear the loud speaker spoke out clearly the sounds which had been spoken directly into the ear. The result was just as if this apparatus had been connected to an ordinary telephone line. Nature had anticipated us in transforming mechanical motion into electrical currents within the individual. She has left us, nevertheless, plenty of opportunity for hard work in extending the reach of electrical currents from person to person throughout the world.

Indeed, Nature has pointed us to many if not all the principles which we use in our art. Consider the voice. Signals from the brain, almost certainly electrical in character, control the motion of the air in our throats; and thus we have an amplifier and loud speaker system transforming tiny electrical currents into powerful air vibrations through the control of the muscular power which drives the lungs.

Consider the ether waves which we use in radio—we are not the first to use them for communication; Nature has also used them in providing us with sight. Wherever we turn we find clues which lead us on in our task of providing between individuals an extension of the communication facilities that Nature has already provided within the individual.

IV

We start then with these bare essentials: voice, ear and eye; air, electricity, and ether. To these are added the grosser material things out of which we must fabricate a satisfactory, economical and lasting communication system. Many of these constituents of our problem we must accept as we find them; but although we may not change them it is absolutely essential that we understand them. With other constituents we are allowed certain liberties; we can arrange them and to some extent modify them to meet our needs.

In the first category are, for example, the voice and the ear. If we are to face our task intelligently we must know exactly what the voice is and exactly how the ear responds. Without these facts we cannot hope to find the ultimate solutions of our problems. The last twenty years have seen a rapid advance in our knowledge of these things, but nevertheless there still remains a vast deal that we do not know and a large and basic part of our research concerns itself with these matters.

In this same category we find air waves, ether waves, and electricity. The nature and behavior of these we cannot modify, but to use them to best advantage we must thoroughly comprehend them. Air waves seem comparatively simple and understandable, yet there is still a great deal to learn even about these elementary things upon which all of acoustics rests. Ether waves are obviously more perplexing subjects of research. Perhaps there is no ether, then of course there are no ether waves. Nevertheless, ether or no ether there is no doubt about the usefulness of light and of radio waves, and whether or not we can completely comprehend what they are we must at any rate bend every effort to understand all the rules which must be followed in using them, and all the difficulties with which their use is surrounded. We must not only know how to start ether waves and how to detect them, we must find out how they behave when they have left our control and are projected into a space filled with static, with ionization, with Heaviside layers, with cosmic rays, and whatever else the sun, moon, stars, and weather may provide.

And then, still in this category of things which we must accept as they are, we find electricity. There is perhaps nothing simpler in the world than electricity, for we have come to think that it is the aggregation of little units which are always the same and quite unchangeable. Yet in the process of arriving at this conclusion we have found astounding new uses for electricity. So long as we thought of it as a fluid with electromagnetic properties we could indeed make marvelous use of it, but when we fully realized its unit structure, we found a magic way opening to new uses in our present day multitudinous electron tubes. And now electricity is taking on new allure. We have found that despite its simple unit structure it somehow succeeds in behaving like a wave motion.

The proof of this fact came about, strangely enough, in our laboratory where we were trying to understand electricity in order to use it better for communication purposes. In what way this knowledge will affect the communication art we can hardly hope to see at this time. Nevertheless, the importance of the knowledge cannot be doubted, and its discovery is just another demonstration that there is still much to be found out about these elementary things which we cannot change but must use. With regard to all these we conceive it our job to thoroughly understand what Nature has provided in order that we may make no mistakes and miss no opportunities in utilizing them.

V

It is in the second category, however, comprising the things which Nature permits us to modify that we find the majority of our research problems. These may be divided roughly into two classes; problems of composition and characteristic, and problems of shape and association.

Compositions and characteristics are the prime concerns of the chemistry and physics of materials. The possibilities of studies and improvements along these lines are practically boundless. Even those properties of materials which relate directly to the communication industry present almost unlimited ground for research.

As a striking example, consider the effect of composition on magnetic properties. Iron is the outstanding magnetic element. For many purposes ordinary commercial iron is sufficiently good. But in transforming the delicately modulated electrical currents that represent speech in our communication systems we need materials far more sensitive and uniform in their response to magnetic forces. These we have found by compounding iron with nickel, with cobalt, with molybdenum. And the end is not yet, for every year we are finding new compositions and new treatments that give us constantly better magnetic properties.

Consider also the combinations of the elements barium and strontium which make possible the truly astounding life and efficiency of our vacuum tubes; of sodium and potassium and caesium and other elements which have so increased the usefulness of photoelectric cells. Or consider the new organic compounds which are constantly giving us better dielectrics, better insulators, greater strength in our materials and more complete protection against wear and weather. Nor is the scope of our research in this broad field of chemistry and physics limited to discovering the characteristics of new compounds; it must also include studies of how to make them available with uniformly good quality and at reasonable cost.

But it is in the problems of shape and association of the materials which we have at our disposal that we find the most complicated and the most immediately important of all our tasks. The telephone transmitter, for instance, is composed of some thirty different parts. The test of the adequacy of this assemblage of parts is that it must take from the air the minute and highly complicated energy flow that is speech and must translate this into a flow of electricity which retains all the voice's complexity; and it must do this reliably and cheaply, under all vicissitudes of location and climate, and throughout a long period of years. Its design is mathematically exact in an unusual sense of the words. Our fundamental studies of the voice have made it possible for us to describe the air-borne form of words in terms of Fourier's analysis—a mathematical description of wave form in terms of frequency, amplitude and phase—with very great accuracy and completeness. We also have developed methods for analyzing the electrical currents which flow out from the transmitter and can describe them in the same mathematical terms. And so we may think of the transmitter as transforming the mathematical equation which, in terms of mass, elasticity and viscosity, represents the motion of the air, into the corresponding equation which in terms of inductance, capacity and resistance represents the motion of electricity in the telephone wire. It is just because this whole problem has been considered as a mathematical one, and every detail of the transformation traced through all the parts of the instrument that we have our present day quality of telephone, phonograph, and sound picture reproduction. The promise for the future rests in the extension of just such exact mathematical analysis to every problem in which there is a translation of energy between mechanical and electrical forms.

While the transfer of energy from one embodiment to another without loss of detail presents one of the most difficult of all our problems in the construction of apparatus there are almost as great difficulties found in associating transformers, condensers and resistances to transmit and preserve the detail of the electric currents themselves in their transit through the communication system. These, too, call for the use of very difficult mathematics in their solution. Indeed, we frequently find that the flow of electricity through complex apparatus presents mathematical puzzles which we cannot solve at all. Nevertheless, it is a source of great satisfaction to be able to engineer in a rigorous mathematical way so many problems whose analogues in other arts must still be handled by cut and try methods. One of the most important aims of our research is to extend this firm mathematical foundation under all the complicated structure of our design and manufacture.

VI

But perhaps the most fascinating of all our problems are those which deal with the rejuvenation of speech currents as they travel along through the communication system. We may be as mathematically exact as we please in transforming sound waves into corresponding electrical currents and yet fail completely in reaching our final objective unless we have some way to restore the energy that is being constantly lost as the currents go along the wires. And yet we must do that very thing not merely once, but scores and even hundreds of times in long distance connections. The delicate pattern of the voice which is contained in the current has to be repaired and restored by the addition of new energy much as a child patches up a snow man as it slowly melts away.

Suppose we ask how much of the original energy can be left in speech that has gone from San Francisco to London. The figures are truly startling, and are more difficult to comprehend than the astronomical magnitudes scientists are now talking so much about. You may remember that the latest estimates put the number of separate particles in the universe at about ten to the seventy-ninth power. That means the difficulty of finding one particular electron in the whole universe is measured by some such enormous number as the digit one with seventy-nine ciphers after it. But a very simple calculation shows that the difficulty of finding a bit of the original energy in the voice current delivered in London is at least one-with-a-hundred-ciphers-after-it times greater than the difficulty of finding one particular electron in the universe. It is because we have mastered this problem of amplifying voice currents that the telephone has stretched out during the past few years from a reach of a few hundred miles to cover the whole world. And this problem of amplication is still a vital and growing one, in which research promises greater accomplishments in the future.

In addition to amplification some curious tricks are resorted to in transporting voice currents. Of course, speech must pass in both directions during a telephone connection, but sometimes it is very desirable that it shall not be moving in both directions at the same time. We, therefore, use electrically operated gates which close the lines to traffic in one direction while it is allowed to proceed in the other. Now the gate must open just before the speech arrives, for if it does not open ahead of time the initial syllable of the oncoming speech will collide with it and be damaged beyond recognition, or lost completely. Perhaps you have driven an automobile on a road protected by signals operated by the car itself. While still at a distance from a crossroad your car actuates an electric circuit which causes the signal light to stop cross traffic and so allows you to proceed. This is relatively simple of accomplishment, for the electric current flies on ahead of your car and there is plenty of time for the signal to operate. But when we try to set stop-go signs for voice currents we are confronted with the fact that there is no way of sending a signal on ahead at a speed greater than that of the voice current itself. So, of course, we must in some way hold back the voice currents until the necessary switches can operate. The idea is simple, but the method of its accomplishment is not so obviously simple. What we frequently do is to send the voice current into an electrical labyrinth which is so artfully designed that the current finds its way through it slowly and yet suffers no ill effect in the process.

Delay and storage devices for speech offer a vast field for research. Some must delay speech for only a thousandth part of a second and others must store it indefinitely. Some must reproduce the speech only once and then present a clean page for the next record, while others must reproduce the speech thousands of times without noticeable change in quality. The methods employed are as varied as the problems themselves and may be electrical, magnetic, optical, or mechanical as circumstances demand. It is in the proper association of all these ways and means of dealing with the energy and form of voice and music that some of the most important advances of recent years have been made, and there is still a wide field of research and exploration awaiting us.

There are also, as you can well imagine, vast complications involved in the electrical signalling and switching which makes it possible to establish telephone connection between person and person. When, for example, you use a dial instrument the motion of the dial establishes electric currents which in turn cause mechanical parts in the central office to move with more than human accuracy and send out electric signals to call the distant person with whom you wish to speak. But this is not all. There are conditions under which it is necessary that the numbers which you indicate with the dial be actually spoken in the central office, and this also has become possible by ingenious combinations of electrical, mechanical and optical parts. Problems such as these are obviously not to be solved by mathematics—they call for a rare type of ingenuity, a mind undaunted by detail and having at its disposal the latest and best of all that research can offer.

But I must not attempt to mention the thousands of researches which have been accomplished, are in progress, or loom ahead of us. Ours is a live and growing art; and research ventures out wherever new growth starts or is demanded. I trust, however, that I have mentioned enough fields of endeavor to indicate how numerous must be the separate streams of research which flow together to stimulate the new growth within the wide domain of communication. And it is most important that they do really flow together and not trickle along separately. For individual effort can not well face problems as complicated as these. It is only by co-ordinated effort that progress can be assured.

VII

Now that we have in mind the ultimate object of our researches, the nature of the problems with which we have to deal, and the materials and forces which we have at our disposal, let us consider briefly how we go about our work. It is very fortunate for me that you have all grown so familiar with research men, their problems and their methods through the lectures of the many brilliant scientists who have in person presented their work to you under the aegis of this Institute. I shall assume your full acquaintanceship with the individual of the genus researcher, and go straight on to some general considerations which underlie our own peculiar problem of conducting researches in an organized way, with an eye toward their usefulness in the art of communication.

But although I must not stop to dwell at any length on the problems of the individual research worker, we must not for a moment forget that research is in its very essence individualistic; for only by keeping this constantly in mind can we understand and evaluate its conduct, its results and its significance.

Nor must we let ourselves fall into the very common confusion which fails to distinguish clearly between research itself and the tools which it uses. Research is of the mind and not of the hands, a concentration of thought and not a process of experimentation. We all know too well the common picture of the research worker—a microscope, a retort, a balance, a measure and a man in an apron. It depicts, it is true, something of the delicacy of the apparatus required and suggests the skill and patience necessary for its manipulation. It fails, however, to represent research itself, which is as apt in the use of crude apparatus as of delicate apparatus; whose special pride, indeed, is to bend the simplest tools to new uses, and whose real interest is not in the skill of the performer but in the meaning of the performance.

Research is not constructing and manipulating; it is not observing and accumulating data; it is not merely investigating or experimenting; it is not "getting the facts"; although each of these activities may have an indispensable part to play in it. Research is the effort of the mind to comprehend relationships which no one has previously known. And in its finest exemplifications it is practical as well as theoretical; trending always toward worthwhile relationships; demanding common sense as well as uncommon ability.

VIII

I think we can get most quickly to a common understanding of research as we meet it in the field of communication if I tell you about one particular problem and what had to be done to solve it. It has to do with the amplification of speech and music by vacuum tubes—a process you are all familiar with in your own radio sets and by which, with the mere turning of a dial, you can proceed at will from the almost inaudible to the all too audible. It has to do, also, in a very practical way, with the cost factors that must underlie the engineering of all long distance communication systems.

Let us approach this particular problem as some of us may have approached our arithmetic problems in school—by first looking in the back of the book for the answer. And this is the way the answer reads: "If when you try to transmit speech over wires you permit the speech current to become smaller than a certain definite size no amplifier can ever restore it to understandable form."

Now this is a fact of obvious and exceedingly great importance; for, as we have already learned in our consideration of the enormous amplification necessary in a transcontinental and transoceanic conversation, once speech currents have been started along their way the farther they go the smaller they become. We can revive them with amplifiers, but it is expensive and sometimes almost impossible to install these at frequent intervals along all our routes. We can also construct our system so that the currents die away less rapidly, but only at a cost which soon becomes prohibitive. What we would like to do would be to allow the currents to go long distances and become very small indeed before we amplify them. Indeed, this is just what we must do in long undersea cables where we can only maintain amplifiers at the terminals. But Nature holds up her hand and says "Stop! You must not go below my ordained minimum current." And so we have the necessary size and cost and ultimate practicability of such a system sharply determined by this fundamental rule which we cannot change and must respect. It is a bench mark from which we must learn to survey our whole scheme of speech transmission engineering.

Why is there any such limit to the size of usable current? The answer is very simple and you will all see it and understand it as quickly as I mention it. You know that in any piece of wire the atoms are always in motion and that it is this motion which determines the temperature of the wire. You also know that electricity in a conductor shares this heat motion and because it does there is a continual surging about of the electricity in the wire. Now this is just what happens when speech is going along a wire, except that the surgings of electricity which are controlled by speech are of an orderly sort and conform to the pattern of the voice, whereas the always present surgings of electricity due to temperature are quite irregular in pattern. Obviously if the speech currents get smaller and smaller they will finally be over-ridden by the random motions of electricity and become so mixed up with them that they never can be extricated in intelligible form. Consider your own radio sets. You know that if there is a thunderstorm and consequently very bad static, and in your effort to hear you keep adding more and more amplification, you really do not improve the situation at all; everything becomes louder, the static as well as the program. That is the way it is if ever you let speech currents become so small that they are obscured by the irregular heat motion of electricity;—the static within the wire.

IX

Now that we know and understand the answer let us go back and imagine ourselves trying to solve this problem and thus we shall learn something of the research processes involved. The very first difficulty that confronts us is that we are not aware there is any such problem. Of course, *you* see the problem plainly enough, but only because I have told you about it. Someone had to see it first and recognize it without any prompting. I want to emphasize that the type of mind which first sees such problems is indispensable to research. Hundreds of people knew that electricity partakes of the heat motion in metals but it never occurred to them that the fact might be of practical everyday significance. The problem was born when, in a mind that understood all these things, there first flashed out the conscious question "Can the random motion of electricity be of such a nature and so big that it is of tangible importance?"

After we have come to recognize the problem we must next attempt to evaluate it. This requires a mind that is critical rather than creative. It must, of course, be constructively critical, for it must not squelch a good new idea at its very start, and yet it must be keenly and coldly critical for it must not let us go on and waste time and money in following a line of unsound thought. It must above all be a closely reasoning mind and equipped with the tools of logic, which in engineering means equipped with the machinery of mathematics. There must be brought to bear all the available knowledge of physics, chemistry and mathematics; whatever additional information is needed must be clearly indicated; and thus we come to the point where experimentation must begin.

When we find that new facts are required to evaluate a problem, as was the case in this matter of the noise of electricity, a still different side of the research mind must be brought into play, a side which is closely in step with Nature herself. It knows how to meet actual material things on their own grounds and cope with them. It knows all about instruments and their limitations. It knows the places to be bold and the places to be cautious in experimentation. It is linked with the experimental touch—something which can never be got entirely by training but which can never find itself properly in any field except through long experience in that field. It must know, for instance, in this particular problem, all the technique, the possibilities and the pitfalls, in carrying amplification to the limit, and measuring and establishing in the face of great experimental difficulties the actual magnitudes of these tiny electrical motions.

Finally we find ourselves confronted with the very practical question—"What does it matter, now that you know all about it?" You and I could never answer this question in any satisfactory manner. We would have to know how large a vagrant current may be and still not mutilate speech—and this is a large research in itself. We would have to know how much it means in cost and trouble to keep speech currents from becoming too small. We would have to know what particular parts of our circuits are most susceptible to this trouble. We would have to know what palliative measures are possible and at what cost. We would have to emerge gradually and imperceptibly from research into the more stabilized field of engineering.

X

I chose this particular problem for discussion because it illustrates the many sidedness of the approach to a research problem and the variety in the mental attitude and training which must be brought to bear. First of all we must have the questing spirit—the mind that fastens to the solid ground of established fact with a grasp so firm that it holds securely while reaching out for unknown and untried positions, and yet so lightly that it swings on unhampered and unrestrained as soon as the new footing is found. This mind must be bold, curious, unbelieving, iconoclastic; perhaps not too scornful of our present accepted beliefs yet always eager for a different and better view. Sure but light in its tread, it is always on treacherous ground but never lets itself be unbalanced into an abyss.

Then we must have the analytical mind to survey the new ground as it is won. This is far more a believing mind. It sums up the knowledge and beliefs of the past and will not budge from its established ground until firmly convinced there is real advantage in doing so.

And at the last we must have the mind of the husbandman that moves into the new territory with all the skill and machinery of research and engineering, and checks and measures and cultivates all the new grounds' possibilities.

These are the three requirements; the spirit to adventure, the wit to question, and the wisdom to accept and use. Few men can lay claim to those three in any superlative degree, but any successful research man must have all to some degree; and he must bring them all to bear on each new problem which he undertakes.

Now the essence of organized research as we visualize it is to give a greater freedom, a surer ground, a wider field, a more constructive expression to these types of mind. We do not seek just to assemble a group of similarly inclined minds and let them function individually. We try by linking hands to support the adventurer so he can reach further and more securely. We try to turn upon new ground a sharper scrutiny by a varied group than would be possible by any individual, and we try to bring to the cultivation of new ground the skill, the technique, the experimental genius of a large group of enthusiastic husbandmen. And yet we do not try to have a group of questers, a group of criticizers and a group of experimenters. We try rather to multiply and to some extent steady the stream of achievement by using these different attributes of all the researchers' minds as though they were one large mind. An ideal difficult, perhaps impossible, to achieve in more than limited measure, and yet, if achieved to any degree, fraught with untold possibilities.

XI

The story of research in communication is a tale of literally thousands of problems and thousands of men. It is too big to be told in its entirety—certainly I would not dare attempt it. But an introduction, after all, is just an invitation and an opportunity to become acquainted. That is all I have pretended to offer; that, and a glimpse of the unifying spirit that holds work and men all together in one strong drive toward the common goal of our research.

H. D. Arnold

Transocеanic Radiotelephony

A lecture delivered at the Lowell Institute, Boston, Massachusetts, on January 12, 1932

IN 1915 speech was first sent experimentally across the Atlantic Ocean by radiotelephony. Today there are 30 transoceanic radiotelephone circuits in operation transporting an international commerce of speech. It is my purpose to trace briefly some of the technical considerations underlying this novel communication development.

Although the first successful experiments were made in 1915 and following the war came further tests and demonstrations, it was not until 1927 that the first commercial system was opened to traffic between New York and London. The next year brought a second circuit on this New York–London route and two circuits between Europe and South America. The map, Fig. 1, shows in solid lines the lace work of international telephone circuits which exists today and with dotted lines the additional circuits in prospect. These invisible speech highways extend the scope of telephone service so that a United States subscriber may now be connected with about 33,000,000 other telephones in the world which constitute 91 per cent of the world's telephones.

The value of these circuits lies in their ability to tie together the existing continental wire networks into a world telephone network. Thus, one of the first problems was to accomplish effectively the junction of space transmission and wire transmission of speech.

Interconnecting Wire and Radio Systems

More clearly to comprehend the nature of this problem let us examine the diagram shown in Fig. 2. This is a diagram

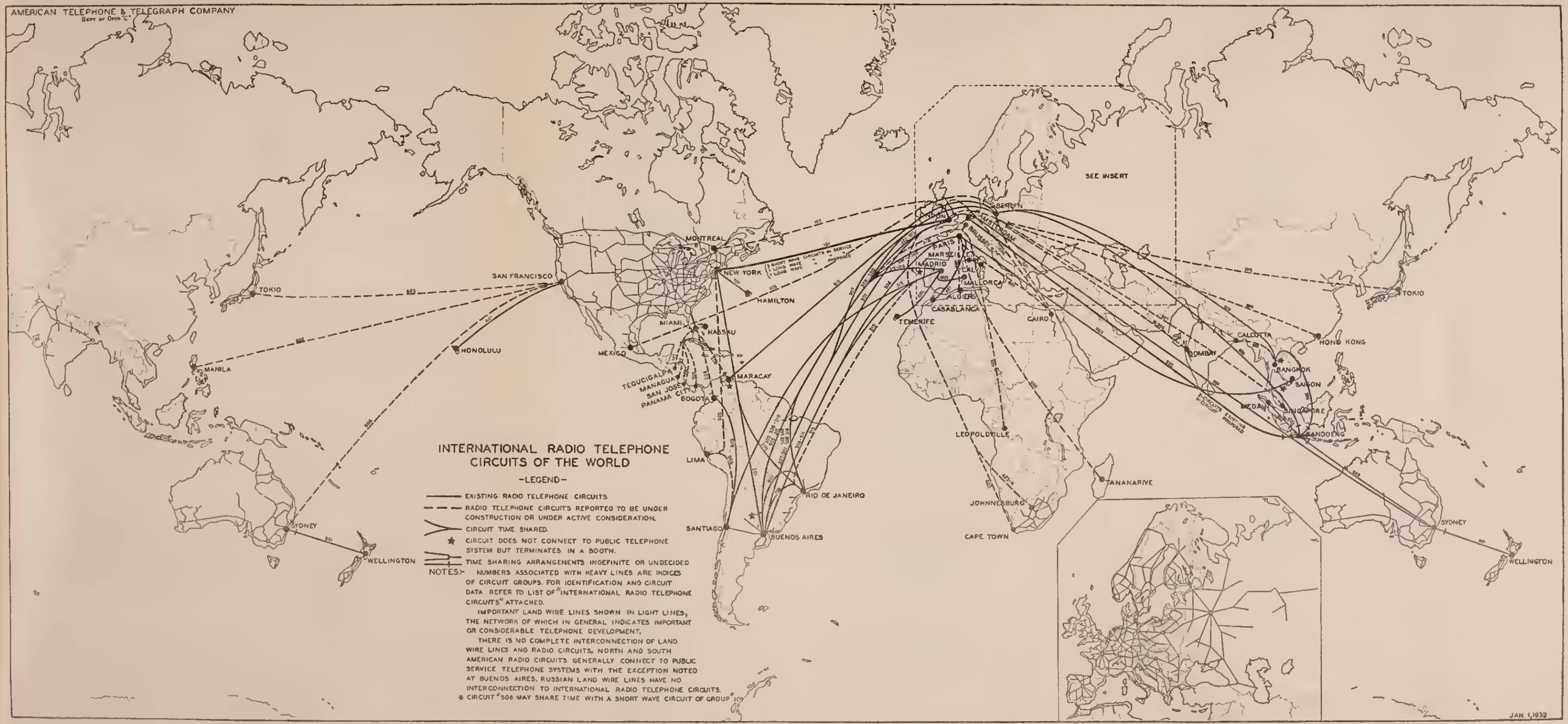


FIG. 1. INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1932.

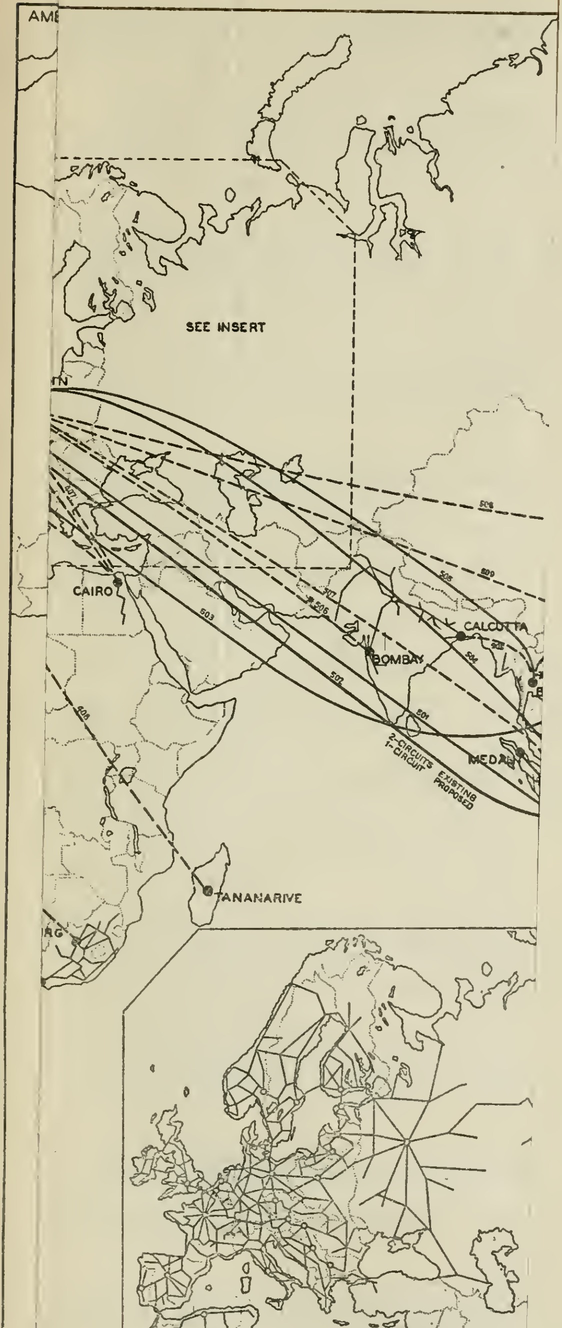
THIS MAP, PREPARED BY DEPARTMENT OF OPERATION C, AMERICAN TELEPHONE AND TELEGRAPH COMPANY, SHOWS ON EACH CIRCUIT LINE AN IDENTIFICATION NUMBER. MORE DETAILED INFORMATION IS TABULATED BY IDENTIFICATION NUMBERS ON THE BACK OF THIS MAP.

Circuit Group Index No.	Circuit Terminals	Ownership	Distance Statute Miles	Service Date	Time Sharing Arrangements
	NORTH AMERICA-EUROPE				
	Existing Circuits				
101.	(1) London-New York (Long Wave)	British P. O.-Am. Tel. and Tel. Co.	3,448	Jan. 7, 1927	Not shared.
	(2) London-New York	British P. O.-Am. Tel. and Tel. Co.	3,448	June 6, 1928	Not shared.
	(3) London-New York	British P. O.-Am. Tel. and Tel. Co.	3,448	June 1, 1929	Not shared.
	(4) London-New York	British P. O.-Am. Tel. and Tel. Co.	3,448	Dec. 1, 1929	Not shared.
	Proposed Circuits				
101.	(5) London-New York (Long Wave)	British P. O.-Am. Tel. and Tel. Co.	3,448	1934	Not shared.
102.	London-Montreal	British P. O.-Canadian Marconi Ltd.	3,245	1932	At London with 404.
103.	Berlin-Mexico City	German P. O.-Mexican Govt.	6,034	....	Note 3.
	NORTH AMERICA-SOUTH AMERICA				
	Existing Circuits				
201.	Buenos Aires-New York	Compania Internacional de Radio*-Am. Tel. and Tel. Co.	5,327	Apr. 3, 1930	At New York with 202.
202.	New York-Rio de Janeiro	Am. Tel. and Tel. Co.-Companhia Radio Internacional do Brasil*	4,849	Dec. 18, 1931	At New York with 201. At Rio de Janeiro with 315-802.
	Proposed Circuits				
203.	Lima-New York	Compania Peruana de Telefonos, Limitada*-Am. Tel. and Tel. Co.	3,679	....	Note 3.
204.	Bogota-Miami	Compania Telefonica Central-Am. Tel. and Tel. Co.	1,514	....	Note 3.
205.	Maracay-Miami	Compania Annonima Nacional Telefonos de Venezuela-Am. Tel. and Tel. Co.	1,362	....	Note 3.
	EUROPE-SOUTH AMERICA				
	Existing Circuits				
301.	Buenos Aires-London	Compania Internacional de Radio*-British P. O.	6,921	Dec. 12, 1930	At Buenos Aires with 307-802. At London with 302-303.
302.	Buenos Aires-London	Transradio Internacional-British P. O.	6,921	Dec. 12, 1930	At Buenos Aires with 305-308-312-316-801. At London with 301-303.
303.	London-Rio de Janeiro	British P. O.-Companhia Radiotelegraphica Brasileira	5,769	May 21, 1931	At London with 301-302. At Rio de Janeiro with 306-309-314-801.
304.	Buenos Aires-Paris	Compania Internacional de Radio*-Cie Gle de T.S.F.	6,868	June 11, 1930	At Buenos Aires with 311. At Paris with 305-306.
305.	Buenos Aires-Paris	Transradio Internacional-Cie Gle de T.S.F.	6,868	Feb. 1, 1929	At Buenos Aires with 302-308-312-316-801. At Paris with 304-306.
306.	Paris-Rio de Janeiro	Cie Gle de T.S.F.-Companhia Radiotelegraphica Brasileira	5,695	Mar. 31, 1930	At Paris with 304-305. At Rio de Janeiro with 303-309-314-801.
307.	Berlin-Buenos Aires	German P. O.-Compania Internacional de Radio*.	7,406	Sept. 10, 1930	At Berlin with 308-309. At Buenos Aires with 301-802.
308.	Berlin-Buenos Aires	German P. O.-Transradio Internacional	7,406	Dec. 10, 1928	At Berlin with 307-309. At Buenos Aires with 302-305-312-316-801.
309.	Berlin-Rio de Janeiro	German P. O.-Companhia Radiotelegraphica Brasileira	6,230	Mar. 21, 1930	At Berlin with 307-308. At Rio de Janeiro with 303-306-314-801.
310.	Berlin-Maracay, (Venezuela)	German P. O.-Venezuelan Govt.	5,150	Sept. 13, 1931	Not shared.
311.	Buenos Aires-Madrid	Compania Internacional de Radio*-Compagna Telephonica Nationale d'Espagna*	6,248	Oct. 12, 1929	At Buenos Aires with 304. At Madrid with 313-315.
312.	Buenos Aires-Madrid	Transradio Internacional-Compania Transradio Espanola	6,248	1929	At Buenos Aires with 302-305-308-316-801. At Madrid with 314.
313.	Madrid-Santiago	Compagna Telephonica Nationale d'Espagna*-Compania Internacional de Radio S.A.*	6,645	Apr. 17, 1931	At Madrid with 311-315. At Santiago with 803-804.
314.	Madrid-Rio de Janeiro	Compania Transradio Espanola-Companhia Radiotelegraphica Brasileira	5,057	1930	At Madrid with 312. At Rio de Janeiro with 303-306-309-801.
	Proposed Circuits				
315.	Madrid-Rio de Janeiro	Compagna Telephonica Nationale d'Espagna*-Companhia Radio Internacional do Brasil*	5,057	Jan. 1932	At Madrid with 311-313. At Rio de Janeiro with 202-802.
316.	Brussels-Buenos Aires	Belgium Govt.-Transradio Internacional	7,028	Feb. 1932	At Brussels with 406. At Buenos Aires with 302-305-308-312-801.
	EUROPE-AFRICA				
	Existing Circuits				
401.	Casablanca-Paris	Moroccan Tel. & Tel. Admin.-Cie Gle de T.S.F.	1,132	Nov. 3, 1930	At Paris with 503.
402.	Madrid-Teneriffe	Compagna Telephonica Nationale d'Espagna*-Compagna Telephonica Nationale d'Espagna*	1,128	Jan. 22, 1931	At Madrid with 1,001.
	Proposed Circuits				
401.	Casablanca-Paris	Moroccan Tel. & Tel. Admin.—French P.T.T.	1,132	....	Not shared.
403.	Capetown-London	Overseas Com. Co. of So. Africa-British P.O.	6,011	Feb. 1, 1932	At London with 301-302-303.
403A.	Johannesburg-London	South African P. O.-British P. O.	5,637	....	Note 3.
404.	Cairo-London	Marconi Radio Tel. of Egypt-British P. O.	2,179	1932	At London with 102.
405.	(1) Algiers-Paris	French P.T.T.-French P.T.T.	836	1932	Not shared.
	(2) Algiers-Paris	French P.T.T.-French P.T.T.	836	1932	Not shared.
406.	Brussels-Leopoldville	Belgium Govt.-Belgium Govt.	3,893	Apr. 1932	At Brussels with 316.
407.	Berlin-Cairo	German P.O.-Marconi Radio Tel. of Egypt	1,805	....	Note 3.
408.	Paris-Tananarive (Madagascar)	French P.T.T.-French P.T.T.	5,448	....	Note 3.
409.	Cairo-Paris	Marconi Radio Tel. of Egypt-French P.T.T.	1,993	....	Note 3.
	EUROPE-ASIA-OCEANIA				
	Existing Circuits				
501.	London-Sydney	British P. O.-Amalgamated Wireless Australasia	10,557	Apr. 30, 1930	At London—Not shared. At Sydney—Note 3.
502.	(1) Amsterdam-Bandoeng	Neth. Govt.-Neth. Indies Tel. Admin.	7,294	Jan. 8, 1929	At Amsterdam—Not shared. At Bandoeng—Note 4.
	(2) Amsterdam-Bandoeng	Neth. Govt.-Neth. Indies Tel. Admin.	7,294	Dec. 1, 1929	At Amsterdam—Not shared. At Bandoeng—Note 4.
503.	Paris-Saigon	Cie Gle de T.S.F.-Cie Gle de T.S.F.	6,298	Apr. 11, 1930	At Paris with 401.
504.	Bandoeng-Berlin	Neth. Indies Tel. Admin.-German P. O.	6,726	Dec. 29, 1929	At Bandoeng—Note 4. At Berlin with 505.
505.	Bangkok-Berlin	Siamese Govt.-German P. O.	5,349	Apr. 15, 1931	At Bangkok—Note 3. At Berlin with 504.
	Proposed Circuits				
502.	(3) Amsterdam-Bandoeng	Neth. Govt.-Neth. Indies Tel. Admin.	7,294	....	Note 3.
506.	Bombay-London	Indian Radio Teleg. Co.-British P. O.	4,545	....	At London with 101(4).
507.	London-Singapore	British P. O.-Imp. & Int. Comm. Ltd.	7,694	....	Note 3.
508.	London-Tokio	British P. O.-Japanese Govt.	5,941	....	Note 3.
509.	Hong Kong-London	Hong Kong Tel. Co.-British P. O.	5,979	....	Note 3.
	NORTH AMERICA-ASIA-OCEANIA				
	Existing Circuits				
601.	Honolulu-San Francisco	Mutual Tel. Co.-Am. Tel. and Tel. Co.	2,393	Dec. 23, 1931	Not shared.
	Proposed Circuits				
602.	Manila-San Francisco	Philippine L. D. Teleph. Co.-Am. Tel. and Tel. Co.	6,969	....	Note 3.
603.	San Francisco-Tokio	Am. Tel. and Tel. Co.-Japanese Govt.	5,133	....	Note 3.
604.	San Francisco-Sydney	Am. Tel. and Tel. Co.-Australian P. O.	7,425	....	Note 3.
	NORTH AMERICA				
	Existing Circuits				
701.	Hamilton (Bermuda)-New York	Imp. & Int. Comm. Ltd.-Am. Tel. and Tel. Co.	795	Dec. 21, 1931	Not shared.
	Proposed Circuits				
702.	Miami-Tegucigalpa (Honduras)	Am. Tel. and Tel. Co.-Tropical Radio Teleg. Co.	919	....	At Miami with 703-704-705.
703.	Miami-Managua (Nicaragua)	Am. Tel. and Tel. Co.-Tropical Radio Teleg. Co.	1,002	....	At Miami with 702-704-705.
704.	Miami-San Jose (Costa Rica)	Am. Tel. and Tel. Co.-Tropical Radio Teleg. Co.	1,120	....	At Miami with 702-703-705.
705.	Miami-Panama	Am. Tel. and Tel. Co.-Tropical Radio Teleg. Co.	1,161	....	At Miami with 702-703-704.
706.	Miami-Nassau	Am. Tel. and Tel. Co.-Bahamas Govt.	175	....	....
	SOUTH AMERICA				
	Existing Circuits				
801.	Buenos Aires-Rio de Janeiro	Transradio Internacional-Companhia Radiotelegraphica Brasileira	1,227	1931	At Buenos Aires with 302-305-308-312-316. At Rio de Janeiro with 303-306-309-314.
802.	Buenos Aires-Rio de Janeiro	Compania Internacional de Radio*-Companhia Radio Internacional do Brasil*	1,227	Dec. 12, 1931	At Buenos Aires with 301-307. At Rio de Janeiro with 202-315.
803.	Bogota-Santiago	All America Cables, Inc.*-Compania Internacional de Radio S.A.*	2,644	Aug. 1, 1931	At Santiago with 313-804.
	Proposed Circuits				
804.	Lima-Santiago	Compania Peruana de Telefonos, Limitada*-Compania Internacional de Radio S.A.*	1,537	....	At Lima—Note 3. At Santiago with 313-803.
	ASIA-OCEANIA				
	Existing Circuits				
901.	Sydney-Wellington	Australian P. O.-New Zealand Govt.	1,375	Nov. 25, 1930	Note 3.
902.	Bandoeng-Bangkok	Neth. Indies Tel. Admin.-Siamese Govt.	1,469	Apr. 15, 1931	At Bandoeng—Note 4. At Bangkok—Note 3.
903.	Bandoeng-Sydney	Neth. Indies Tel. Admin.-Australian P. O.	3,392	Dec. 23, 1930	At Bandoeng—Note 4. At Sydney—Note 3.
904.	Bandoeng-Medan (Sumatra)	Neth. Indies Tel. Admin.-Neth. Indies Tel. Admin.	875	Sept. 16, 1931	At Bandoeng—Note 4.
	Proposed Circuits				
905.	Bangkok-Calcutta	Siamese Govt.-Indian Radio Co.	1,008	....	Note 3.
	EUROPE				
	Existing Circuits				
1,001.	Madrid-Mallorca	Compagna Telephonica Nationale d'Espagna*-Compagna Telephonica Nationale d'Espagna*	330	Oct. 24, 1931	At Madrid with 402.
	Proposed Circuits				
1,002.	Calvi-Marseilles	French P.T.T.-French P.T.T.	185	1932	Note 3.

NOTES:

1. *Indicates Int. Tel. and Tel. Co. subsidiary or affiliate.
2. Service dates for proposed circuits are those planned.
3. Definite information not available.
4. At Bandoeng there are 5 transmitters:
   - 1 transmitter operates with 502-504-903-904
   - 1 transmitter operates with 502-504-902
   - 1 transmitter operates with 502-504-903
   - 1 transmitter operates with 502-504
   - 1 transmitter operates with 903
5. The circuit group index system employed is as follows:

Intercontinental Circuits—	Index
North American-Europe	100-199
North America-South America	200-299
Europe-South America	300-399
Europe-Africa	400-499
Europe-Asia-Oceania	500-599
North America-Asia-Oceania	600-699
Intracontinental Circuits—	
North America	700-799
South America	800-899
Asia-Oceania	900-999
Europe	1,000-1,099
Africa	1,100-1,199



32.

...TAILED INFORMATION IS TABULATED BY IDENTIFICA...

Circuit
Group
Index No.

N ls
Exis ANIA
101. (1) I
(2) I. . . . . Bı
(3) I
(4) I . . . . N
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. . . . Si
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409. Cairo

Ownership	Distance Statute Miles	Service Date	Time Sharing Arrangements
itish P. O.-Amalgamated Wireless Australasia...	10,557	Apr. 30, 1930	At London—Not shared. At Sydney—Note 3.
eth. Govt.-Neth. Indies Tel. Admin.............	7,294	Jan. 8, 1929	At Amsterdam—Not shared. At Bandoeng—Note 4.
eth. Govt.-Neth. Indies Tel. Admin.............	7,294	Dec. 1, 1929	At Amsterdam—Not shared. At Bandoeng—Note 4.
ie Gle de T.S.F.-Cie Gle de T.S.F...............	6,298	Apr. 11, 1930	At Paris with 401.
eth. Indies Tel. Admin.-German P. O...........	6,726	Dec. 29, 1929	At Bandoeng—Note 4. At Berlin with 505.
amese Govt.-German P. O.....................	5,349	Apr. 15, 1931	At Bangkok—Note 3. At Berlin with 504.
eth. Govt.-Neth. Indies Tel. Admin.............	7,294	....	Note 3.
dian Radio Teleg. Co.-British P. O.............	4,545	....	At London with 101(4).
ritish P. O.-Imp. & Int. Comm. Ltd............	7,694	....	Note 3.
ritish P. O.-Japanese Govt.....................	5,941	....	Note 3.
ong Kong Tel. Co.-British P. O.................	5,979	....	Note 3.
utual Tel. Co.-Am. Tel. and Tel. Co............	2,393	Dec. 23, 1931	Not shared.
hilippine L. D. Teleph. Co.-Am. Tel. and Tel. Co.	6,969	....	Note 3.
m. Tel. and Tel. Co.-Japanese Govt.............	5,133	....	Note 3.
m. Tel. and Tel. Co.-Australian P. O............	7,425	....	Note 3.
np. & Int. Comm. Ltd.-Am. Tel. and Tel. Co....	795	Dec. 21, 1931	Not shared.
m. Tel. and Tel. Co.-Tropical Radio Teleg. Co. ..	919	....	At Miami with 703-704-705.
m. Tel. and Tel. Co.-Tropical Radio Teleg. Co. ..	1,002	....	At Miami with 702-704-705.
m. Tel. and Tel. Co.-Tropical Radio Teleg. Co. ..	1,120	....	At Miami with 702-703-705.
m. Tel. and Tel. Co.-Tropical Radio Teleg. Co. ..	1,161	....	At Miami with 702-703-704.
m. Tel. and Tel. Co.-Bahamas Govt.	175	....	....
ransradio Internacional-Companhia Radiotelegraphica Brasileira..........................	1,227	1931	At Buenos Aires with 302-305-308-312-316. At Rio de Janeiro with 303-306-309-314.
ompania Internacional de Radio*-Companhia Radio Internacional do Brasil*................	1,227	Dec. 12, 1931	At Buenos Aires with 301-307. At Rio de Janeiro with 202-315.
ll America Cables, Inc.*-Compania Internacional de Radio S.A.*...........................	2,644	Aug. 1, 1931	At Santiago with 313-804.
ompania Peruana de Telefonos, Limitada*-Compania Internacional de Radio S.A.*............	1,537	....	At Lima—Note 3. At Santiago with 313-803.
ustralian P. O.-New Zealand Govt..............	1,375	Nov. 25, 1930	Note 3.
eth. Indies Tel. Admin.-Siamese Govt...........	1,469	Apr. 15, 1931	At Bandoeng—Note 4. At Bangkok—Note 3.
eth. Indies Tel. Admin.-Australian P. O.........	3,392	Dec. 23, 1930	At Bandoeng—Note 4. At Sydney—Note 3.
eth. Indies Tel. Admin.-Neth. Indies Tel. Admin.	875	Sept. 16, 1931	At Bandoeng—Note 4.
amese Govt.-Indian Radio Co..................	1,008	....	Note 3.
ompagna Telephonica Nationale d'Espagna*-Compagna Telephonica Nationale d'Espagna*..	330	Oct. 24, 1931	At Madrid with 402.
rench P.T.T.-French P.T.T.	185	1932	Note 3.

Co. subsidiary or affiliate.

rcuits are those planned.

ilable.

nsmitters:
h 502-504-903-904
h 502-504-902
h 502-504-903
h 502-504
h 903

5. The circuit group index system employed is as follows:

Intercontinental Circuits—	Index
North American-Europe	100-199
North America-South America	200-299
Europe-South America	300-399
Europe-Africa	400-499
Europe-Asia-Oceania	500-599
North America-Asia-Oceania	600-699
Intracontinental Circuits—	
North America	700-799
South America	800-899
Asia-Oceania	900-999
Europe	1,000-1,099
Africa	1,100-1,199

of what is known as a four-wire telephone toll circuit. It is called a four-wire circuit because in the long-haul portion of the circuit from toll office to toll office separate one-way paths are provided for the speech in the two directions and two pairs of wires are used. Speech amplifiers or telephone repeaters are placed along these paths to bring up the volume of the speech currents whenever, due to losses, they fall to a

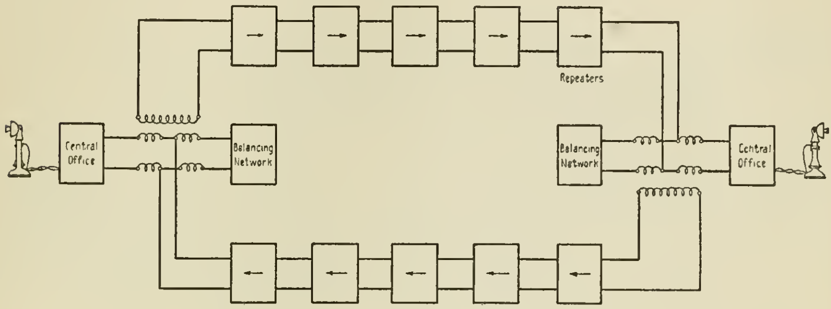


FIG. 2. FOUR-WIRE TELEPHONE CIRCUIT.

value too close to the noise currents on the lines. The total amplification may be very large but it is *distributed* and the speech currents are at no point much stronger or much weaker than at the subscriber's transmitter and receiver. At the terminals of this four-wire portion are shown three-winding transformers known as hybrid coils. These function after the manner of Wheatstone bridges and by virtue of the balance between the two-wire connected line and an artificial line called the balancing network, tend to prevent speech currents from getting across from the output end of one path into the input of the other path. It is evident that if this were to occur, speech currents would circulate round and round the two paths. The balances are not perfect and to some extent this does occur. Those wayward portions of the speech currents, which go back to the talker or make one or more round trips before passing on to the listener, are delayed by this detour and sometimes sound like echoes, which indeed is what they are called by the telephone engineer. But the wire system is comparatively stable and by simple devices and adjustments, these echoes can be kept from causing trouble.

The diagram of Fig. 3 has been set up to show a simple radiotelephone link in such a way as to make apparent its similarity to the four-wire type of wire telephone circuit. The

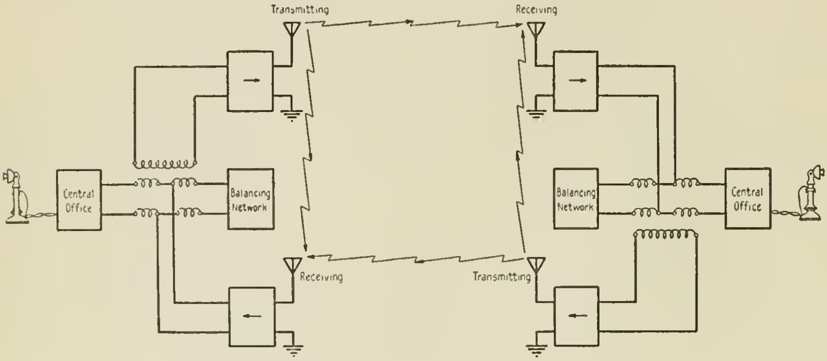


FIG. 3. SIMPLE FORM OF RADIOTELEPHONE CIRCUIT.

differences also become apparent. The amplification is all *lumped* at the terminals of the two paths rather than distributed along them. At each end is a powerful radio transmitter and a sensitive radio receiver.

The transmitter is a tremendous amplifier sending out the voice in the form of radio waves with a power so great that its equivalent in sound might be pictured as a chorus of all the people in the United States assembled in a multitude and speaking in unison.

The receiver is far more sensitive than the human ear. It "hears" radio waves equivalent in power to the voice of a single man several miles away in free air.

Thus, it is evident that even though the transmitter and receiver are many miles apart and operating on different radio channels, the crossfire from the former into the latter may be very severe.

For this and other reasons, it is necessary to provide some means of shutting off the receiver when the transmitter is sending out by the speaker's voice and correspondingly shutting off access to the transmitter when the receiver is active. The telephone subscriber cannot do this but we can make his

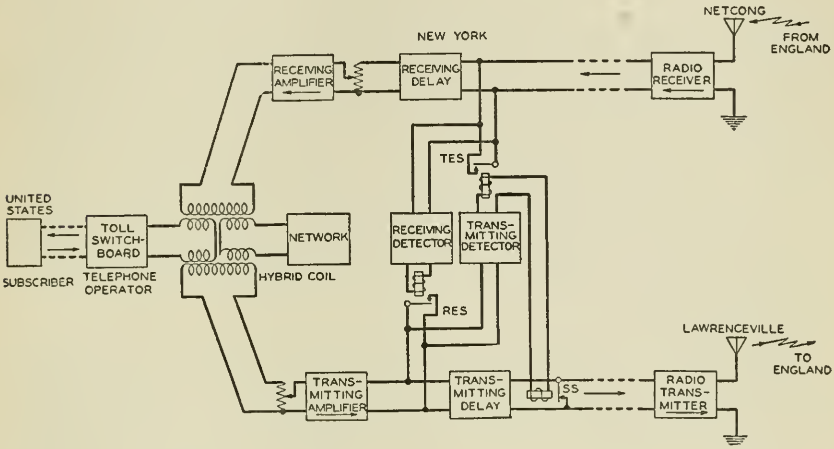


FIG. 4. VOICE-OPERATED SWITCHING SYSTEM FOR RADIOTELEPHONE TERMINALS.

voice do it for him through the agency of automatic switches operated by the telephone currents which his voice generates.

Fig. 4 gives a schematic diagram of the United States end of one of the transatlantic circuits showing the essential features of such a voice-operated device. The functioning of the apparatus illustrated is briefly as follows: The relay TES is normally open so that received signals pass through freely to the subscriber. The relay SS is normally closed to short-circuit the transmitting line. Speaking in terms of automobile traffic signals, it is as if the transmitting line showed a red light and the receiving line a green one. When the United States subscriber speaks and his voice currents come speeding down the line toward the transmitter, they pass the transmitting detector which, like an automatic traffic control, recognizes their presence and acts to open the short circuit at TES, or turn the light to green. Simultaneously the relay SS is closed to short-circuit the receiving line, placing its traffic signal at red. It takes time to accomplish these functions and it is necessary to prevent the speech currents from getting into trouble by passing the red light before it has a chance to change. The delay circuit does this. Electrically the delay circuit is an artificial telephone line of such length that the voice currents spend several hundredths of a second in getting through. In our traffic analogy we might say that it was represented by forcing each car to make a little side trip around a block before being permitted to confront the traffic light. By the time this side trip is completed the light has changed to green. When the speaker ceases sending out his voice current travelers, the traffic lights go back to their original colors; that is, the relays assume their original positions.

When the distant subscriber speaks and his voice currents come in the receiver, they find an open path with a green light and proceed through to the home subscriber's ear. However, there is provided an automatic protection in the receiving detector and delay circuit, which, acting in conjunction with the relay RES, disables the transmitting detector so that stray noise currents, or incoming speech currents which get across the hybrid coil and start toward the transmitter, cannot act to change the state of affairs until the distant speaker has finished.

All these actions which it takes some minutes to describe occur so fast that the subscribers are able to converse back and forth without being conscious that there is anything unusual about the system.

A device of this kind so completely cuts away from the two one-way radio circuits the limitations which would otherwise be imposed by the junction with the wires that they become effectively independent systems which are simply called upon to transport speech between the terminal stations with a minimum of distortion and noise interference. Except that these one-way circuits must be co-ordinated in some degree to avoid excessive interaction, they may be designed as separate systems and we may consider but one of them in developing further the purely radio aspects of the entire circuit.

Radio Links

A one-way radio system across the ocean differs from the familiar broadcasting type of radio system in that the sole purpose of the transmitter is to reach one particular and generally very distant radio receiver with the greatest effectiveness. Evidently great power at the transmitter is the first desideratum. The developments which have occurred in vacuum tube construction, based largely upon the invention of a technique of sealing copper vessels to glass vessels with vacuum tightness, have produced high-power water-cooled tubes capable of handling almost any power which can be economically justified. In Fig. 7 such a tube is shown in the hands of the two engineers.

To broadcast power in all directions would be wasteful. Directive antenna systems for converging the radiated waves into a beam aimed at the distant receiver have been studied intensively and are applied in modern point-to-point radio systems. Many types have been evolved. Two, used for short-wave transoceanic telephony are shown in Figs. 5 and 6. These two types are roughly of equal effectiveness. They serve to illustrate the advances made in the past two years. The lofty steel towers hung with great wire curtains are replaced by a few telephone poles carrying a conductor around the four sides of a diamond.

At the distant end the receiver has problems all its own. The most important of these is radio static noise. Thunder storms are going on continuously somewhere on the earth.

Each lightning flash sends a powerful electromagnetic disturbance radiating round the world, which produces a crackle in every radio receiver it passes. It has been estimated that the sum total of these flashes is equivalent to the continuous operation of a one million-kilowatt radio transmitter, certainly a potent source of interference. Refined tuning of the receiver can eliminate the interfering signals from radio stations on other channels, but the impulsive character of static disturbances defies attempt to eliminate them completely by any tuning process. Fortunately these disturbances come from many directions, while the desired signals come from but one direction, the direction of the transmitting station. A directive receiving antenna system which responds freely to waves coming from that one direction and is deaf in all other directions goes far to mitigate the effect of atmospherics. Antennas of the diamond type similar to that shown in Fig. 6 are being employed in new receiving installations.

To summarize this discussion of the radio stations, we may say that (1) at the transmitting end there should be as much power as the cost will permit justifying and it should be radiated efficiently and as far as possible only toward the receiving station, and (2) at the receiving end the system should employ refined selective tuning or filtering circuits and it should receive as little as possible from other directions than the direction of the transmitter. Let us now examine some of the other ways in which these desirable things have been accomplished and some further problems and refinements.

Long-Wave System

The first commercial transatlantic radiotelephone circuit operated (and still operates) on long waves at 5000 meters (or 60 kilocycles). In addition to employing a power amplifier of nearly 200 kilowatts capacity comprising the battery of water-cooled tubes shown in Fig. 7 it employs a method of

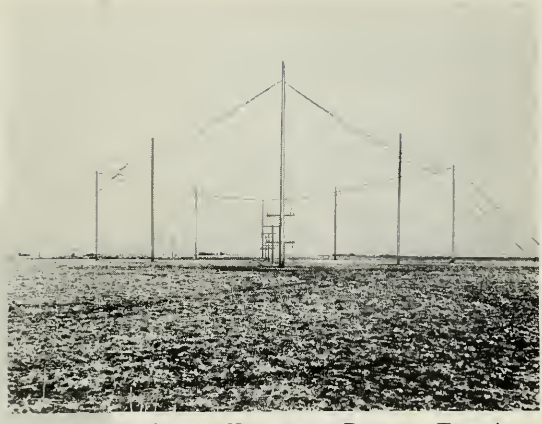


Fig. 6. Horizontal Diamond Type Antenna Connected for Transmitting.

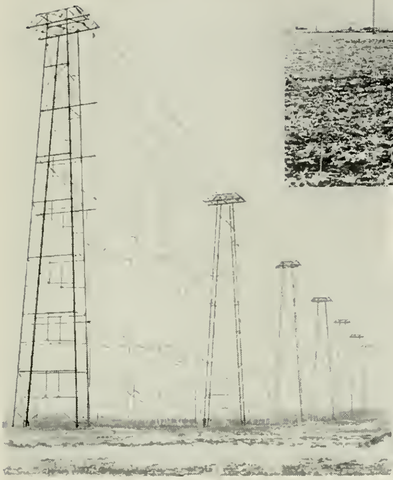


Fig. 5. Short-wave Directive Transmitting Antennas at Lawrenceville, New Jersey.

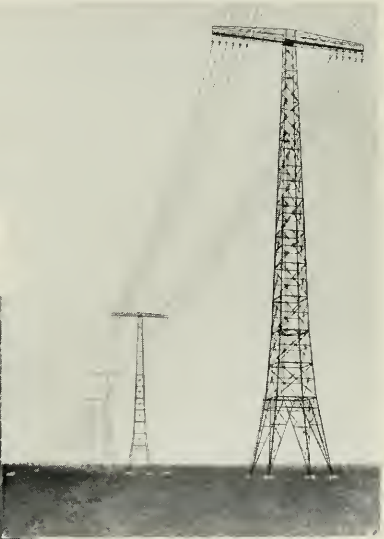


Fig. 8. Long-wave Transmitting Antenna at Rocky Point, Long Island.

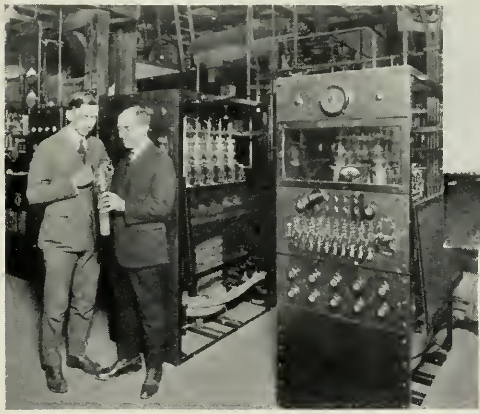


Fig. 7. Long-wave High Power Amplifier at Rocky Point, Long Island.

Fig. 9. Receiving Wave Antenna at Houlton, Maine.

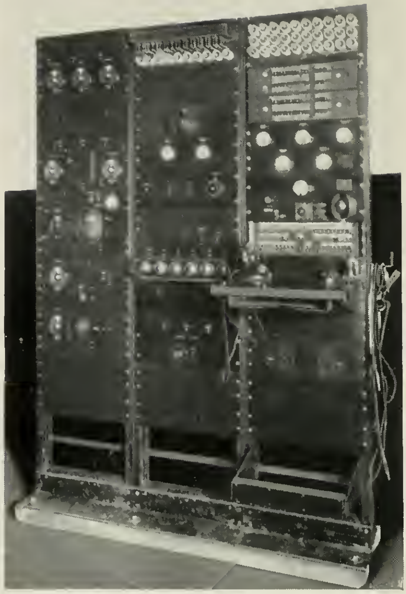


Fig. 12. Short-wave Transoceanic Telephone Receiver.

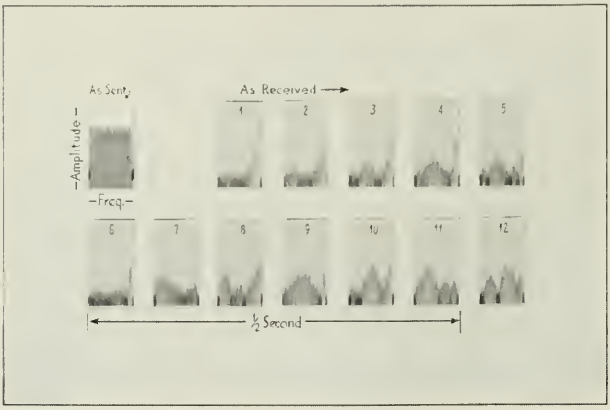


Fig. 13. Oscillographic Records of Short-wave Selective Fading Tests.

transmission unique in radio, giving a power effectiveness several times as great as the ordinary method. In the usual method used in broadcasting and for short-wave systems, there is transmitted continuously a constant carrier wave which carries no intelligence but is necessary to permit a simple detecting apparatus for receiving. There are also two bands of frequencies resulting from modulation, called sidebands, one just above the carrier frequency and one just below it. Each of these sidebands carries the message in full. The single-sideband-carrier-eliminated method of telephone transmission, originally developed for wire carrier telephony and now applied to long-wave radio, lops off one sideband and the carrier and transmits the remaining sideband only. This permits the full power capacity of the transmitter to be brought to bear on this one message carrying component. At the receiving end the eliminated carrier frequency is resupplied from a small oscillator in the receiving set.

In the original long-wave system a non-directive transmitting antenna is employed. Fig. 8 shows a picture of this antenna at Rocky Point, Long Island. In the new additional long-wave system now being designed there will be a directive transmitting antenna adapted from the so-called wave antenna used in long-wave receiving.

The wave antenna is simply a pair of wires several miles long carried on telephone poles in a straight line toward the correspondent station, and grounded at the ends through suitable terminating circuits. Fig. 9 shows one of them in use at the transatlantic receiving station at Houlton, Maine. To increase the directivity for receiving, several of these antennas are placed side by side separated some distance apart. They are connected to the receiving set through transmission lines.

Since thunder storms predominate in the warmer portions of the globe, it might be expected that the more northern latitudes would be freer from static. Putting the receiving station in Maine combines this advantage with the further one that this location places most of the static sources to the rear of the directive system where their effectiveness in producing interference in the receiver is much reduced.

This long-wave circuit has been described because it illustrates the problems met in the pioneer work on transoceanic radiotelephony and because it illustrates further the basic problems common to all point-to-point radio circuits. But it is not likely that any considerable number of them will ever be built. In spite of the fact that the single sideband method of transmission narrows the frequency channel occupied by such a system and that further economy of frequency space has been achieved in the existing system by operating both the eastbound and westbound channels in the same frequency band, the total frequency space available for long-wave long distance use is too limited to accommodate more than a few circuits. The diagram in Fig. 10 shows how limited this frequency space is.

Short-Wave Systems

The discovery that short waves of the order of 15 to 50 meters could be sent long distances made it evident that further expansion should be sought in the short-wave range.

The short-wave range (also shown in Fig. 10) is vastly wider in kilocycles but, nevertheless, has its limitations as to the number of communication facilities it affords. For a given route of a few thousand miles a single frequency gives good transmission for only a part of the day. As shown in Fig. 11, for example, from the United States to Europe a frequency in the neighborhood of 18,000 to 21,000 kilocycles (17 to 14 meters) is good during daylight on the Atlantic. But in the dusk period a frequency of about 14,000 kilocycles (22 meters) is better. For the dark hours something like 9000 kilocycles (33 meters) gives best transmission. For midnight in winter an even lower frequency near 6000 kilocycles (50 meters) is

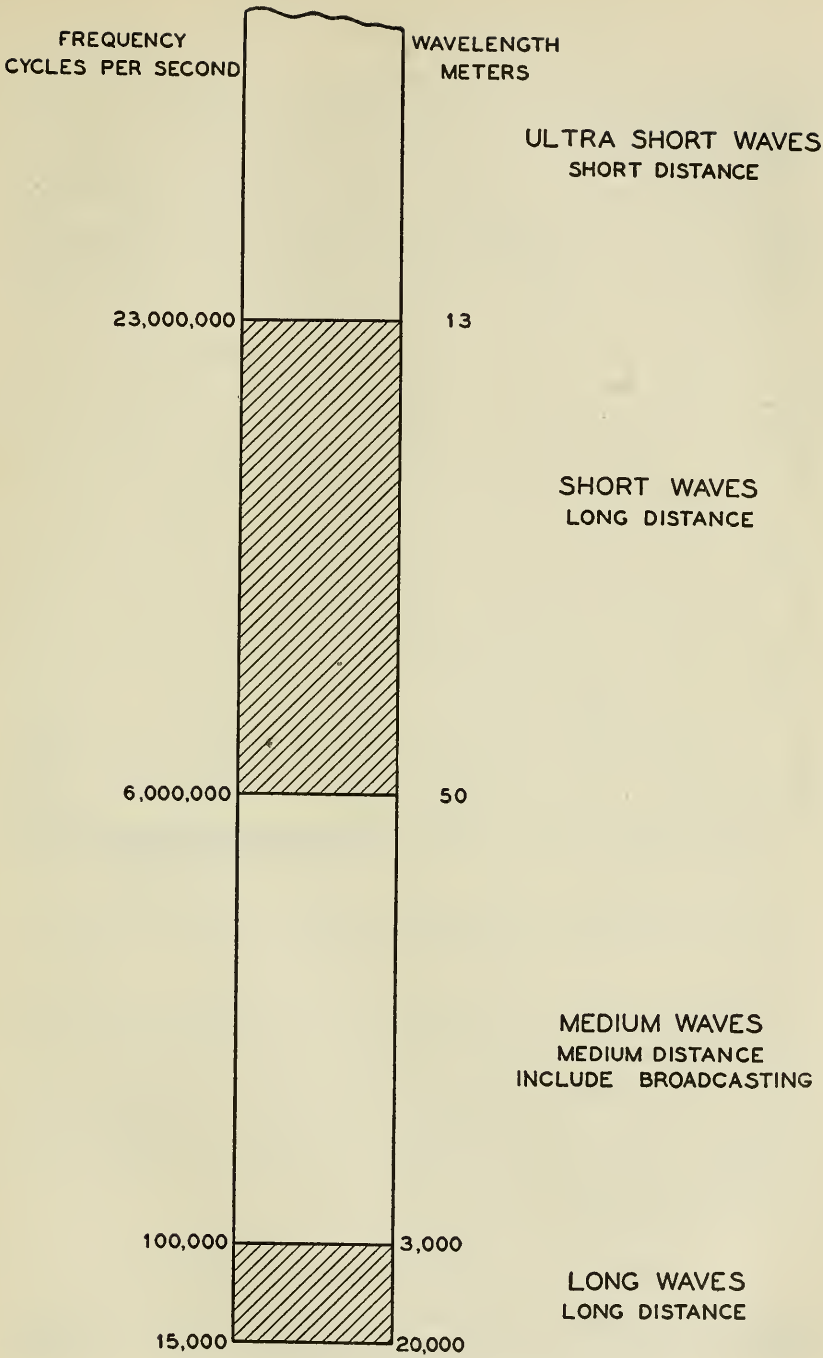


FIG. 10. RADIO FREQUENCY SPECTRUM.

advantageous. Thus, in considering the short-wave range in terms of communication circuits, we must shrink its apparent width materially to take account of the several frequencies required for continuous service. Fig. 11 shows that stronger signals are received at night on the longer of these short waves. This is fortunate since the radio noise also increases in strength at this time.

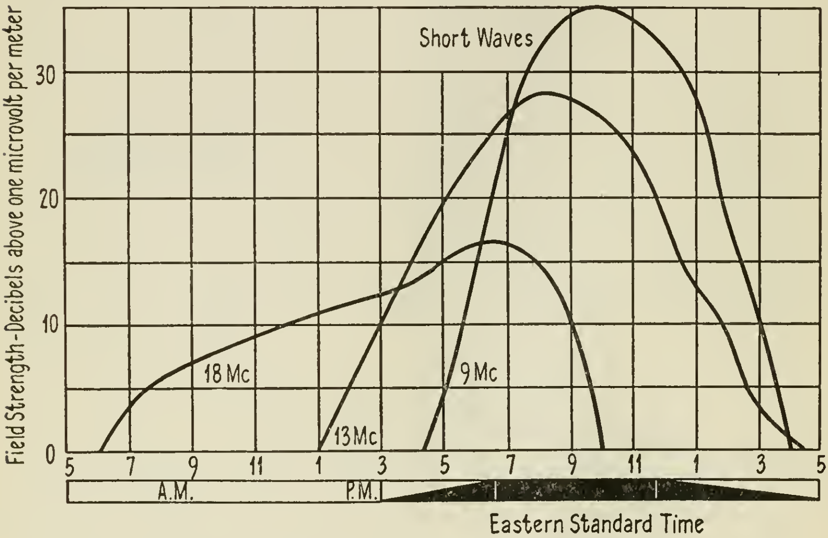


Fig. 11. Representative Curves Showing Strength of Received Signals Against Time of Day. (Mc.—Megacycles.)

All but one of the long distance radiotelephone systems now in use in the world are of the short-wave type. From the United States three such circuits extend to Europe, one to Bermuda, one to Buenos Aires, one to Rio de Janeiro and one to Hawaii. Circuits to other South American, Central American and Pacific points are in preparation.

Short-Wave Transmission Problems

Short-wave transmission is subject to one frailty which particularly hampers its use for telephony. This is fading.

Where fading is of the ordinary type familiar to broadcast listeners, consisting of waxing and waning of the loudness of the entire transmitted band of frequencies, a device called an automatic gain control is of value and is employed at the receiving station in the transoceanic telephone circuits. With this device the amplification in the receiver is automatically controlled by the strength of the incoming carrier wave. As the carrier strength falls the amplification is increased and as it rises the amplification is decreased so as to result in substantially constant signal output. A commercial short-wave receiver employing automatic gain control is shown in Fig. 12.

The fading problem is unfortunately not so simple as this. It is rarely that the entire signal band fades in and out as a unit. More usually certain parts of it are down while others are up. That is to say the fading is selective as to frequency. This is perhaps best illustrated by referring to Fig. 13 which shows a variety of the changes through which a fading signal may go. (*Figs. 12 and 13 are facing page 105.*)

These figures are oscillographic records of a test signal. The test signal consists of twelve tone frequencies spaced through a part of the audio-frequency range ordinarily employed for voice transmission. Each of the vertical lines on the record corresponds to one of the tones. The first line on the left is 425 cycles, having a pitch about midway between middle C and high C in the musical scale. Proceeding to the right the tones are spaced at 170-cycle intervals up to the last at 2295 cycles. The tones are all put into the circuit together in equal amplitude, as indicated by the upper left-hand figure. When they have been transmitted through the radio circuit they come out much modified. The remaining figures taken consecutively, as numbered, show the curious shapes through which the record passed in a short time under the particular conditions for which the record was made.

It is possible to set up experimentally, in the laboratory, a cathode ray oscillograph in such a way that this characteristic is delineated continuously on the screen of the tube. The characteristic is seen to be constantly in motion, passing through strange configurations.

When these tones are listened to at the transmitting end by means of a telephone receiver the sound is a sort of chord of definite and steady musical character. Listened to at the receiver after they have been transmitted over a short-wave transoceanic circuit when selective fading is present, the changes in tonal character, as the maxima and minima of the fading characteristic wander through the band, are clearly distinguishable. When speech or music is being transmitted the effect of selective fading is noticed as a distortion of the quality.

Defects in short-wave transmission due to radio noise and fading with its consequent distortion are nearly always present to some extent and, when any or all are severe, cause a certain amount of lost service time. These interruptions are of relatively short duration and, furthermore, there is enough overlap in the normal times of usefulness of the several frequencies available, so that shifting to another frequency may give relief. There is, in addition, a kind of interruption which from the standpoint of continuity of service is more serious. At times of disturbance of the earth's magnetic field, known as "magnetic storms," short-wave radio transmission is generally subject to such high attenuation that signals become too weak to use and sometimes too weak to be distinguishable. These periods affect all the short wave lengths in use and may last from a few hours to possibly as much as two or three days in extreme cases. They are followed by a recovery period of one to several days in which transmission may be subnormal.

The cycle of events which accompanies magnetic storms is shown graphically in Fig. 14. It is apparent that the disturbances take about a day to reach their greatest intensity and the recovery to normal takes several days.

Experience indicates that on North and South routes such as between North and South America, the interruptions associated with magnetic storms are less severe and of shorter duration. Transmission paths which pass through the polar

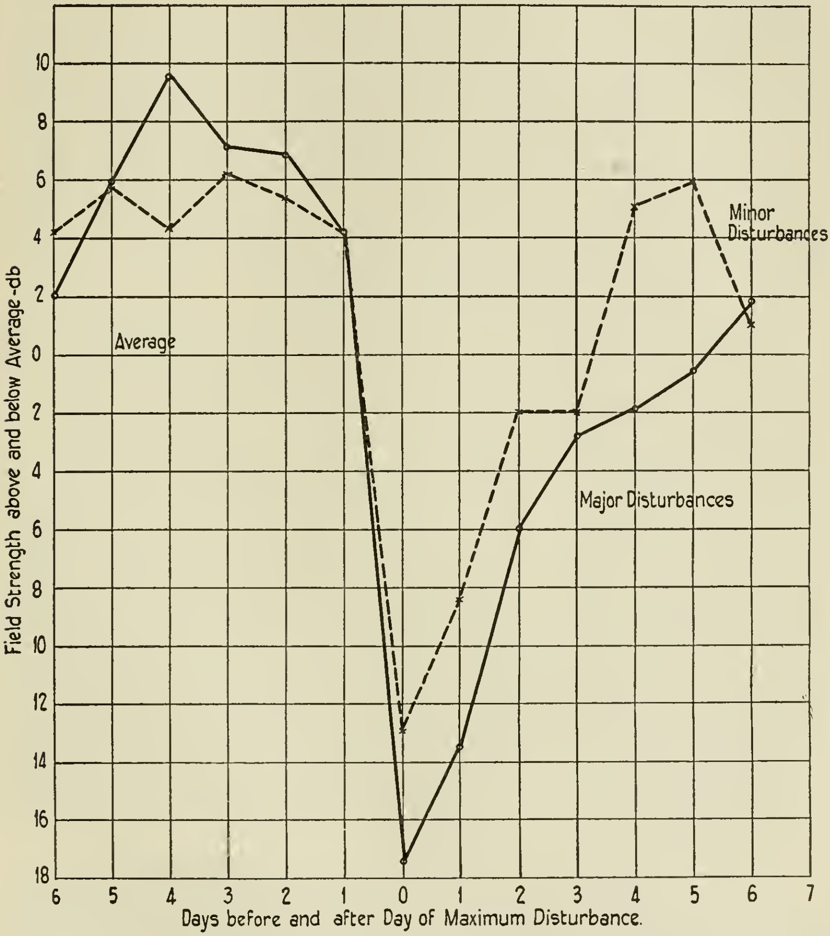


Fig. 14. Weakening of Received Short-wave Signals at Times of Magnetic Disturbance.

regions where the Aurora Borealis is common seem to be most affected.

All these vagaries of short-wave transmission, including diurnal and seasonal variations, fading, distortion, and magnetic storm effects, appear to be caused by or dependent on the characteristics of the earth's upper atmosphere at levels far above those subject to direct meteorological observation. The atmosphere at 50 to 100 miles above the earth is a rarified gas, ionized by the action of the sun. These ionized layers have radio transmission characteristics widely different from those of our lower atmosphere. The radio investigator is devising many novel methods of studying them by their effects on special forms of test signals, but the subject is one which has far to go before it can do more than furnish empirical bases of action to the designing engineer.

One of the things it is desirable to know is the height of these layers above the earth. To measure the height, the radio engineer has adapted to his purpose a time honored device of the marine navigator. In certain waters where the shore is lined with cliffs, pilots when in a fog sometimes determine the distance to shore by noting the time between the blowing of the ship's whistle and the return of the echo from the cliffs. The radio investigator uses an electrical timing device called an oscillograph which makes a photographic record on a moving film. He records the time of departure of a short radio pulse and the time at which echoes reflected from the overhead layers are received in a nearby radio receiver only a thousandth of a second or so later. By such experiments, reflecting atmospheric layers are found at apparent heights of 70 to over 300 miles above the earth's surface.

Another interesting line of study in this subject is the correlation of natural earth currents with variations in radio transmission. There are electric currents flowing in the earth much as there are natural currents of water in the ocean. A recording galvanometer connected by a telegraph wire between two ground connections separated by a few miles or more may be used to record the difference of potential between these points which is a measure of the current flow. The larger variations on such records are found usually to coincide with poor short-wave radio transmission.

Privacy

So far we have considered methods and devices designed to fashion from radio waves speech highways having many of the transmission characteristics of wire telephone circuits. There are other characteristics of wire circuits with which it is desirable to endow radio circuits for commercial telephone service. An important one is privacy. If the wire telephone is thought of as being like a speaking tube system where the voice is confined to a pipe and guided from speaker to listener, the radiotelephone may be likened to two people shouting to each other or talking through megaphones. Any one within hearing may listen in on the conversation without effort.

If two members of this audience, seated on opposite sides of the hall, were to stand up and carry on a conversation with each other in the English language, we would all hear and understand it. In fact, to a degree it would be forced upon our attentions. But if each of these two persons had brought with him, we shall say, a Laplander to whom he might whisper his questions and answers, the Laplanders could speak the translated words across the hall in their own language without our being the wiser for listening, unless perchance we were especially intrigued and had brought a Lap interpreter with us. A radiotelephone privacy system may be thought of as a sort of electrical interpreter.

Although perfect transmission of speech may be noticeably marred by the slightest defects in the transmission system, it is remarkable that speech currents may be subjected to severe distortion without complete sacrifice of their intelligibility. This ruggedness of speech currents is the principal stumbling block in the approach to the question of disguising speech to make it unintelligible. In developing privacy systems for use in transoceanic radiotelephony it has been necessary to devise means for converting speech into meaningless sounds, but in such a way that they may, by proper apparatus, be converted back into their original form at the receiving end. One of the simplest forms, by suitable modulation and filtering processes, inverts the entire speech frequency band, turning the bass into treble and the treble into bass. The result is to make English sound like some outlandish foreign tongue. A second inversion at the receiving end puts it back into its original form. Other more complicated systems divide the speech frequency band into several parts by means of electrical filters and then transpose these parts with reference to each other. Here again, retransposition at the receiving end brings back the original.

World Telephone Network

One of the most interesting of the activities of a development engineer is to study the probable future trend of an art and attempt to foresee new problems. In looking at world telephony with this attitude of mind we must see at once that it is now in a stage of rapid, sporadic growth and just beginning to enter the stage of integrated development and coordination which intracontinental wire telephone systems like our own in the United States have partly completed. Trunk routes such as North America to Europe may be expected to develop heavy loads of important traffic which require speed and reliability. That this trend is already under way is illustrated by the chart, Fig. 15, which shows the component parts of the growth so far occurring on the transatlantic system.

But what of the smaller outlying centers of population and local telephone development? How will they talk to the world? Speaking broadly, a radio path can be set up from one station to another in any direction simply by pointing antennas in that direction and using a wave length suited to the distance and time of day. It is not difficult to envisage,

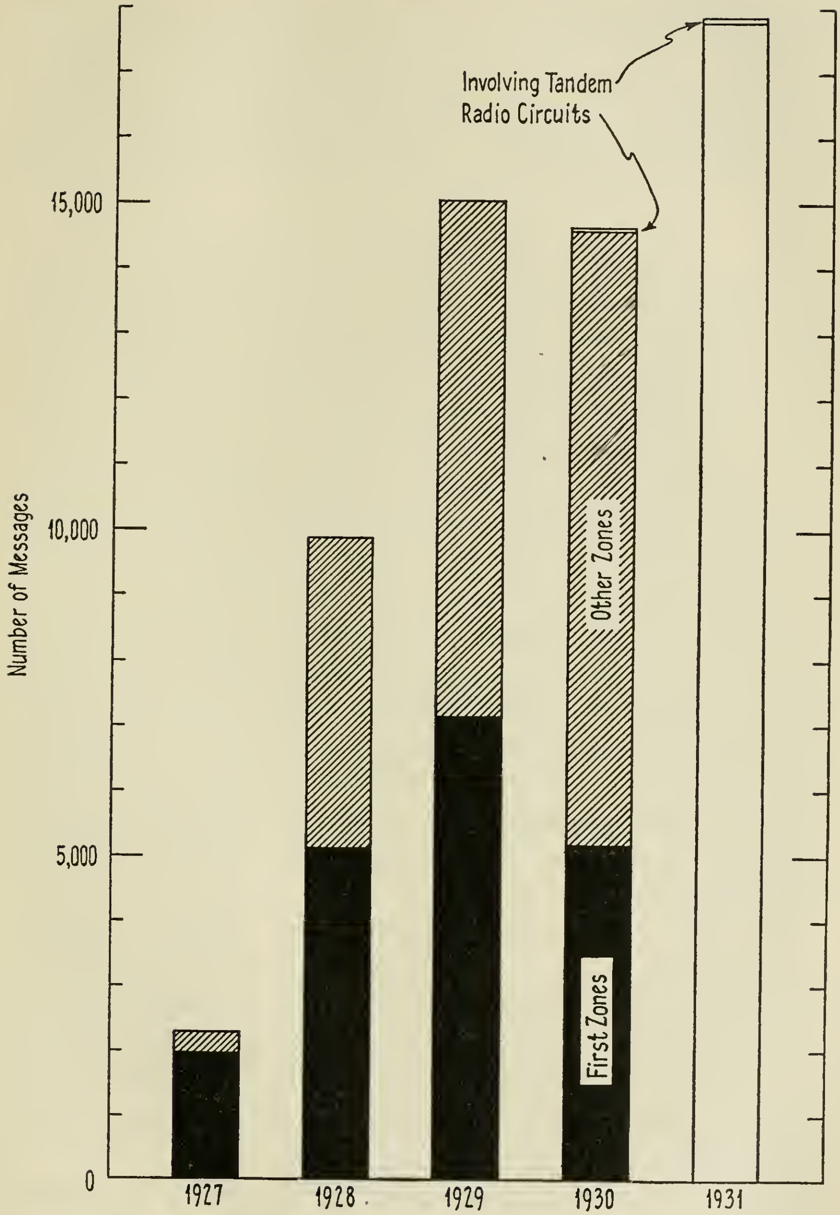


Fig. 15. Growth of Transatlantic Radiotelephone Traffic.

for example, at such a point as the Hawaiian Islands, a radiotelephone station able to work in almost any direction and connecting with other stations scattered over the world to set up connections between telephone users near these respective stations, as demanded. The luminiferous aether would become the switchboard, and the radio waves the operator's cords.

The engineer may appreciate the poetry of this conception but he is constrained by the liberal rather than the fine arts. The Hawaiian Islands have their greatest community of interest with the United States and are linked to it by a radiotelephone system. It is more economical to handle the occasional call from the Mid-Pacific to another outlying point by relay or tandem connection through trunk routes to some center where a circuit to that point is available. For example, a call from Hawaii to Bermuda would naturally go by way of San Francisco and by wire to New York whence a radio circuit connects to Bermuda. The stations on these two island groups are not sufficiently powerful for reliable direct communication, but they easily reach the nearest continental centers, and these are joined by efficient wire lines. It is evident that over-water trunk routes might be involved in such connections. If, for example, it were desired to interconnect Bermuda with a point in Europe, this might be done by way of New York and London.

This line of speculation would tend to indicate that radio links pieced end to end with wires are the ultimate method of connecting widely separated points. But Australia has great community of interest with antipodal England and has its only long distance overseas connection directly with London. Circuits over the longest possible distances obviously have a place in the scheme and merit technical study.

Without attempting any predictions as to the form the world telephone network may ultimately assume, it seems clear that (1) radio links may be called upon to interconnect with other radio links and must, therefore, be made more perfect than would be necessary simply for communication between their terminal wire networks and (2) main trunk routes tend to become so important that their need for reliability and excellence may well tax the capabilities of the telephone art for some years to come.

Intercontinental Wire Telephony

On the important route between North America and Europe the capabilities of both long- and short-wave radio in their present stage of development have already been enlisted. Together they give more reliable service than could either alone. Recent developments in the submarine cable art have brought it also into the field and preliminary steps have already been taken toward the laying of the first transatlantic telephone cable.

In its technical system aspects, the cable shares many of the problems of the radio. Intermediate repeater stations are not at present practicable and the entire attenuation of the path must be made up by terminal amplifiers. Voice-operated switching systems are necessary. Reducing the attenuation offered by the cable to the higher frequencies essential to voice transmission has been made possible by extended researches in the field of special materials for insulating and electrically loading the single conductor type of cable used for deep sea conditions.

Whether submarine cables and new overland wire routes can ultimately take over a large part of the field of intercontinental telephony which radio has pioneered, or radio will be so improved as to maintain its place, only the future can tell. But it seems quite certain that a new era in long distance telephone communication has definitely opened and that research and development will again be expected to turn the miracle of today into the commonplace of tomorrow.

Ralph Bown

Picture Transmission and Television

A lecture delivered at the Lowell Institute, Boston, Massachusetts, January 15, 1932.

IN PREVIOUS lectures of this series, you have heard almost exclusively about the problems encountered in transmitting signals to be perceived by the ear. It is my purpose to-night to tell you about the problems encountered when our electrical communication systems are used to carry signals to be perceived by the eye. At the outset let it be clearly understood that there is nothing in our communication channels, whether these be metallic wires or the hypothetical ether, which differentiates between messages which originate as light or as sound, or which must be received by the eye or by the ear. In every case, the transmission medium carries electrical signals, that is, electrical currents which vary from time to time in intensity. Whether these signals shall be translatable into light or into sound is a question of what kind of terminal apparatus is used in conjunction with the communication channel. This does not, however, mean that a communication channel which has been established and engineered for the transmission of signals originated by sounds will necessarily be satisfactory or adequate for the transmission of signals originated by light. There are characteristic differences between the kind of sound signals that we are interested in transmitting and the kind of light signals that we wish to translate into and recover from electrically transmitted signals. These differences go back to certain fundamental characteristics of our human organs of sight and of hearing, and for a complete understanding of these, we must take a few minutes to discuss the eye and the ear.

Sounds are essentially "single track" signals. The vibrations of matter which are detected by the ear and the auditory nerve constitute a single sequence of pulses or variations in intensity following one after another, differentiated from each other only in frequency and intensity. Consequently in the transmission of sound signals by electricity, a single electrical channel, such as a wire, is adequate, provided only that it is capable of conveying signals rapidly enough and without distortions such as those of intensity or of the relations of one signal to another in time; that is, in proper phase relation. When we consider the eye, we find a very different state of affairs. Our visual signals originate not along a single channel, but along a vast number, reflecting the fact that our visual field of perception is spread out into two dimensions, that is, it has *area*. Let us refer to Figure 1, which is a representative picture, such as is presented to the eye at any instant, and which we might wish to transmit to a distant point by electrical means. This may be analyzed into a very large number of small elements, each of uniform brightness, but which may differ in brightness value from any of the elements adjoining it. In order to appreciate this picture all of these elements must be perceived in their relative values *simultaneously*. In the human eye we have a light sensitive device capable of sending to the brain just such a group of simultaneous impressions. An image of the picture or scene is formed upon the back of the eyeball or retina by means of the crystalline lens, as shown in Figure 2. The retina consists of an extremely large number, many millions, of small separate light sensitive elements, called rods and cones; each so small that the images of all the ordinary objects with which we are concerned in our everyday life are divided up into imperceptibly small elements, in the same manner but to a much more refined degree than the little squares shown in Figure 1. From each of these sensitive retinal elements a separate nerve fibre goes through that cable or bundle of nerve elements called the "optic nerve" to the brain. As the scene presented to the eye changes from instant to instant, the signals sent from the light sensitive elements through the fibrils of the optic nerve also change. If we admit, for the sake of argument, that each of the millions of nerve fibrils in the optic nerve is a conducting channel similar to the single auditory nerve, then we may say that the job of the optic nerve is to send *millions* of sequences of "sounds" while the auditory nerve is sending only a *single* sequence of sounds. Or to put it in another way, if our sense of vision were only that of the most primitive organisms, which appreciate merely variations of light, but have no optical system provided by which images may be formed, then the communication channels between the eye and the brain, and the ear and the brain, could be essentially the same.

If our technical development of image transmission systems were bound to slavishly follow the examples set by nature, we would proceed to devise picture and image transmitting systems in which, in place for instance of a single telephone wire, we bound up into one cable some thousands or even millions of wires, furnishing this cable at the sending end with an artificial retina or mosaic of light sensitive elements which would send an appropriate electrical signal from each small element of the image upon it.

There have not been wanting inventors who have proposed to do just this thing, that is, to build what are called "multichannel" picture transmission systems. The number of electrical conductors required is, however, so enormous for a picture containing any useful amount of detail that such systems have, by general consent, been agreed to be quite impracticable. Instead, all picture and image transmitting systems which have met with any success, have done with signals originated by light from a picture exactly what we do with signals originated by sound; that is, they send them over the communication channel in sequence, that is, one after another. Thus to illustrate from Figure 1, the light signal originated by the small element in the upper left-hand corner is transmitted first, then the signal from the next adjacent element to the right followed by

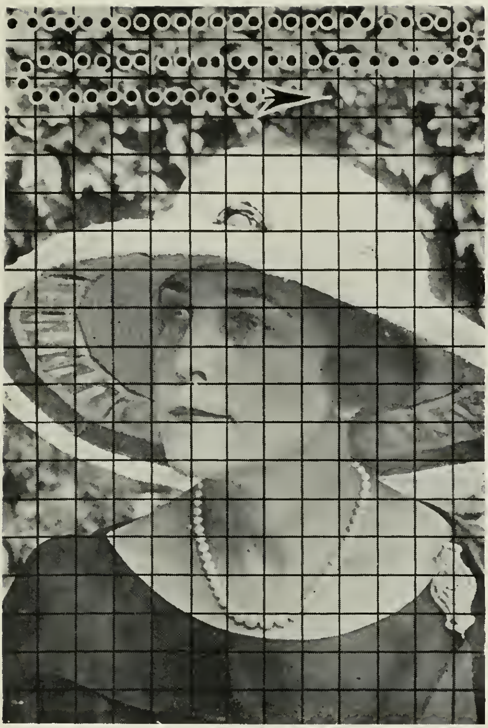


Fig. 1. Picture Divided Into Small Elements, to Illustrate the Process of Scanning.

Fig. 3. Alkali Metal Photoelectric Cell, as Used in Electrical Picture Transmission.

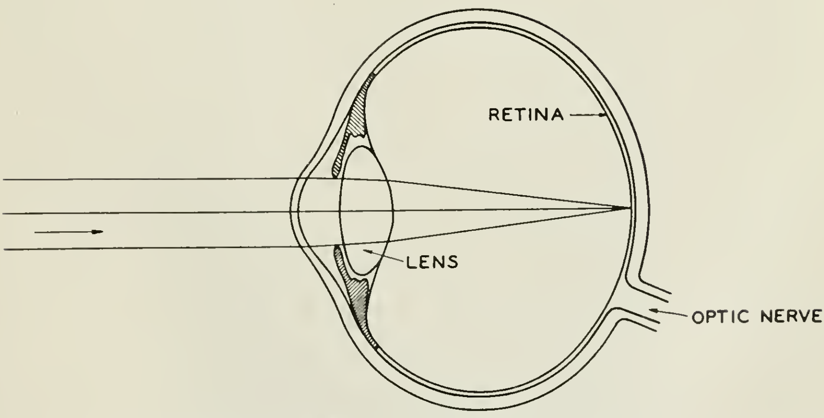


Fig. 2. Schematic Section of Human Eye.

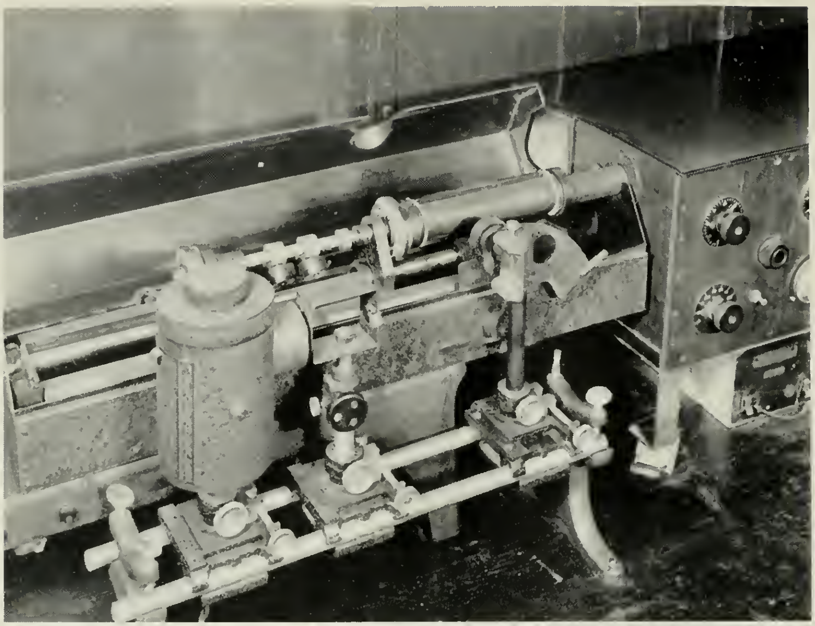


Fig. 4. Photograph of Scanning Drum Used in Picture Transmission.

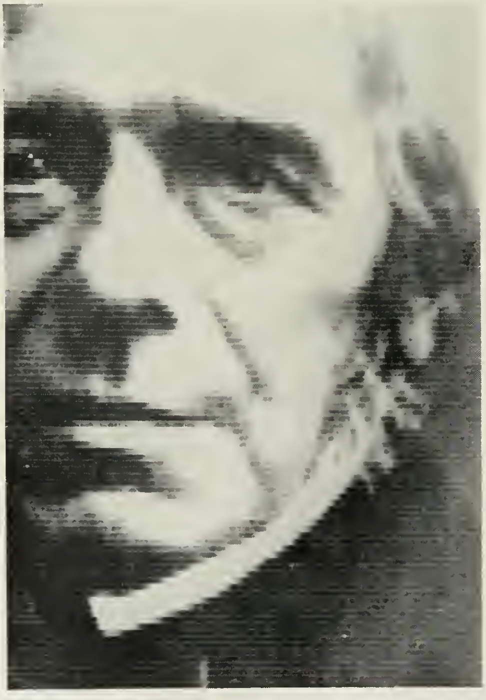


Fig. 6. Enlargement of Small Section of Electrically Transmitted Picture.

the 3d, 4th, 5th, and so on, and then in turn by the signals from all the elements in all the rows and columns of the picture. The process of picking up signals from each element of a picture in turn, translating what is in vision a simultaneous presentation into a series of presentations, is called *"scanning,"* an operation which is fundamental to all present day systems of electrical picture transmission and television.

Now there is a fundamental consequence of this process of scanning. This is that the transmission of all of the signals which convey the characteristics of a picture or scene takes *time.* Those characteristics of a visual impression which, as compared to an auditory impression, demand *space,* can be met, where a process of scanning is used, only by calling upon the other one of our fundamental variables, namely *time.* We shall see as the problem develops, that this requirement for time may dominate our task in either of two ways. Either we must take a considerable overall time for the transmission of a picture, say a matter of minutes for a picture which can be seen in the flash of an eye, or our communication systems must be so built that they transmit signals at enormously higher speeds than are necessary in the case of sound.

With this introduction, we are prepared to discuss understandingly the two chief developments in the electrical transmission of images, namely the electrical transmission of pictures, and television. These two developments are, in many of their fundamentals, closely similar to each other. They do, however, differ in this fundamental respect, that in the case of picture transmission, the transmission is relatively slow, and practical systems have been adapted to operate at the speeds which are set by communication channels already in existence and engineered for the transmission of sound, that is telephone lines. On the other hand, any television transmission must be so rapid that the transmitted image runs with the scene itself, and for this purpose, communication channels adequate for sound are hopelessly left behind in the race, and new and extraordinarily severe communication requirements must be met.

The Electrical Transmission of Pictures

In the time at my disposal, it will not be possible nor is it appropriate that I attempt to give a history of the subject of picture transmission, nor that I attempt to describe all the present-day forms of apparatus. I shall instead select one, namely that now in operation between a number of the principal cities of this country by the American Telephone and Telegraph Company. I shall in this discussion, however, plan to emphasize the functions of the various parts of this system rather than the particular form which these structural elements take, so that you may carry away an idea of the essentials of the problem, on the basis of which you will be easily able to understand other methods of meeting the same fundamental requirements.

The first essential for a picture transmission system is a device corresponding to the retina of the eye, or, since we shall assume a method of *scanning* or presentation of all parts of the picture in sequence, the equivalent of a single light sensitive element of the retina, a rod or cone. We must have a light sensitive device whose reaction to light takes the form of producing an electrical current. For this purpose, we use today the photoelectric cell, which makes use of a phenomenon first discovered by Heinrich Hertz, namely, that certain substances become electrically charged, when light shines upon them or, as we now put it more specifically, give off electrons. Photoelectric cells, a typical sample of which is shown in Figure 3, now used in picture transmission, consist of glass bulbs similar in some respects to those enclosing filaments of incandescent electric lamps or the now familiar vacuum tubes used in wire and radio communication. In such a glass bulb, which is evacuated to a low gaseous pressure, is a cathode of alkali metal, such as potassium or caesium. Standing opposite to the cathode is a metal collector which may be a wire ring or a grid, which is also connected through a leading-in wire to an external electrode. If the two electrodes are connected together through a galvanometer, no current is observed when the cell is in the dark. When light falls upon the alkali metal cathode, a current flows. This current has two valuable characteristics for our purpose. It is proportional in strength to the intensity of the light, and it follows the variations of intensity of the light practically instantaneously. This current has, however, a very serious defect which is that it is excessively small, thousands of times smaller, under any practical illumination such as the light reflected from a picture, than are the currents which are produced by a telephone transmitter, and which all our existing telephone lines are fitted to carry. While the photoelectric cell has been known for a matter of thirty or forty years, it is this particular limitation which has prevented its use in picture transmission, and thereby has postponed the practical transmission of pictures to a very recent date. What was needed was exactly the thing which was required to make long distant telephony possible; namely, a "repeater" or amplifier which could step up small currents to large values. The amplifying device which has made this possible is the three-electrode vacuum tube, which has come into such enormous use with the expansion of long distance telephone service and the development of radio. By its means, the faithful but minute photoelectric currents are boosted in value by thousands or millions of times, and become acceptable to our telephone lines. The "eye" of our present-day picture transmitting systems therefore consists of an alkali metal photoelectric cell with which is associated a vacuum tube amplifier system; the whole constituting a device which, when illuminated by a sequence of *light* signals, delivers to the telephone line a sequence of *electrical* signals similar in intensity to these signals which are originated in the telephone transmitter and which are ultimately to be recreated as sound.

The second element of a picture transmission system which we shall consider is the practical means for *scanning* the picture. One method of scanning, which is familiar to everyone, is that exemplified by the back and forth motion of a typewriter carriage. If we place our picture, which is to be transmitted, on a typewriter, and focus upon it a small bright spot of light and then place close to this spot of light a photoelectric cell, it is readily seen that as we punch the spacing key different elements of the picture come opposite the spot of light in turn, and our photoelectric call with its associated amplifying system would deliver currents of different strength to the telephone line. The reciprocal motion of the typewriter carriage is, however, mechanically inefficient because of the changes of direction of motion and the frequent stops, and has not often been used in picture transmission. Figure 4 shows a photograph of the scanning device which has been most commonly employed. This is a cylinder around which the picture to be transmitted is tightly wrapped. Means are provided for rotating the cylinder and at the same time moving it along parallel to its axis, or, sometimes, the light source which concentrates the small bright spot of light on the cylinder is moved along while the cylinder merely rotates. In either case, the result is that the small spot of light describes a helical course around the cylinder and in its complete progress from one end to the other covers in succession every part of the picture, thus building up a sequence of signals. So much for the sending end. At the receiving end, this long procession of signals must be reassembled in rows and columns exactly corresponding to the positions of the picture elements which originated them. For this purpose, an exactly similar scanning device is demanded at the receiving end, that is, another rotating cylinder on which is tightly wound some sort of receiving surface upon which can be impressed spots of varying intensity or reflecting power.

With this brief statement, we can dismiss the mechanical features of the scanning process, leaving for more detailed discussion two further features: first, the means for translating the incoming electrical signals into light and shade in the received picture, and second, the means for assuring that the two scanning mechanisms rotate in perfect step with each other, or are *synchronized.* Taking up the first of these problems, we shall assume at once that reception is to be made photographically; that is, we are to place upon the receiving cylinder a piece of photographic paper or sensitive film, and we are to expose it to a light whose intensity shall vary in accordance

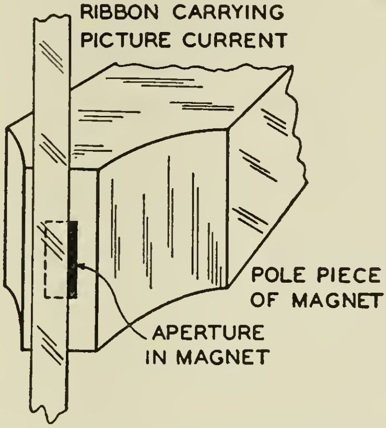


Fig. 5. The Light Valve Used in the Reception of Electrically Transmitted Pictures.

with the signals. We have therefore to produce, just as at the sending end, a small spot of light, but whereas at the sending end the spot of light is of constant intensity and the portion of it which is reflected to the photoelectric cell varies, the spot of light at the receiving end must itself fluctuate in accordance with the signals. In the picture transmission system which we are describing, this variation of the intensity of the light is brought about by what is called a "light valve." The essentials of this are shown in Figure 5. There is first of all a narrow metal ribbon through which the incoming picture currents pass. This ribbon stands directly in front of the pole-piece of a magnet. In this pole-piece, there is a small aperture through which shines an intense light which is focussed into a small spot which falls on the sensitive film. When there is no current passing through the narrow ribbon, the ribbon is so positioned as to obstruct all the light coming through the pole-piece of the magnet. When, however, a current flows through the ribbon, the interaction of the current and the magnetic field causes the ribbon to move sidewise and so transmit more or less light to the film. This is a simplified account of the operation of the light valve, to which I shall return, discussing it in greater detail after dealing with some of the other aspects of the problem.

There remains one fundamental problem in picture transmission, and that is the matter of synchronization. If the two cylinders at the sending and receiving ends rotate at different but uniform speeds, the successive strips of which the received picture is built up will be displaced, and the whole picture, as a result, will be warped or skewed. If, during the process of transmission, one cylinder fluctuates in its speed, that is, goes faster than the other for a time, then slower, a local distortion or jiggle of the picture results. The two cylinders must in short rotate at the same speed to a high degree of accuracy. One method of securing this, which has been used extensively, is to operate the two ends of the picture transmission system by electric motors which are driven from the same source of high frequency current; this source being in turn controlled by an accurate tuning fork. This requires a separate communication channel from that used for the picture, and this method has been in part superseded by a method which has been made possible by the great advances in recent years in superaccurate forms of clocks. The "clocks" now used in the Bell System picture transmission system consist of tuning forks enclosed in constant temperature baths which, when adjusted to a given standard frequency, will maintain this frequency for long periods of time without varying enough to appreciably distort the picture. These forks in turn operate electric motors of the phonic wheel type, which are pulled back to speed or speeded up as their poles attempt to get out of step with the electrical pulses delivered by the accurate tuning forks.

We are now ready to discuss the important matter of transmitting the electrical signals which go between the two rotating cylinders and the light translating devices associated with them. It has already been said that these signals are quite similar to those originated and utilized by telephone transmitters and receivers. Now historically the present practical picture transmission systems have been a very recent development, and an essential requirement they have had to meet is that their signals should not merely be similar to ordinary telephone signals, but that they shall adapt themselves rather accurately to certain characteristic limitations which modern telephone lines embody as a result of their having been engineered primarily for voice transmission. One of the reactions of the characteristics of ordinary telephone lines on picture transmission is the matter of speed. We are not at liberty to run our picture transmission cylinders at any speed we want, for the simple reason that if we operate the cylinders too fast the signals run up to much higher frequencies than those present in the voice. The telephone lines being only built to carry voice frequencies, would not transmit these high speed signals and detail would be lost in the pictures. The electrical signals which are originated either by pictures or by the voice can be analyzed into what is known as a Fourier series, which shows that they correspond to the superposition of a large number of different frequencies of vibration. In the case of the voice, these frequencies run from 200 or 300 per second up to some thousands per second. For speech to be intelligibly transmitted, we must transmit a range of frequencies or a " frequency band " as it is called from about 300 to 3000 cycles or back and forth variations per second, and ordinary telephone lines are set up to carry just this band. Frequencies above this higher figure do not go across, and frequencies below this lower figure, not being necessary for speech, have been neglected in telephone engineering and can now be transmitted only by special arrangements of line elements.

Now first of all, with regard to the question of speed of picture transmission. The picture cylinders must be rotated at a sufficiently low speed such that the finest picture elements which we wish to transmit do not cause variations of current occurring more than 3000 times per second. What the upper limit of this speed shall be is a simple matter of arithmetic, in which the factors are the size of our little spot of light, which represents the smallest detail which can be distinguished in the scanning operation, and the number of rotations per second of the cylinder. In the American Telephone and Telegraph Company system, to give a practical figure, the small spot of light is 1/100″ square. The picture transmitted is 5 inches × 7 inches in size, and the overall time for sending this over a telephone line is approximately seven minutes. This is well below the upper limit of speed which may be computed as indicated above. An enlarged reproduction of a portion of such a picture is shown in Figure 6. (*Figure 6 faces page 121.*)

In general, any telephone line which will transmit telephone messages faithfully in all respects is suitable for the transmission of pictures by a system, such as that we have described, which has been carefully fitted into the frequency limitations characteristic of telephone transmission. However, picture transmission imposes certain special requirements on a transmission system different from those for voice transmission. The picture constitutes a permanent record of conditions during the period of transmission, whereas the characteristics of the voice signals are to a large degree forgotten shortly after they are perceived. Thus in listening to a telephone conversation, if the intensity rises and falls by a small amount, we either do not notice it or assume that the speaker is moving his head with respect to the transmitting instrument. If small disturbances, such as extraneous noise, or let us say a cough, interrupt the speech, they are disregarded. If there are slight echoes, either actual sound echoes or echoes in the electrical system, they are discounted. With a picture, however, if the transmission level changes,—the phenomenon of "fading" in radio—the resultant picture shows permanent areas of different intensity. Disturbances of transmission which we call "static" in radio show as permanent blotches, and echoes show as repeated images; all of which may easily destroy the value of the picture. So, as a matter of practical transmission engineering, it has been found that the transmission lines must be maintained to a more uniform level of performance for picture transmission than was formerly considered necessary in voice transmission. For the same reason, radio, with its many electrical disturbances, has never been found as suitable for picture transmission as have wire systems.

There is one other point connected with transmission, and that is how the very low frequencies are transmitted. These, as already stated, are not present in the voice and the telephone lines do not transmit them. In a picture, however, frequencies will be present from that represented by the speed of rotation of the cylinder, say one cycle per second, up. Now in order to transmit all of these low frequencies, we make use of the same scheme which is used in putting signals on to the air in wireless telephony. That is we use the picture signals to modulate or to vary the intensity of a steady high frequency current, which is called the "carrier." In the case of picture transmission, we choose a carrier lying in the voice frequency range, say about 1500 cycles per second, and by means of a modulating device we impress upon this the picture signals, with the result that they are now spread out into frequencies above and below the carrier value in what are called "sidebands," the lower one of which now lies wholly above that of the frequency region which the telephone lines do not transmit. Now let us return for a minute to the light valve, which has been described above as opening and closing in proportion to the strength of the signals. We have to modify our description now to this extent that instead of imagining the valve to be opening and closing relatively slowly in the direct proportion of the original light signals, the ribbon actually vibrates at this carrier frequency, with varying amplitude. The impression upon the photographic sensitive surface, therefore, consists of a band of photographic action in which the intensity is varying some 1500 times per second, whereby the picture, examined with a microscope, would exhibit fine strips or cross hatchings. These are however in practice so smoothed out by the finite size of the spot of light as to be rarely detectable. Mention of them is however necessary to build the complete story of the production of the picture.

With this necessarily somewhat superficial description of a typical picture transmission system, we must pass on, for we still have the second of our problems—that of television, to discuss. Before proceeding to this, however, something should be said about the field of usefulness of picture transmission. In general, of course, a photo-telegraphic system finds its primary use in the transmission of information in which form and arrangement are essential factors. In this category fall primarily, pictures, such as news photographs; but there are many other subjects logically calling for transmission by such a system. These are construction drawings, advertising material, particularly such as embody pictures, special arrangements of type, or a large range of significant figures which might readily be misinterpreted over an ordinary telegraph system. An excellent illustration of this is given by financial advertisements, carrying numbers or prices of stocks and bonds which must be simultaneously advertised over the whole country. Contracts and legal manuscripts of all sorts in which absolute facsimile fidelity is required are at times profitably routed over the picture transmission system. It is, however, to be recognized that the elements of time and of expense are of dominating importance in electrical picture transmission. Even for those pictures and documents which must be transmitted with the perfect fidelity which the picture transmission system provides, the use of electrical communication systems is only indicated if the information must be secured *sooner* than it can be through the mails, or particularly now, by air mail. The urgency of securing accurate information must be matched against the cost of electrical transmission, which at present is somewhat greater than the cost of telephone conversations occupying the same length of time. Thus in the system which we have discussed, if all of the pictorial information can be embodied in a 5 inch × 7 inch picture, the transmission costs cannot reasonably be expected to be less than those for a seven minute telephone conversation, which, over such distances as New York to San Francisco, is of necessity much greater than the postage rates on the same material.

Television

By television is ordinarily understood the transmission by electrical means of moving images at such a speed that the images are produced concurrently with the original scene, that is, the actions in the reproduced image occur not only *at the same speed,* but *simultaneously* with the original action. We can no longer, as in the case of picture transmission, allow a matter of minutes for the picture to be developed. The image must, like the image on the retina of the eye, be complete at any instant and capable of complete change from one instant to another. In order to meet this requirement absolutely, it would be necessary to copy the multi-channel communication system used in the optic nerve, that is, the process of scanning which has been described in connection with picture transmission would be inapplicable. There is, however, a loophole, which does permit us to use the process of scanning, which is the only practical one for image transmission. This loophole is provided by the fact that the process of vision in the human eye is incapable of distinguishing between images which are continuously complete and images which are presented for only a part of the time, *provided* the intervals between these images be short enough. The phenomenon in question is called "persistence of vision" and is used by us whenever we view an ordinary motion picture. This interval between successively presented pictures, which causes them to appear continuous, is about 1/20 of a second, so that in our immediate problem, if the scanning operations and the transmission of signals can be performed for a complete image or field of vision in 1/20 of a second, the signals can be transmitted in sequence, and the problem of television remains essentially similar to that of picture transmission. There is, however, the important condition to be met that the speed of the various operations involved must be enormously increased over those satisfactory in picture transmission.

In order to carry with us an idea of the speeds of scanning and transmission which are called for by television and how these compare with the kind of transmission with which we are familiar in existing practical communication lines, such as are used in telephony, let us take the kind of picture we have already considered, that is, the 5 inch $\times$ 7 inch picture scanned in 100 strips per inch. This picture contains 100×100 or 10,000 elements per square inch or 350,000 elements altogether. It is transmitted in seven minutes, and the "sideband" or range of frequencies into which the transmitted signals may be analyzed, is approximately 400 cycles per second. Now if we are to transmit this same picture in 1/20 of a second, this frequency band must be multiplied by the ratio between seven minutes and 1/20 of a second, which is about 8000 times, giving a frequency band of over *three million cycles* per second. Compare this with the frequency band of approximately 2500 cycles on which intelligible speech may be transmitted, or the 5000 to 8000 cycle sideband which is used by our radio broadcasting stations, and we see at once that the transmission requirements as expressed in figures are extraordinarily great. The problem of television is affected by this requirement in two ways. First of all, communication channels are called for whose performance is altogether outside the range of anything which has heretofore been developed or used. In the second place, when we view the economic aspects of the problem, we must recognize that communication channels cost money, and that, broadly speaking, it is inevitable that television of the quality we have just assumed would pre-empt communication channels otherwise occupied by a thousand or more telephones or broadcasting stations, and that the cost in dollars and cents of television transmission must therefore be multiplied by a large ratio.

The problem of achieving television has been met, insofar as it has been met up to this time, not by developing or using apparatus and transmission channels which can carry the kind of image we would *choose,* because adequate apparatus and transmission lines have not been available, but by limiting ourselves to such primitive and coarse grained images as we *can* generate, with means provided by the present state of physical science, and can transmit over communication channels which are available. We crowd into a 20th of a second all that our present knowledge of physical phenomena and technical methods will permit; and the future of television promises to be a long pull to squeeze more and more into this 20th of a second fixed by persistence of vision.

The seriousness of the problem of television has just been illustrated in terms of transmission requirements, but it is not alone in the transmission that we meet with grave difficulties. The terminal apparatus of television, which converts light into electrical signals at one end and electrical signals back into light at the other, is also in difficulties when the number of image elements is made large enough to be of real value. One great difficulty has to do with the *amount* of light with which we must work at the two ends of the system. At the sending end, the amount of light which will fall on the photo-sensitive device is that which comes through some kind of small aperture of the size of an image element. As the scene to be transmitted is divided into more and more elements, these elements correspondingly decrease in size, and the amount of light acting on the photoelectric cell or other device soon becomes so small as to produce no useful effect. At the receiving end, we have a similar situation in that as the number of light producing elements out of which the picture is built becomes larger, the elements each become smaller and the time during which they can be turned on is decreased, consequently the brightness of the image which is built up at the receiving end always threatens to drop below the threshold of satisfactory vision. There are other obstacles to the attainment of high quality television, but these are sufficient illustrations of the general nature of these problems, and we may now profitably proceed to a description of the means by which our present day television has been attained.

As in the electrical transmission of pictures already described, the general scheme by which television is attained is by means of scanning devices coupled with light sensitive means at the sending end to convert light into electrical signals, and coupled with light producing means at the receiving end to convert electrical signals into light. Between the two ends is an electrical communication channel, and the two ends are operated in synchronism by some appropriate means. In order to present to you concretely what particular means have been found successful, I shall again describe one particular system, again a system as developed by the American Telephone and Telegraph Company and used in its first demonstration of television in 1927.

The scanning device used in this apparatus and in the majority of television apparatus thus far developed is a rotating flat circular disc in which is a spiral of small holes as illustrated in Figure 7. Close to the disc is placed a small aperture of approximately rectangular shape of such a size that as the disc rotates about its axis, only one hole of the spiral at a time is exposed by the aperture, and as the holes follow each other, adjacent narrow strips across the aperture are scanned until, on a complete revolution of the disc, the whole area is covered. All of the light which is to reach the photo-sensitive device at the sending end or the eye at the receiving end must go through these holes. Let us now direct our attention to Figure 8, where the sending end apparatus for the television system is shown in skeleton form. The scanning disc is readily recognized toward the left of the picture. In this case, it is a disc 15 inches in diameter, provided with 50 holes in its spiral. Off to the

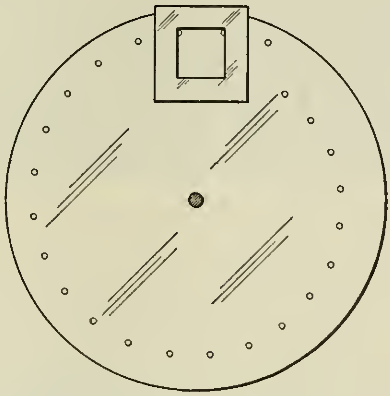


Fig. 7. The Scanning Disc, Widely Used in Television.

right of the figure is an intense source of light; in this case, a high power arc lamp. By means of condensing lenses, the light from the arc is concentrated in a spot on the back of the disc. A small part of this light goes through the particular hole of the disc which is behind a field limiting aperture and extends as a narrow pencil out to the left and falls upon the face of the subject. As the disc rotates at 20 revolutions per second, successive pencils of light sweep across the face so that it is completely scanned once during each revolution. Slightly to the left of the scanning disc and arranged in an inverted "U" form are seen three large photoelectric cells similar in nature but of much larger size than those used in picture transmission apparatus. These pick up the light reflected from the face and produce electrical currents whose intensity at any instant is governed by the reflecting power of the object on which the spot of light is then resting. This method of scanning is called "beam scanning" and is a scheme which has been devised particularly for television purposes in order to make the most efficient possible use of the light. While the spot of light is exceedingly intense and throws a relatively large amount of light to the photoelectric cells, it rests for such a short time over any spot, such as the eyes of the sitter, as to give an average illumination which is not too great for comfort. Ordinarily, of course, objects are illuminated by light which is constantly falling upon every part, and it is indeed possible to use a scanning disc with an object thus uniformly illuminated, but this illumination must be everywhere as intense as the small spot which is being used at any instant, and this means in television a very intense illumination indeed; such as full sunlight or intense flood lighting of the sort used in motion picture studios.

Electric currents generated in the photoelectric cells are next amplified many thousands of times by vacuum tube amplifying systems, the first elements of which are shown in the small boxes adjacent to the large photoelectric cells, and these currents when boosted to the magnitude of ordinary telephone currents are ready to be sent over a proper communication channel.

Going now for simplicity of discussion to the scanning means used at the receiving end, let us examine Figure 9. Here we have again a scanning disc with a spiral of holes with a small rectangular aperture in front which exposes only one hole at a time. Behind this disc is a light source, which in this case is an electrical glow lamp containing neon gas at a low pressure; this gas, when excited by an electric current, causes a glow of light to cover a flat plate electrode which is of the same size and shape as the aperture over the disc. In front of the disc to the left is shown the observer, who looks through the holes in the disc at the flat glowing area of the electrode. At any in-

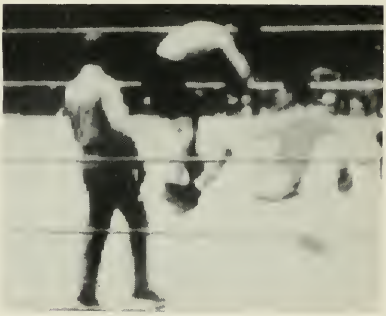
Fig. 8. Apparatus Used at the Sending End for Television.

Fig. 9. Television Receiving Apparatus.

Television images as they would appear if transmitted by usual methods over an ordinary broadcast band. 27 scanning lines, 600 elements, 5000 cycles.

With 40 scanning lines, using two ordinary broadcast channels, some improvement is noticed.

By using 72 scanning lines and ten ordinary broadcast channels, the appearance would be as above.



By using 120 scanning lines and employing twenty ordinary broadcast channels greater detail is gained as indicated in the group above.

FIG. 10. CHARACTER OF TELEVISION IMAGES CORRESPONDING TO DIFFERENT NUMBERS OF SCANNING LINES.

stant he sees, of course, only one hole and this hole is of the brightness corresponding to the intensity of the glow lamp at that instant. Since the disc is rotating at 20 revolutions a second, an observer is not conscious of the fact that he is seeing a single spot at a time. He sees the whole area of the aperture illuminated, but its brightness at any particular point is the brightness of the lamp at the instant when a scanning hole was at that point. Now if this receiving disc is rotating in exactly the same speed as the sending disc and is accurately in step or phase with the sending disc, and if further the variations in brightness of the glow lamp are accurately following the transmitted signals which originate in the photoelectric cells of Figure 8, then each point seen in the aperture over the receiving disc will correspond in brightness and position with the illuminated area in front of the sending end disc. In other words, the image will be recreated. It is obvious that the lamp which is used for receiving the electrical signals, in this case a neon glow lamp, must be extremely rapid in its action in order to follow the signals accurately, and it must be sufficiently bright so that with the 50 hole disc here shown 1/2500th of this brightness, which is all that one hole transmits, must still be bright enough to be satisfactorily visible.

Let us consider now the problem of synchronization. If the discs at the sending and receiving ends are going at uniform rates but not rotating at exactly the same speed, the image as received will drift out of "frame." If the discs are not rotating with a high degree of uniformity, the received image will waver in position and various parts of it may waver at different rates, introducing distortions of shape. The degree of uniformity of motion required for the two discs is very high. For instance, with the system under description, if one disc moves out of position by the width of a scanning hole, a distortion of the image will be easily noticeable, yet this deviation is only the distance which the disc moves in about 1/50,000th of a second. Synchronization in television, therefore, demands "clocks" or identical control means for the two ends of extraordinary accuracy. In the system under description, this control has been achieved by using synchronous electric motors, which are driven by high frequency currents of the order of 2000 cycles per second, generated by vacuum tube oscillators and transmitted over separate communication channels from those used for the images. Looking ahead to the future, one of the requirements for widely used television systems appears to be the provision of widespread accurately synchronized electrical circuits. The first step in this direction has been made in the accurate timing of the alternating currents now widely used for lighting and power supply, and a simple means of television synchronization where the highest accuracy is not required, is to drive both the sending and receiving ends from the same alternating current lighting supply.

We now come to the problem of transmitting the television signals from one scanning apparatus to the other. Before describing the characteristics of the actual lines used, let us consider the requirements and how they are arrived at. As already pointed out, in the case of the electrical transmission of pictures, the method of attack is to decide on the size of picture and the number of picture elements which must be transmitted in order that *the picture may be satisfactory*. *Then* a speed of transmission is picked such that this number of picture elements may be transmitted over some existing available transmission system, such as a telephone circuit. In the television system now under description, the problem was dominated not by the kind of image one would *like* to send, but the kind of picture that could be scanned and sent in our fundamental period of 1/20 second, considering the limitations of the apparatus and the transmission channels. Now on surveying the size of photoelectric currents which can be generated, the frequency bands which could be transmitted by special telephone circuits and the available light sources which could be made to follow electrical signals at high speed, it was found at the time of these experiments that a frequency band of about 20,000 cycles per second seemed a feasible thing to work to. If we work back, therefore, the arithmetic gives us a figure of about 50 holes as the number to be incorporated in our scanning discs. This means approximately 2500 image elements in our scanning rectangle. This is exceedingly small compared with the 350,000 which constituted a satisfactory number for transmission of a photograph for news purposes. What can we do with this small number of elements? An idea is obtained by noting that a coarse newspaper half-tone, which also consists of little picture elements, in this case dots of various sizes, contains 2500 elements in a rectangle about ¾ inch on the side. Now while not much of a picture can be included in a ¾ inch square of newspaper, it is true that if we restrict ourselves to a single face, we can get a recognizable picture with this number of elements. Accordingly, the first television transmissions, which met with any success, were transmissions of images of the human face. While in the several years which have elapsed since the first demonstrations the number of image elements has been slowly and laboriously increased (by a factor of approximately two) and wider transmission bands have been used, it is still the situation that satisfactory television transmission is restricted to one or at most two faces. While this is reasonably adequate for television in conjunction with the telephone, it is far below what we would like to have in television for purposes of home entertainment. It is however what we are now limited to by the capabilities of the best scanning and transmitting means which technical science has as yet produced.

A few words more about the transmission problem. The electrical signals produced by television scanning apparatus can, like those originating in sound, be transmitted over any kind of electrical communication system, that is, either by wire or by wireless, provided only that the band of frequencies transmitted is wide enough and is sufficiently free from irregularities in transmitting efficiency at the different frequencies or from time to time. Thus in the experimental demonstration in 1927, television images were sent by wire from Washington to New York, and the attainment of greater distances is merely a matter of setting up telephone lines to carry the necessary frequency bands with sufficient freedom from distortion. At the same time that the wire demonstration was given from Washington to New York, a demonstration was given of radio transmission of television between the Bell Laboratories experimental radio station at Whippany, New Jersey, and New York City, a distance of 27 miles, with similar results. However, as was found at that time and must be recognized in general, radio is more subject to disturbances of transmission, such as fading, static and multiple transmissions due to electrical echoes, than is wire transmission, and therefore presents a somewhat more difficult transmission problem.

The above description covers the essential problems presented by a simple and relatively crude television system. While there have been some interesting developments beyond the simple one-way apparatus we have considered, such as two-way television, for use in conjunction with the telephone, television in color, the projection of television images to large size (although, it is important to note, with no more detail), the use of television methods for sending images from motion picture film, the time at our disposal will not permit discussing these in detail. Our consideration of the subject can accordingly be most profitably concluded by a few words about the possible future developments and future uses of television.

The outstanding physical characteristic of television which offers a fundamental difficulty in its development is that improvement means inevitably the transmission of many more image elements than any physical means now available can generate, transmit or recover. While no figure can now be agreed upon as representing a "satisfactory" number of image elements for a television system, the several pictures in Figure 10, which show how the delineation of an image depends upon the number of elements, indicate clearly that this number must be very much higher than anything as yet attained in television. It is to be remembered that while in sound transmission, apparatus which will faithfully transmit the voice of a single person, will transmit equally well all the voices of a chorus, the situation with television is altogether different. As the number of faces is multiplied, so must the complexity of the apparatus and the transmission facilities be likewise increased. The problem of developing and constructing television apparatus to handle satisfactorily extended scenes such as are presented by athletic contests, public ceremonies or theater stages, is one the method of whose solution is not clearly visioned at the present time. Even when the means are discovered or developed, it appears inevitable that the cost must be relatively very high compared with any other form of electrical communication. The two-way television system in experimental operation by the American Telephone and Telegraph Company, which transmits only a single face in each direction, uses communication facilities which could otherwise be utilized to carry about fifteen telephone conversations, so that the cost of performing this relatively simple television task would, on a commercial basis, of necessity be many times that of ordinary telephony. The cost of transmitting extended scenes by television must, insofar as the communication channel cost is concerned, be tens or even hundreds of times greater than satisfactory sound transmission. These facts make the future of television, to a large extent, an economic question. What value will be placed by the public on the addition of sight to sound? This question in turn may be considered under two aspects; one, is what value is to be placed upon *simultaneity* of event and viewing, and the other is what value is to be placed upon the transmission of images by *electrical* means as contrasted with their transportation by other existing methods. In television used as an adjunct to the telephone, it is, of course, essential that the image be sent simultaneously with the sound by which the two-way conversation is carried on. In image transmission for purposes of entertainment, on the other hand, the element of simultaneity, which pertains to television in its strictest interpretation, is probably not generally necessary. As a consequence, many of the functions often thought of as belonging to television are really quite adequately taken care of by quickly transported motion picture film. If instead of carrying the motion picture film from place to place, motion picture images could be transported electrically by a television system, the choice between the use of a home motion picture projector and a television apparatus receiving film images from a broadcasting station would depend entirely on the question of cost and convenience. The comparison is similar to that between the possession of a phonograph and the possession of a radio set. Practically, the present radio provides a very large library of sound records and saves the listener the labor of changing records. Should television be so developed as to compare in simplicity and cost with the home motion picture projector about as the present-day radio does with the phonograph, its future as a form of entertainment would probably be assured. At the present time, the technical and economic obstacles appear to make such a consummation far distant.

Herbert E. Ives

Utilizing the Results of Fundamental Research in the Communication Field

A lecture delivered at the Lowell Institute, Boston, Massachusetts, January 22, 1932

WHEN the suggestion of a course or series of lectures for the Lowell Institute on the application of science in electrical communication was first broached, the question of how best to cover so vast and diverse a subject, within the limits of seven or eight short lectures, immediately arose. It was finally decided to resort to the series rather than the course method and to handle the matter as is outlined on your program. Whether we succeed or not, what we attempted to do was to present first, in Dr. Arnold's lecture, something of the methods and processes by which science is being applied in the field of electrical communication, and to illustrate types of problems with which we in that field are confronted.

Following Dr. Arnold's address we have attempted, in the addresses of Dr. Fletcher, Dr. Bown, Dr. Ives and Mr. Otterson, to present first in Dr. Fletcher's address a picture of those fundamental problems in speech and hearing which are at the very base of that part of electrical communication which is telephony. The addresses by Dr. Bown, Dr. Ives and Mr. Otterson have sought to give you a glimpse of what is involved in one of the newer developments of telephonic communication and in a few of the by-product results which have developed in our attempt to advance and expand the main body of telephony and telegraphy through a well organized long continued application of scientific knowledge and scientific research.

In these last two addresses of the series Mr. Page and I will attempt to present, first, a general overall picture of how we have utilized and are seeking to utilize the results of fundamental research in the communication field, and second, something of our picture of the social aspects of communication development and a bit of the philosophy which has guided us of the Bell System in our endeavor to broaden, to better and to cheapen the tool of electrical communication.

Arranging for presentation in this way has the possible risk of leaving you with an erroneous idea of the magnitude and scope of our scientific work and of the fields in which our maximum effort is applied. In a word, it may tend to leave you with the thought that our principal scientific interest is along the outlying fringe of electrical communication and in the region of the by-product satellites. Such is distinctly not the fact, as I shall indicate to you a little later. Our reason for choosing the particular topics which we did was partly because of the sheer impossibility of presenting a fair and interesting picture of our entire scientific activity in a limited number of detail papers; partly because of the inherent interest which resides in the newest things of applied science, and partly because some of these newer things combine in their solution the maximum of all that we now know about the possibility of applying scientific knowledge usefully. With this explanation and against the background of the preceding lectures it is my task this evening to attempt to give you in words, and without the aid of charts, slides or demonstration apparatus, an overall picture of the manner, method and extent to which we utilize the results of fundamental research in the field of electrical communication.

Before undertaking this task a word of explanation is required as to the meaning of the word "fundamental" in connection with research, as I propose to use it. In scientific parlance the word "fundamental" when associated with research has come commonly to designate that type of research which has to do with the acquisition of new knowledge dissociated from any idea of possible utilitarian application. In this sense it is the type of scientific research work which is sometimes designated as "pure" research in contradistinction to "industrial" research. In this sense the use of the word "fundamental" is preferable to the use of the word "pure" because of the implication contained in the latter that all other forms of research are impure.

In the sense in which I propose to employ the term "fundamental" this evening, you should understand that it embraces not only all that is contained in the scope of its general usage but also embraces all that portion of scientific research which is fundamental to the application of science in the field of communication. Put another way, it embraces everything derivable in the way of new knowledge that is productive of the elements from which new or improved communication structures can be created.

Reduced to its simplest fundamental elements, every electrical communication system involves two main and essential elements, the terminal apparatus and the channel for transmitting electrical impulses between the terminal apparatus. In very simple communication systems these two elements are sufficient and whatever other things are required are merely in the nature of conveniences to facilitate operation. Where, however, as is the case in telephony generally, and in modern telegraphy to a large extent substantially, ability to make rapid interchange between different terminals is a primary requisite to successful operation, a third element, namely, switching machinery, becomes of fundamental importance.

The primary requirements for terminal apparatus are that at the transmitting end it should provide an efficient means of translating some form of non-electrical intelligence material into electrical impulses which can be transmitted over the connecting channel in an amount and of a character to be properly interpreted by the receiving apparatus. This latter apparatus must be capable of efficiently and correctly translating the electrical impulses from the distant transmitting station into a form of non-electrical communication material which is directly relatable to the non-electrical communication material submitted to the transmitting apparatus. This non-electrical communication material delivered by the receiving apparatus may be substantially identical in form and character with that submitted to the transmitting apparatus, as is the case in telephony and its variants as they may appear in such things as broadcast sounds, or as is required in most forms of picture transmission and in some forms of telegraphy. On the other hand it may, as is the case with much of telegraphy, be in substantially different form from the exact non-electrical thing which is submitted to the transmitting apparatus. In this latter case, however, it must be of such a form and character as to be translatable into the exact arrangement of intelligence material as that supplied by the human being who proposed the originating message.

In a word, since the function of all electrical communication systems is to transmit to a distance, and substantially instantaneously, some one of the several forms by which human beings intercommunicate ideas, either directly by sight or sound when they are close together, or by non-electrical means when they are separated, the sending and receiving apparatus must be such as to accept and deliver the intelligence material without substantial impairment of form or context.

In addition to these primary translating requirements for terminal apparatus, there is a secondary requirement which in many cases assumes substantially the proportions of a primary requirement. This is the provision of some form of signalling device to attract the attention of a distant party, and which apprises him that a message is desired to be forwarded through his receiving apparatus. We are all familiar with this signalling apparatus in the bell of our telephone substation equipment. Similar and frequently much more complex signalling apparatus is required in connection with the proper operation of switching mechanisms in order to permit those responsible for them to perform their functions expeditiously and with that degree of reliability which is a prime requisite to good and satisfactory service to the originator and receiver of the messages.

Because all forms of electrical communication involve the transmission of electrical impulses the efficiency and general characteristics of the transmitting channels are of the utmost importance. This is true irrespective of whether they are material things like the wires which extend from point to point, or the more immaterial properties of free space as that space is utilized in radio transmission. This importance resides not only in the efficiency and fidelity with which any given set of impulses is transmitted from one point on the earth's surface to another, but also in the insurance against extraneous electrical impulses entering the transmission channel in a way to degrade or mask the impulses delivered to the receiving apparatus for translation into a non-electrical form. We have all had innumerable illustrations of the importance of this latter requirement in connection with the use of our telephones or of our household radio receiving sets. In the case of the former we have had perfectly satisfactory communication interfered with by extraneous electrical impulses, such as those resulting from inductive interference with power circuits or nearby thunderstorms producing highly objectionable noises, while in the latter, particularly in the summertime, so-called static disturbances have frequently rendered our receiving sets entirely useless or have been so objectionable as to cause us to abandon their use temporarily.

Telephony, involving as it does the requirement of a faithful translation and transmission of highly complex wave forms over a wide range of frequencies, imposes by far the most severe requirements on both terminal apparatus and transmitting media of any of the more generally utilized forms of electrical communication.

While the translating and transmission requirements of high quality program material for entertainment purposes are somewhat more exacting than those normally involved in commercial telephony, they are not different in kind since this service is merely an extension of telephonic translation and transmission.

When we come to the lesser used field of picture transmission and to the still highly experimental field of television, we encounter requirements which are decidedly more exacting. In the case of picture transmission, freedom from extraneous electrical disturbances and absolute uniformity of transmitting efficiency of the channel during the period of transmission are of the utmost importance, since the record at the receiving end is a permanent affair on which every deviation from perfection is recorded.

Television, if it ever comes to have a substantial place in the field of electrical communication, will impose requirements of character and stability on the transmitting channels which are quite outside the range required for ordinary telephony and telegraphy. This is so both because of the enormously wide band of frequencies on which it will be necessary to transmit and also because of the fact that the eye will perceive and be annoyed by the objectionable results of extraneous electrical impulses.

As telephony involves more delicate actuating forces in the transmitting and receiving terminal apparatus than does telegraphy, and as it involves requirements of a much wider and more complex transmission band than telegraphy, it is quite safe to say that the successful solution of a telephone problem carries with it in general essentially the basic solution of telegraph problems under corresponding conditions. Not only are telegraph problems, particularly as they relate to the transmission channels, inherently simpler than telephone problems, because of the much narrower bond of frequencies involved and the far greater simplicity in number and form of the impulses required, but they are simpler also because of the fact that at the receiving end considerable variations in form of the wave impulses can be tolerated without disastrous results. This is due to the fact that telegraph receiving apparatus can be made to rectify variations of wave form provided only that the number and arrangement of impulses in the wave train are the same as at the transmitting end. This flexibility is substantially absent in the design of telephone receiving apparatus where the ultimate translator from electrical to non-electrical impulses can only follow these impulses and so produce sound waves which closely approximate in form the electrical waves delivered to the receiving apparatus. If these latter waves are badly distorted as compared with those at the sending end, so also will the sound waves be badly distorted. There comes thus a point where the value of the system as a means of intelligence communication is destroyed because the received signals are no longer understandable even though they may possess large amounts of energy.

In all forms of electrical communication the final standard by which judgment is rendered is the degree of perfection of operation after the desired connection has been established between transmitting and receiving apparatus. Deviations from perfection in this respect are involved either in our inability to produce a perfect plant, through lack of understanding, or other reasons, some of which I will mention in a moment. While this is the final standard of judgment, speed and accuracy in establishing the desired connection is of only slightly less importance, particularly in the case of telephony, where final judgment resides in the patrons of the service, whose only interest is in the usefulness of that service to them and in the price which they must pay for the facility.

In all forms of commercial electrical communication—and practically all electrical communication outside that of the military services is in this category—cost is an essential element. There are numerous instances in every branch of electrical communication where deviations from the best that it is physically possible to produce are imposed by this element of cost. Only in very rare instances in the field of commercial communication can a general service be justified for any length of time without regard to the item of expense. This is not necessarily so in connection with electrical communications for the military services, where the criterion is different and where in many instances almost any price can be paid for the accomplishment of a desired result.

I have taken the time to give you this rather long preamble concerning the more important fundamental requirements of electrical communication so that you might better understand why we devote so much time, energy and capital to an intensive program of physical research. Every item which I have mentioned, and an innumerable list of secondary items which I have not mentioned, are known to be susceptible of improvement in performance, reliability, simplicity or cost, provided only that we have a sufficient knowledge of the things of nature and sufficient ingenuity to apply them. So great are the number of directions in which improvement can be anticipated, that the limit of our activity is imposed by our ability to obtain the right kind of men and the amount of money which we can afford to devote out of our current resources in any given year to the securing of results which must of necessity find their application and profit in a period ahead.

Electrical communication, resulting as it has from the scientific discoveries of the past one hundred years, is in its main aspects devoid of that help which numerous other industries derive from the accumulated experience of many centuries of human activity. Since it is the practical application of relatively recent research in the fields of physics and chemistry, it is both natural and inevitable that to a very large extent it has had to look to the colleges and universities which produced the new knowledge, for a very large proportion of the men who have contributed to its advancement.

Quite early in the development of telephony it became apparent that progress could best be made by a different and more profound adoption of the scientific method of attack than was ordinarily employed in the so-called experimental laboratory. In many directions, even, it was clear that no progress at all could be anticipated unless the problems were attacked with the type of men and the methods which have proved to be so powerful in extracting new knowledge from nature. The embryo of what is now a vast scientific research and development organism thus came into being.

Growth was at first slow and somewhat halting. This was due partly to ignorance of how best to proceed, partly to that conservatism which seems inherent in our human activities, and largely to sheer inability to obtain the right type of trained men. The graduate schools of thirty-odd years ago, which were the sole potential source of the type of men required, were not organized to train men for a life in industry, nor did they then attract many men who were temperamentally qualified for such a life. In the years which have elapsed, these obstacles have disappeared with a rapidity which is akin to the progress of an autocatalytic reaction, until at the present day, expansion of the research laboratory is limited principally by the element of current cost, although as mentioned earlier, the question of suitable human material is still a factor.

Initially the problems of the research and development laboratory were largely those connected with the removal of obstacles immediately blocking development. In the main they were solved by application of existing scientific knowledge, and little or no attempt was made to produce new scientific knowledge or to break out new methods of electrical communication in remote fields. As time went on three things became increasingly obvious: first, that there were innumerable problems in the existing art which, while not presenting serious obstacles at the moment, could nevertheless be attacked advantageously by the new organization; second, that in many directions it was not sufficient to depend entirely on the store of existing scientific knowledge; and third, that there were possible developments in the field of electrical communication which offered alluring prospects but for which as yet there was no need. This latter development evolved rapidly as the size of the research group increased and its members became more conversant with the needs of the communication business and the possibilities it offered for useful expansion.

Coincident with the developments just mentioned there was a growing appreciation of the fact that in every direction in which improvement could be anticipated, the best results were obtained when there was the most complete and certain knowledge of each constituent element which in any manner entered as a factor.

Thus, gradually, under the influence of these several forces, our present great industrial research laboratory has evolved. As you are aware, it now comprises literally thousands of highly trained men and women, many of whom are recognized throughout the world as leading authorities in their several fields of major activity. While many of these men and women are essentially specialists in some particular field, the Laboratories organization is not simply an aggregation of specialists; rather, it is an association together of a large number of broadly trained intellectually competent individuals capable of attacking effectively a wide variety of problems. This organization of the personnel of the Laboratories is of the utmost value, not only in the orderly expansion of electrical communication but likewise in the maintenance of that stability and continuity of association without which it would be both expensive and unsatisfactory. No better proof of the flexibility and soundness of the arrangement is required than that found in the history of the organization during the past three or four years, which have seen such stupendous changes in the general economic structure. Three or four years ago, at the height of the boom period, a major part of the activity of the Laboratories was concerned with the rapid solution of problems of immediate and pressing necessity. Many of the more fundamental problems concerned with future development had either to be deferred or attacked in a moderate way only. As conditions changed and the pressure of immediate urgency relaxed, there was no material contraction in the size of the research and development force. There was, rather, a smooth transfer of emphasis to attack on those fundamental problems which we have reason to believe are involved with the future developments of electrical communication. No such result could have been obtained in a less flexible organization or in one whose personnel was essentially that of a group of narrowly trained specialists.

To an observant outsider entering the research and development laboratories for the first time the impression is largely that of a great university laboratory. The type of men and women is the same, many of the problems under way are akin, and the general atmosphere of the human relationships is not dissimilar. In two major respects only is there a marked difference; first, in the obvious presence of the fact that time is an essential element, and second, the almost equally obvious fact that practical results and ultimate cost are controlling factors.

Now a brief picture of the kinds of problems with which we deal, of where these problems arise and of how we utilize the results of our work.

In the last analysis nothing which comes out of the research and development organization is of value or is undertaken unless it is a useful physical thing; a useful part of a useful physical thing, or a useful arrangement of useful things. Mainly these have to do with improvements in the field of electrical communication, although latterly they have been concerned to some extent with arts just beyond the border of electrical communication narrowly defined. Such applications have resulted from the obvious by-product advantages of knowledge acquired in the quest for a broader, better and cheaper electrical communication.

These being the criteria by which the activities and results of the research and development organization are measured, and since useful physical things can be no better than the poorest of the elements of which they are composed, it follows that a very large part of our activity is concerned with the ultimate properties of matter in so far as those properties are a factor in our problems and in developing the various useful ways in which materials and simple structures can be assembled together in the complex things which go to make up a communication system. In a word, our problem in one of its larger aspects is to provide the fabricator and operator—using these words in a broad sense—with the best possible building material. Thus we have come to be vitally concerned not only with the ultimate properties of matter in its most elementary forms but also with the properties of matter in its grosser and more complex aggregates, and in the controls which must be exercised and maintained if the desired properties are to be assured when large quantity production is undertaken. Metals, both primary and in the form of alloys, the methods of their manufacture, the effects of heat treatment and manipulating operations, and their stability under a wide variety of conditions, all come within the scope of our interest. So also do practically all of the non-metallic materials likely to have any place in the field of electrical communication.

Since magnetic materials have a very important place in electrical communication, as they do in all other fields of electro-technology, their non-material characteristics are of very great interest to us. So also, during the last decade or so, have come to be the properties of metals, their alloys or compounds, as producers of electrons.

In quite a different field we are vastly interested in the so-called laws which govern the propogation of electro-magnetic impulses through space, whether it be free space or that portion of space which is limited by the guiding effect of wires. Likewise, we are interested in the means and methods by which electrical impulses may be created, controlled and manipulated to the end that they may be used as vehicles for the transmission, to a distance, of intelligence. The quest for knowledge and power of control in this field has led us not only far in the physical laboratory but far also into the realm of abstruse mathematics, which is a terra incognita to the great mass of human beings.

With the passage of time the extension of our knowledge and the increasing stringency of requirements brought about by growth in size and complexity of the communication network, we have found it necessary and profitable to carry our research investigations ever deeper into the realm of the physically obscure or unknown on an increasing number of our problems. Today, as Dr. Fletcher and the others may have told you, we are vitally interested in an accurate knowledge of many things which a few years ago would have appeared to be quite foreign to the specific interest of the developer of electrical communication. For example, we are now vitally interested in questions of anatomy and physiology in so far as they pertain to the production and character of speech or the sense of hearing. Likewise, we are interested in knowing all that the most powerful ultraviolet microscope can tell us about the internal structure of matter, and in the life and propagation of molds and other organisms of decay. To an extent also we are interested in the life and habits of insects, such as termites which attack and destroy non-metallic substances, and those rarer but more remarkable insects which in some regions attack certain metallic structures.

Having given you a skeleton picture of some of the things in which we are interested and the reasons for that interest, let me conclude by outlining briefly the origin of our problems, the methods by which we attack them, and the uses to which we put our results.

The sources of the problems which present themselves to the research and development organization are four in number.

First, there are the problems which arise out of the day by day commercial operations in the communication field. These may be due to any one of a variety of causes—demand for new types of service which cannot be furnished through the use of existing instrumentalities—high maintenance costs—prospective economies through simplified apparatus or systems, etc.

Second, there are the problems of a more general and less immediate nature which arise out of the general understanding of communication needs possessed by the development and research organization itself. In the main these are problems which, when solved, inaugurate more or less sweeping changes in existing methods or instrumentalities, or open up hitherto undeveloped fields of electrical communication.

Third, there are the problems which arise in connection with the manufacture of physical things. They may come about because of difficulties that have been experienced, because of a belief that through research new materials or new methods of fabrication may result in more efficient or cheaper and less bulky and less complicated apparatus, or they may be initiated by the development of entirely new methods or new materials in entirely different fields but which our general knowledge leads us to believe can be utilized in electrical communication.

Finally, there are the problems which arise directly out of the current discoveries in and expansion of the fundamental sciences. Some of these discoveries and some of this expansion are the result of our own work, but for the most part they are the work of scientists throughout the world which, when published, adds to the store of common knowledge and presents to the trained industrial research man the possibility of useful application. More even than is the case with problems in the second category, the results which follow the solutions originating in this new knowledge are destined to find their field of application in the communication systems of the future and are most likely to involve radical general changes from the then existing methods. In this respect they are frequently the problems in which the greatest return for the least expenditure of time and money is to be found.

When a problem, from whatever source it emanates, is proposed, the first step is to formulate it as simply, exactly and concisely as possible. The next step is to scrutinize it from every angle with a view to determining not only the probability of a successful solution, but likewise the probable time and cost of obtaining the solution and the benefits likely to be derived from its successful completion. If and when it is decided to proceed with the work, the next step is to break the problem down into its component uncertainties, to formulate for each of these the most rigid possible set of requirements, and then to submit the several parts to the scrutiny and attack of those who are most competent to handle them.

During the course of this frontal attack general supervision is exercised to insure, first, that progress toward an answer is at a reasonably uniform rate everywhere; and second, that the results obtained in one portion of the field are not of such a character as to alter the entire picture as it was originally conceived. Where this latter occurs it results in a realignment of requirements and a new frontal attack from the new point of departure.

In time the separate results are brought together and the complete solution begins to emerge. Finally, when a satisfactory answer seems at hand, the composite solution is subjected to those overall tests which are to determine its ultimate utility.

In general, so far as the Bell System is concerned, it can be said that no piece of apparatus, no equipment and no method of operation is ever released for commercial use until it has been subjected to all of the tests in the laboratory which the human ingenuity of the research and development organization can devise. In a word, no part of the research and development program contemplates the acquisition of knowledge through experimentation on the customer or with the facilities provided to give him service where this can be avoided. Since from its very nature much of electrical communication, particularly in the field of telephony, must be judged finally by its reaction on human beings, and since the more complex structures can only be tested finally through extensive usage, it is not always possible to avoid entirely a certain amount of experimentation with the patrons of the service. Where this kind of thing cannot be avoided it is, however, always limited as much as possible and confined to carefully supervised trial installations under conditions which previous study has determined as most typical of the general results to be anticipated in universal usage.

As all of the research and development work in the field of telephony, and much of that in telegraphy, is directed to the simple objective of a better, cheaper and more extensively usable system of electrical communication, the multitude of problems which present themselves in never-ending succession, all resolve themselves in the last analysis into the problem of finding better, cheaper and simpler ways of making new things to take the place of existing things, to the problem of making new things for new uses, of broadening, cheapening and making more reliable the band frequency characteristics of the transmission channels, and finally, of making improvements in methods which will take us farther toward the goal of a substantially instantaneous service of universal applicability at a cost which will place this service, in all its parts, within the reach of the largest possible number of people who may desire to avail themselves of it.

A complete list of all the things of utility in the communication field which have resulted from our fundamental research work is entirely too long to incorporate in a lecture of this kind. A few examples of the results which have had the widest general applicability must therefore suffice to illustrate the things which could not have been obtained except through the work of the Research Department.

In the field of transmission we have substantially obliterated distance as a limiting factor. Further, where wire lines are involved—and they of course constitute all except a fraction of a per cent of telephone communication channels—the size of the conductors has been so reduced that in many cases the limits to a further reduction are imposed not by any electrical requirement but merely by the grosser mechanical requirements. In a word, where it was necessary a couple of decades ago to employ copper wires approximating in diameter the diameter of a lead pencil to insure satisfactory telephone communication over even a moderately long distance, it is now quite feasible to give a better grade of transmission over many times that distance using wires which are not larger than the lead in a lead pencil. Moreover, as a result of fundamental research it is now possible to incorporate in the limited diameter of a 2½″ pipe as many as 1800 non-interfering telephone channels, where only a few years ago but a fraction of this number could be obtained, and where at a slightly earlier period none whatever.

It was not so many years ago that each pair of wires supplied for a telephone circuit was limited in its capacity to a single message at a given time. Now, as a result of our fundamental work it is physically possible to transmit a multitude of non-interfering telephone messages, or non-interfering combinations of telephone and telegraph messages over each pair of wires. The question of how and the extent to which this is done are now purely matters of relative economy. In all of this the fundamental developments underlying the distortionless amplifier and the production of highly magnetic alloy materials, both the products of fundamental research, have played an important part.

All of the recent improvements in radio telephony have of course flowed directly from fundamental research work and could have been obtained in no other way.

It is not only in the field of transmission, however, that startling changes have resulted from applying the results of a vast fundamental research. The whole of modern machine switching is predicated on items which have been obtained in the fundamental research laboratory. Probably no other structure thus far created by man comes so near to simulating the operation of an intelligent human being as does the modern machine switching apparatus which is now so commonly used. Save only for the element of articulate speech, the machinery in a modern telephone exchange performs all of the functions originally performed by the telephone operator, and many others besides. Even in the matter of articulate speech, fundamental research has devised machinery by which intelligence originally transmitted by the finger actuated dial used in originating calls is translated into the spoken word in order to convey instructions to a human being—the operator.

In the course of so great and extensive an undertaking as that which is carried on in the Bell System research and development organization, and one in which the satisfactory solution of problems in the field of electrical communication requires such a detailed and intensive study of elementary things, it is inevitable that unsuspected and unsought for by-product results will accrue. Some of these by-product results have been outlined to you by Mr. Otterson and the others who have preceded me. When such by-product values develop they frequently present serious problems in the determination of the disposition which should be made of them. Being things of value, they cannot be abandoned entirely, nor can they in many instances be disposed of in their initial stages. Many of them require specific additional research and development to render them commercially available. In some cases therefore the research and development organization has carried these by-product values a distance along the course of their development into things of utility. Oddly enough, almost without exception, when this has been done, the further work has resulted in secondary by-products which have had a field of application in electrical communication.

In closing I can only say that the conduct of fundamental research work in the communication field and the utilization of the results from such work are controlled through a combination of the best that fundamental science and scientific training can afford, mixed with the best commercial guidance which we have been able to bring to bear on the matter. Our research and development organization is a truly scientific body, but one in which the results of science are designed to be things of utility to fit into the orderly progress of electrical communication and must be produced with due regard to cost.

Frank B. Jewett

Social Aspects of Communication Development

A lecture delivered at the Lowell Institute, Boston, Massachusetts, on January 26, 1932

THE gentlemen who have preceded me in this series of lectures have explained to you some of the methods and results of telephone research. This work has laid the foundations of the talking moving picture industry, prepared the way for television, advanced the method of aiding the deaf to hear, produced an artificial larynx and contributed to the advancement of knowledge of electricity, metallurgy, pure mathematics and in many other ways, but these things are incident to the main purpose to which this research is devoted.

That main purpose is to improve electrical communications, particularly the transmission of the human voice. Specifically it is to enable you to be connected by telephone more rapidly and easily to any one of an ever increasing number of people and when you are so connected to have your conversation clearer and more free from imperfections, errors and delays. It is the desire of these scientists to create as nearly as possible a condition in which you can talk to anyone anywhere in the world with the same satisfaction and with the same effect as if you were talking to some one immediately in front of you. To do that the telephone operation must be so good that you use it as naturally as you use your own vocal cords and it must reach anywhere that you desire it to reach.

Towards this ambitious goal telephone research has made tremendous progress in its half century of effort and it has ever widening possibilities ahead for it is one of the fascinations of the effort to add to human knowledge that each advance instead of tending to reduce the possibilities that remain, seems to increase them.

In the charter granted to the American Telephone and Telegraph Company some nine years after Dr. Bell invented the telephone, the following vision of the future was recorded:

> "And it is further declared and certified that the general route of the lines of this association, in addition to those hereinbefore described or designated, will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said State, and in each and every other of the United States, and in Canada and Mexico, and each and every of said cities, towns and places is to be connected with each and every other city, town or place in said States and Countries, and also by cable and other appropriate means with the rest of the known world as may hereafter become necessary or desirable in conducting the business of this association."

That romantic idea was written into the charter at a time when in actual practise there was very little intercommunication between points any distance apart, no telephone communication beyond 250 miles and, of course, none at all overseas.

Yet, although they had no definite knowledge of how their prophecy was to be fulfilled, their faith in the future was largely justified because at present about 92 per cent of the thirty-five million telephones in the world can be reached through any telephone in this country.

The vision that lies ahead is not, therefore, one of possible interconnection with other telephones in the world. In fifty years that prophecy has been largely fulfilled. The vision of the future is one of making telephone connections anywhere and everywhere so convenient and easy that its effect upon humanity will not be gauged by the possibility of people talking anywhere, but by the degree with which that possibility is used.

Some years ago, Dr. Wallace Buttrick, then the head of the General Education Board, said in a discussion of educational problems, that most graduates of Harvard College were illiterate.

A Harvard man present challenged that statement.

"Dr. Buttrick," he said, "do you mean that in your opinion most of the graduates of Harvard College can not read and write?"

"Oh, no," replied the jovial doctor, "I don't mean that they can't. I mean that they don't."

The difference between the possibility and actuality is likewise an important distinction in the use of the telephone. Technically, the telephone system can be made to reach the whole world. Practically, the task is to increase our telephone systems as fast and as far as the use the public will make of them justifies. There are several limitations on the use that the public will make of them.

The habits of the sun constitute one of the great limitations on world wide telephony. As it shines on only half the world at a time most of the people on one side of the world are asleep at the time those on the other half want to telephone. I remember when we were putting through the experimental calls to Australia. There were several of us talking, one after the other, on the New York end. We were all answered by one gentleman at the Australian end. Finally, I asked him if there was anybody else in Australia who could talk on the telephone. He said there was, but he reminded me that while we were talking at a convenient time of the afternoon in New York, it was half past five in the morning of the next day in Australia and there were not so many people who liked to get up at that time.

There is also the handicap of language, for while the telephone can translate the numbers you dial into language, it can not translate English into Chinese nor Persian into Spanish.

The question before the communication business is not what can we do technically, but what can we do that the people want and will use? We like to look upon our activities as a benefit to mankind and measure our progress in those terms. What good does modern communication do to humanity? It is some aspects of that question that I would like to suggest.

Up to the time of the invention of the telegraph, communication was, generally speaking, tied to transportation. A message had to be carried by a man and it could go no faster than he could go. It is true that semaphores, beacons, smoke signals and carrier pigeons were used, but the very limited amount of their use indicates the severe limits of their effectiveness. In spite of them it is still generally true to say that from the beginnings of history until the invention of the steamboat and the locomotive, man, horse, and sail provided the maximum speed of communication. The Romans, the Incas, and Kubla Kahn all had highly organized communication systems, as did the Persians. In one sense these are the ancestors of the modern post office and telegraph and telephone systems. In another sense they are not at all. The runners of the Incas, the Romans and the great Kahn were an essential part of the machinery by which a small ruling class kept large populations in subjection. These communications were largely made up of the military and political information necessary for the conquerors to maintain this rule over the populace.

Modern communication is chiefly useful so that large populations may know themselves by constant intercourse and thereby improve their economic status and their ability to govern themselves. The underlying purpose of the two systems is exactly the opposite. One gave inside news exclusively to the few. The other is to enable every one to have the same news at the same time and to have equal facilities for personal communication. One tended towards exclusive power, the other tends towards equalization of opportunity. Communications are now one of the great agencies of democracy. In their origin they served the opposite purpose. I believe that the change began with an event not directly within the field of communications.

In a civilization like that of the Romans, the written word was used as a record and to some extent for communication. But the great mass of people being unable to read and write, were restricted to such messages as they could carry themselves or some messenger could remember for them. There was no substantial change in this condition until the invention of the printing press. That gave the written word, the printed word, a new status for the inevitable result of the printing press was that the mass of the people gradually began to learn to read and write.

That was the necessary foundation for the establishment of any general post office system with a modern purpose. While the messenger services conducted by the Persians, Chinese and the Romans might be called a postal service, they were not of the same character as the modern postal service—a cheap, rapid and inviolate delivery of written messages for the masses. That kind of a post office, which is a democratic agency, had to wait for the infusion of learning which was based upon the spread of the printed word. The change in point of view did not come suddenly. Queen Elizabeth prohibited the carriage of letters abroad except by the master of the posts because she wanted to be able to censor all foreign communication. Cromwell applied the same idea to all of England.

The first post office in what is now the United States was organized under a royal patent granted to Thomas Neale in 1691 authorizing him to settle and establish within the chief parts of their Majesties' colonies and plantations in America an office or offices for the receiving and dispatching of letters and packets and to receive same and deliver the same. Post riders were dispatched between Portsmouth, N. H., and Virginia weekly except during the winter, when the trips were made fortnightly.

By the time of the Revolution the immense importance to a self-governing country of a general, regular and inviolate communication system was well recognized and the articles of confederation provided for interstate mails. The Constitution gave Congress very wide powers under which to establish a comprehensive post office, and on the earnest recommendation of Washington this power was immediately used. The post office was to be one of the main ties that would bind the scattered population together.

In Washington's first annual message in which he strongly urged a comprehensive postal law, his arguments for it were based chiefly upon the fact that a well operated post office would encourage a knowledge of the laws and the proceedings of the government. The sociological value of general popular intercourse by mail was not generally grasped at the time for in the society in which he moved in the new republic, there were few people compared to the present who had occasion to use the mail except on rare occasions.

But the general use of the post office grew very rapidly. Communication by steamboat and rail added to its speed. None the less communication was still tied to transportation. Communication, or at least a part of it, took on a separate existence with the invention of the telegraph.

The work of a surprisingly small number of men of which Benjamin Franklin was one, made up the basis of knowledge of electricity up to the beginnings of the nineteenth century. Many people had worked in electricity but the essential contributions to the development of electrical communications were from a surprisingly small number of sources. The next steps, as is often the case, were made almost simultaneously in two places. Michael Faraday, one of the most distinguished members of the Royal Society in London, and Joseph Henry, a school teacher in a small academy in Albany, each without the knowledge of the other, contributed the scientific knowledge necessary for the invention of the telegraph. Neither was utilitarian minded and neither envisaged a public telegraph system. That came from the brain of a painter, Samuel F. B. Morse. With his application of Henry's and Faraday's science, fast communication began to be released from transportation.

As war dramatizes whatever it touches it is perhaps fair to contrast certain military events before and after the release of communications from transportation.

The United States declared war against Great Britain on June 18, 1812 chiefly on account of British activities under the so-called Orders in Council. In order to smooth the situation the British rescinded these Orders eight days after we declared war, but of course without knowledge of our declaration, just as our Congress had no intimation of their intentions. The peace that concluded this war was signed December 24, 1814, and the largest battle of the war took place at New Orleans on January 8, 1815. In contrast to this—at the end of the world war several million men in arms opposite each other ceased firing on the stroke of eleven.

Andrew Jackson's inaugural message in 1831 took 15 hours to reach New York and that speed was due to the extraordinary enterprise of the Courier and Enquirer. Seventeen years later, in 1848, Philip Hone, a New York merchant, wrote in his diary:

> " The Milwaukee Sentinel contains the following article—a most wonderful illustration of the magical performance of the lightening post, the last miracle of the scientific triumphs of the present age: At nine o'clock yesterday morning we had, by telegraph the news and markets from New York, distant fourteen hundred miles, up to three o'clock of the preceding afternoon. This is, indeed, a startling fact and may well make us pause and wonder at the agency which has brought it about." Hone comments, " I was once nine days on my voyage from New York to Albany."

The effect of the telegraph on the dissemination of news and on the conduct of politics would occur to every one, but I am not sure that the revolution in commerce created by instantaneous news would occur to every one so readily.

The Business Historical Society has given me copies of various New England merchants' letters in the days prior to the telegraph and cable. They are letters of instructions to captains and supercargoes of vessels. They are nearly all vague and indefinite, because the merchant had no idea of what the prevailing price of his goods would be when they reached Canton, Tabago, Manila, nor what would be the price of the tea, molasses, hemp that the ship was to bring back. And if the captain of the ship sold his cargo well in Manila and bought hemp at what was a good price in Boston when he left, he could only hope that it would likewise be a good price when he got back. There is one letter from Canton from a captain of a Boston ship in which he says "The advices from England by the July mail do not warrant the prices previously demanded here for black teas." The letter was written on October 3d. He was bargaining on the basis of information from Britain three months old and the price he finally paid for it would not be known to William Appleton and Company in Boston, for whom he was acting, for several months more. Moreover, while he waited to bargain he had to hold his ship and crew idle, and while he was bargaining he had no idea what was happening to the price of tea in Boston and London.

The commercial situation between Baltimore, Philadelphia and New York on the one hand, and Cincinnati, St. Louis, New Orleans and Milwaukee on the other, would be only relatively better than that between Boston and Canton.

It was not surprising, therefore, that the printing of the New York markets of Monday in Milwaukee on Tuesday morning was an event of importance.

The old trading without knowledge involved tremendous risks. Risk is expensive and the public ultimately pays the expense. We are disposed to criticize our present distribution methods. Perhaps we should do better than we do with the facilities for instantaneous reports from all markets. But what is possible now would seem the millennium of safety to the William Appleton and Companies of the thirties.

There is a story rather commonly accepted to the effect that the Rothschild fortune was greatly augmented by the purchase of securities in London the day after the battle of Waterloo was fought, when the Rothschilds had the news of the victory by special messenger and no one else knew the facts. Whether this case be true or not it is typical of the results of an undemocratic state of communications, in which the men with fastest messengers could be in the position of prophets. And so long as communication was based on a horse race or a boat race or a train race—so long as it was tied to transportation—this condition continued.

For example, let me read you a part of a letter from Jefferson describing what happened when Hamilton touched the dead corpse of credit so that it sprang upon its feet. As you remember his touch consisted of having the United States agree to pay at par the obligations of the Continental Congress and obligations of the different states.

Mr. Jefferson after describing the measures wrote: "This being known sooner within doors than without, and especially to those in distant parts of the Union, the base scramble began. Couriers and relay-horses by land and swift-sailing pilot boats by sea, were flying in all directions. Active partners and agents were associated and employed in every state, town and country neighborhood, and this paper was bought up at five shillings and often at two shillings in the pound, before the holder knew that Congress had already provided for its redemption at par."

Had a modern communication system been in existence then the government could probably have put its credit on its feet without a scandal that created a prejudice impairing that credit from its restoration until Jackson destroyed the United States bank.

Prior to the advent of electrical communications there was a far greater opportunity for men to bet on events the outcome of which they knew with men who did not know the facts, and to call this practise trade and commerce.

By the time the telegraph was established the written word had attained both speed and mass production. Letters formed the main point of communication between people and letters were delivered as fast as man could deliver them with the aid of steam on shore and at sea. But the telegraph supplemented this with much greater speed for individual messages and also for new items so that the dissemination of news over the country through the papers was, for the first time, practically simultaneous.

The invention of printing, the spread of education and the invention of the telegraph had all greatly increased the value of the written word in communication. The spoken word had remained exactly as it had been in the city states of Greece. Man had still to find his neighbor before he could talk to him and he could reach no more of an audience than the strength of his voice would allow.

But the study of the science of electricity did not stop there. Moreover, scientists began to find out a great deal about sound waves and light waves as well as electricity. I hope no one will think me an iconoclast if I say that philosophy would have been more pleased with the logical sequence of communication development if at this time, or even earlier, the third type of communication waves had been discovered, that is, electrical or radio waves. Sound waves, light waves and radio waves are ideally suited for general communication purposes because they move in every direction from their point of origin, but sound waves and light waves can not travel great distances over the surfaces of the earth. Radio or electrical waves on the other hand, do travel great distances in spite of the curvature of the earth. If man had discovered radio waves when the Lord intended him to do so, then in all probability we would have had radio telegraphy before Morse discovered wire telegraphy. And wire telegraphy would have been recognized to be what it is—an improvement upon radio telegraphy for the purposes of taking a message from one particular point to another. In the same manner had electric waves been understood when they should have been, when Alexander Graham Bell had discovered how to transmit speech waves, that is, sound waves, to electric waves, he would have had at his command, first, radio broadcasting and after that the next logical discovery would have been the method of carrying speech from one particular point to another along wires. The use of private circuits to carry speech from one person to a particular desired listener would have been acclaimed as a most notable advance. And as this could be done with none of the extraneous noises of interference which characterizes much of radio reception, it would have added to the marvel. The world would then have assessed the discovery of wire telephony even higher than they did in 1876, for the world would have understood very much more what Bell had achieved.

Electric waves predicted mathematically by Maxwell in 1865, experimentally produced in 1888 by Hertz and adapted to commercial uses by Marconi in 1895, provide the most direct use of electricity in communication. The wire telegraph and the wire telephone are additional steps to that fundamental discovery. The discovery of the wire telegraph and the wire telephone came first. When radio came along the public to some degree looked upon it, not as a predecessor as it properly was, but as a successor of wire communication, and failed to realize that these things are of a complementary and not a competitive character.

Radio is ideally suited for broadcasting with all that the word broadcasting signifies. Radio waves serve admirably in a one way communication system for the dissemination of news, music and entertainment. They serve also for two way communication over those routes where the cost of wires in relation to the amount of traffic renders wires or cables for the present, commercially unjustifiable. Radio also is the only method of reaching ships at sea and aircraft in flight. But for the millions and millions of two way telephone conversations and telegraph messages between particular points, the wire systems are by far the most practical media.

Since the time of this discovery in 1876 the spoken word has regained in a large measure the position it had in the time of the Greeks and Romans, that is, it is the most common form of intercourse between individuals at a distance as well as when they are close together. The increase in speed which came to the written word first through the post office and then by the telegraph has been applied to the spoken word in even greater degree. Mankind is now equipped with both facilities. A man may write to another anywhere in this country and have the written message promptly delivered. He can take up his telephone and talk almost instantaneously to anyone anywhere in this country. If he and his correspondent have a great deal of business, he can write on the teletypewriter in his office and have his correspondent's teletypewriter on the other end of the wire type the message in unison with his own. He can even, within the last few months, have his teletypewriter connected by a switchboard to different subscribers just as his telephone is connected through a switchboard. He can send messages by cable or radio and he can talk by a combination of wire and radio telephony to any one of 92 per cent of the telephones that exist in the world. In other words, we have the instruments for talking or writing instantaneously to anyone anywhere at any time. And the wires carry news to newspapers and the wire networks for broadcasting enable us to get a message from any point in this country to practically everybody in it simultaneously.

What use do we make of these facilities?

The post office which does the part of written communications still handled by transportation, delivers about sixteen billion letters a year, that is, sixteen billion personal messages, as they are first class mail. The telegraph companies deliver one-fifth of a billion messages or one to every seventy-five letters. There are about twenty-seven billion telephone messages, or about five telephone messages to every three letters. The voice has become the main method of communication between those who are separated, which is entirely natural, as talk is the main method of communication between those who are together. The social consequences which have eliminated distance as a barrier to the human voice have been as revolutionary as the elimination of time from the transmission of the written word and is quite as much taken for granted.

These communication facilities are the natural tools of a democracy. To what extent they have increased democracy it is idle to speculate, but they have come with it and are a natural part of it. Knowledge is power and the control of knowledge is power. The control of communications and, therefore, of the knowledge of specific events, is a very important element in power. If that is in the hands of a few autocracy is almost inevitable. If it is in the hands of the many, democracy is possible. And generally speaking, the wide use of public communication is a symptom of democracy. Those countries which are democratic in their social, political and economic structure use the tools of communications to the greatest extent. I said particularly that where communications are available to the many democracy was possible. It is not inevitable for the tools of mankind can not automatically make mankind over. Providing China with railroads and telephones will not make a stable democratic government. To do that the Chinese will have to acquire the knowledge and habits and desires for that kind of government.

There are those who are critical of our modern age and seem to believe that at the present time the tools control the man rather than the man controlling the tools. But I think they say this chiefly because it is easier to blame the machines than it is the people. Our machines do what we tell them to—they add to our powers but they do not direct our purposes.

The ability to have personal contact with other people is the principal source of both pleasure and power for the individual. That increase in power is easily thought of in connection with business. It is true that modern business could not go on in its present form without modern communication. It could not go on without the telephone. Without the telephone you could not have a skyscraper, for you could not get enough elevators in a skyscraper to carry the messenger boys that would be necessary to deliver the notes and telegrams. The telephone has in this way allowed us to congregate where we wish to congregate. It has also facilitated living in the suburbs and in the country so that it has allowed us to disperse where we have wanted to disperse. Instantaneous communication has had an essential part in increasing the average income in this country for it is an essential part of the improved machine tools and methods of production and distribution.

Modern business is based in varying degrees upon the communication system in which the spoken as well as the written word can be instantaneously projected to any necessary point. It is true as the last two or three years have made painfully apparent, that all these modern tools put together have not eliminated the vicissitudes of human affairs. They are not automatic and as I said before they do not control mankind. They give man the power to do many things he could not do before and to do other things with greater facility, but they do not control the degree nor the direction in which he uses that power.

But equally important with the business use of the telephone is its social use. It has added safety, comfort, convenience, and a wider range of friendly human contacts to the people's lives. How do you measure the value of hearing a baby's laugh over the telephone? What good is it that you can get a friend for lunch on the spur of occasion? How valuable is it to be thirty seconds from the fire-house even if the fire-house is half a mile from you?

Before the advent of electrical communication a man was apt to confine his human contacts largely to his immediate neighbors, for the simple reason that he could not easily maintain contacts with any one else. A man's neighbors now are more the people of his choice than those who happen to live next door. This may add to his enjoyment and development.

These things are so common that it is hard for us to realize that, taken in the aggregate, they form an immense addition to human comfort and happiness. In saying that, I know that there is no statistical proof possible that people are happier than they used to be, for happiness is not yet a measurable quality. Yet there is one basis on which to gauge the increase in comfort or happiness arising from rapid communications and that is the ever increasing desire of the people for them.

Of course there is occasionally a reaction against increasing power, for with it goes inevitably an increasing sense of responsibility.

We have had instances in this country of voting to abolish the results of science because they tend to increase the necessity for thought. There are other people who dislike the other aspects of modern science because they too increase both opportunity and responsibility. I have heard of a summer colony in this country that is in this state of mind. The inhabitants hold, with O. Henry, against having their retreat damaged by improvements. Tradition is against the telephone. Yet some years ago a new comer joined this colony and brought a telephone with him. Outwardly respecting the traditions of the place he had the line to his house as well screened by trees as possible and he put the instrument in the upstairs hall so that no visitor would be scandalized at its sight. The tradition against the telephone still remains but the gentleman with the telephone has had to take great care in what costume he emerges from his bedroom for at any time of the day or night there may be a neighbor in the hall telephoning.

Years ago I used to hear people complain of the farmers' wives gossiping on the telephone. Yet that was probably by far the most important function of many a rural line, for to keep a woman from going insane from loneliness is far more important than finding a market where pigs sell a half cent higher a pound. The telephone in its social uses saves people, particularly women, an immense amount of time and drudgery.

What do we do with the time we save? I don't know. Again I can't prove that it is usefully, profitably or spiritually employed. But people think, at any rate, that it adds to the fullness and happiness of their lives to save that time and I think there is an instinct in all of us that cries out for the opportunity to experiment with the high art of living without having the experiment entirely controlled by the time and difficulty of making a living.

Temporarily, now and then, the world and the people in it are too much with us, but we, like our ancestors, are an energetic and sanguine people. We want more command over nature, more tools, more appliances, more power, for we believe in ourselves and enjoy being, in so far as we can manage it, the captain of our souls and the masters of our fate.

To those of us who work in the science, art or business of communication, this is the inspiration for our work. We believe in the urge of mankind towards better things. We believe that in removing the limitations of time and space from the words of man we are giving him the ability to make a more effective civilization. And particularly we believe it is important to increase the influence of his brain by facilitating human intercourse for it is by the origination and spread of ideas that progress is made. They are far more important than any material things.

Electrical communication has been used to revolutionize the methods of commerce, to make the news instantaneously common to all men, to restore the influence of the spoken word in politics, to bind this country together with a constantly changing but ever present web of words, and recently by the trans-Atlantic telephone, to make a great change in the conduct of international relations. These and many others are the proof that electrical communication has given man immensely increased power. Whether it is used to make more money or better men, to increase comfort and happiness or the opposite, to make a better or worse civilization, to promote peace or war depends not on the facilities at his disposal but on man's desires. But being optimists both as to the public's intentions and abilities in the long run, we get a satisfaction from adding to those powers by spreading the word of man instantaneously to the four corners of the country and almost anywhere else he wishes.

Arthur W. Page

Another Evidence of Evolution

IN the making of America's telephone system, the rule of the survival of the fittest has been applied without discrimination to the equipment which makes service possible. This is the inflexible law of progress. In the process of evolution, there is no room for sentiment. And yet—there is always something a little heart-stirring when a veteran piece of equipment, a time-honored tool of the telephone service, is laid aside to make way for something which can perform a particular function more efficiently.

So it is with a circuit layout chart which hangs on the wall in a room on the third floor of 15 Dey Street, New York City. On it are shown all the open wire telephone and private wire telegraph circuits maintained and operated by the Long Lines Department of the American Telephone and Telegraph Company. It is, in effect, a diagramatic map of the United States, from coast to coast. It is forty feet long and seven and a half feet high—and it is to be discarded because, of all possible reasons, it is too small.

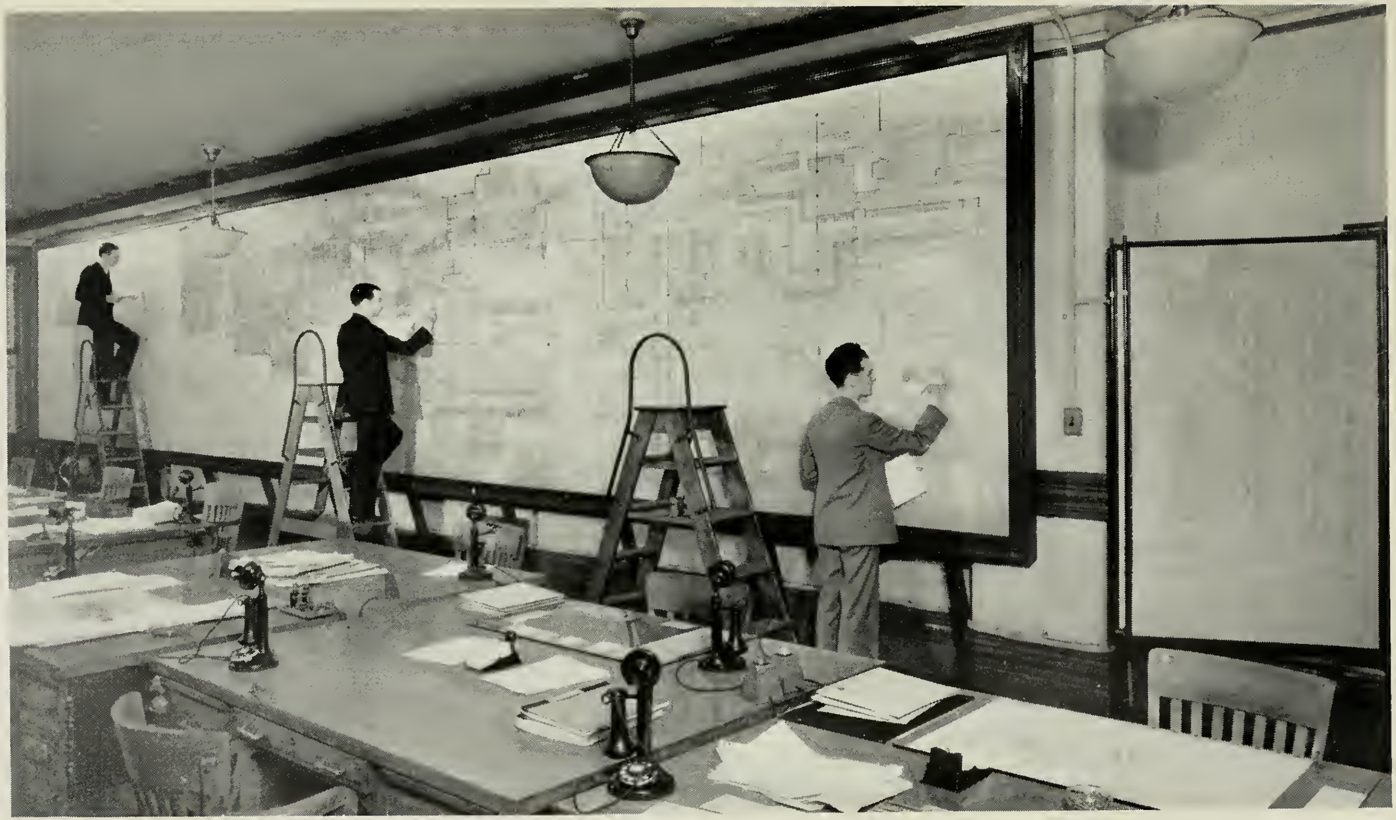
When the Long Lines Department moves up to its new quarters at 24 Walker Street, this month, the open-wire circuit layout chart will be replaced by another which will be fifty feet long and ten feet high—another illustration of progress through evolution. The chart has been in service since 1922. Now, ten years is a long time, as the lives of charts are measured, so that this particular chart is really a grizzled veteran, facing retirement with many scars to show for long years of service. If it were possible for inanimate objects to become articulate, it might look back upon the events of a decade of telephone history and remark, with a hero of old, "All of these things I have seen, and a part of them I was."

From year to year, almost from day to day, its notations have reflected ten years of growth of telephone facilities—possibly the most remarkable ten years in the history of communication. It has borne mute but eloquent testimony to the extension of the Bell System's lines to meet a nation's needs. It tells, of course, only a part of the story of this telephone growth, for the record of cable circuit layouts is kept on a separate set of charts—216 of them, with a total chart space of 3456 square feet. But it tells, by inference, something of the story of cable development as well as that which has had to do with open wires. There are great white spots here and there—where erasures have been made to indicate that open-wire facilities have been dismantled and replaced by cable. A study of these erasures will show that they have moved from the right hand side of the chart toward the left, silently telling the story of how the Bell System has pushed its network of long distance cables far into the Middle West.

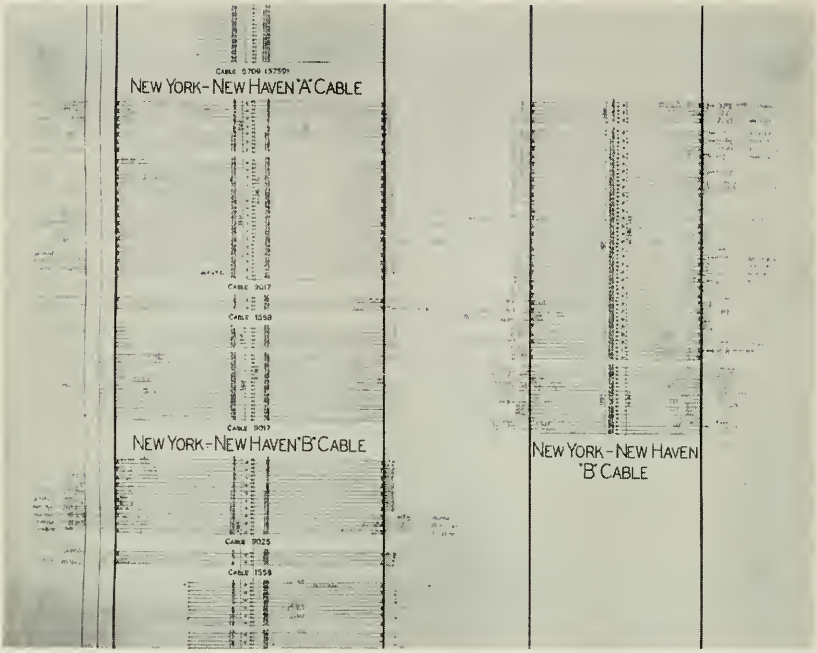
The circuit layout charts tell more of a story than that which relates to the development of telephone service. It is not difficult to read between their lines another story—the current history of the American people: their economic and social habits; their political battles; the ebb and flow of their business; the sporting events that absorb their interest; their carefree migrations to places where they find rest and recreation; their periodic outbursts of unashamed sentiment.

The Circuit Layout Group

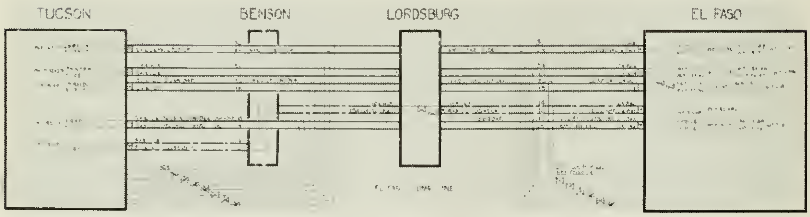
Maintenance of these records is one of the functions—but only one—of a most important but little known branch of the Long Lines Department which is designated as the Circuit Layout Group. It may be well to review briefly the activities of this organization and to see how important a part it plays in enabling the greater organization which has come to be known as the Bell System to perform its functions. As its name implies, this group is responsible for engineering and



Open Wire Circuit Layout Chart at New York Headquarters of Long Lines Department, A. T. & T. Co. At right is shown one of the cable circuit layout charts.



Part of One of the 216 Charts on Which Are Recorded Data Regarding the Long Lines Cable Circuit Layout.



A Typical Portion of the Big Open Wire Circuit Chart Seen at Close Range.

ordering into service a layout of telephone and telegraph circuits that will provide efficient and economical service. It should be understood that it has jurisdiction only over the circuits maintained and operated by the Long Lines Department of the American Telephone and Telegraph Company for the purpose of linking the Associated Companies of the Bell System. Each Associated Company has its own circuit layouts for local and toll telephone service, private line telephone and telegraph service, etc. Within its own territory each Associated Company consequently has its own organization for engineering these layouts and ordering them into service.

The Circuit Layout Group here discussed is located at Long Lines headquarters in New York and is made up of representatives of the Long Lines General Plant, General Traffic and Engineering Departments. The group is composed of one general Circuit Order Committee and nine section Circuit Order Committees. These section committees correspond to the nine sections into which the United States has been divided for long distance telephone traffic purposes. Each section committee, as well as the general committee, has a Plant, Traffic and Engineering Department representative.

These sections are: 1. New England States. 2. New York State. 3. New York-Pittsburgh. 4. Pennsylvania west of Pittsburgh and the State of Ohio. 5. South and west of Chicago and the Mississippi River. 6. Southern States. 7. New York-Washington. 8. Indiana and Michigan. 9. North and west of Chicago and the Mississipi River.

The Circuit Layout Group has nothing to do with the actual planning and construction of new facilities. With the steps involved in the provision of these facilities, from the forecast of the General Commercial Department to the setting of poles by the Plant Department, many readers are more or less familiar.

Let us assume that these steps have been taken and that a particular group of telephone and telegraph circuits is about to be made available for service. As the work has gone along, its progress has been noted on monthly construction schedules issued by the Division Plant Construction Department. Copies of these schedules have been turned over to the Circuit Order Group and the dates appearing on them are the determining factors which control the issuing of circuit orders.

How Circuit Orders Are Issued

Once a week the Circuit Order Committees meet to review layout work and schedule circuit orders. Based upon reports of the Plant Department as to construction progress and statements of the Traffic Department as to its circuit requirements, circuit orders are tentatively agreed upon, either placing new construction in service or authorizing rearrangements of existing layouts so as to meet the requirements of the existing situation or those of the immediate future. The draft of each proposed circuit order is submitted to each office interested and such changes made as may be necessary. Work on the draft is scheduled so as to have the final copy of the circuit order released to the field from two to four weeks before the "for service" date upon which the facilities will be put into commercial operation.

So much for the routine of issuing circuit orders for newly constructed facilities. In the main, the same routine applies to changes in layout of existing facilities. As soon as a circuit order becomes effective, the essential facts regarding the circuits involved are recorded and the assignments of facilities are noted on the charts. These notations are made in pencil so that changes may be made conveniently when necessary. The gauge and loading of the facilities are shown on the charts and a card index is kept showing the detailed makeup and necessary transmission information of each telephone circuit. A separate card record is kept for telegraph circuits, showing the routing and methods of operation of each circuit.

Extent of Long Lines Facilities

Let us see what maintenance of such a record involves. The Long Lines Department has more than 895,000 conductor miles of open wire and more than 5,161,000 conductor miles of cable in service for telephone and private line telegraph purposes. These are actual, physical circuits. In addition, there are 180,000 circuit miles of open wire phantom circuits; 1,290,000 circuit miles of phantom circuit in cables; 375,000 channel miles of carrier telephone circuits; and 1,018,000 channel miles of carrier telegraph circuits. Telephone and telegraph circuits assigned to these facilities are as follows: telephone message circuits, 6581; private line telephone circuits, 411; private line manual telegraph circuits, 681; and private line teletypewriter circuits, 570. In addition, many more circuits are assigned for program transmission, telephotograph transmission, teletypewriter exchange service, maintenance purposes etc.

It might well be assumed that, after doing all the detailed work required in getting new circuits ordered into service and properly recorded on these layout charts, the easiest thing to do would be to let them alone. And so it obviously would be —but it would not always be the efficient or economical thing to do. There is nothing static about the telephone business. It changes from year to year—almost from day to day, hour to hour and minute to minute—to meet requirements arising from changing conditions. As the service changes—and, indeed, before it is possible for it to change, in many cases—there must be changes in the circuit layouts.

Changing Layouts to Meet New Conditions

It is because the Long Lines circuit layouts must be changed constantly to meet the requirements of new conditions that the charts kept by the Circuit Layout Group so accurately reflect the life of millions of Americans. If one were to run through the records of a year with a member of the Circuit Layout Group, as the writer did recently, one would find that a series of changes in circuit layouts is made every year to keep pace with the shifting seasonal demands for telephone and private line telegraph facilities arising out of movements of great masses of people to vacation resorts. Atlantic City, for example, must be given a group of additional circuits to take care of its winter peak, which extends from about Lincoln's Birthday through Easter, and still other facilities to meet the demands of its greatly increased mid-summer population.

In early June or thereabouts, circuits must be provided to handle calls of vacationists in the Catskills and the Adirondacks—the New York State summer layout. There is a similar New England summer layout which furnishes extra circuits for the use of those who seek recreation on Cape Cod or the Maine Coast or in the White Mountains. The resorts of northern Michigan must be taken care of, and an extra circuit or two run into the Yellowstone National Park.

Just when the Circuit Layout Group has a chance to catch its breath after its efforts to take care of the summer vacation peak, another makes itself manifest. From the latter part of August through Labor Day, extra circuits must be assigned to Montreal to care for the requirements of Americans who make pilgrimages across the Canadian Border.

Early in December circuit orders for the Florida layout must be in the field, including private line telegraph and telephone circuits as well as extra long distance telephone facilities. It is important that the American business man on vacation be able to keep in touch, not only with his home and his office, but with the activities in Wall Street, and the tapping of teletypewriter keys at various points along the Florida shore helps to provide this necessary communication link. The Florida long distance telephone and private line traffic reaches its peak in February and recedes as the army of vacationists moves northward.

Holiday Traffic Peaks

These traffic peaks are, it will be observed, geographic as well as seasonal. There is another peak which knows no state boundaries, but pervades the whole nation. It has nothing to do with climatic conditions. It is purely a matter of sentiment. It comes with the arrival of Christmas and continues through New Year's Day. During this week Americans forget the fluctuations of their investments for a little and think of friends and relatives far away. From one corner of the continent to the other, long distance telephone calls increase in number by leaps and bounds. For this temporary overload the telephone circuits must be made ready. Circuit orders are issued, erasers are applied to one portion of the layout chart and pencils to another, and spare facilities are made available where experience has shown they will be most needed. When the holidays arrive, every available circuit must be ready for service—because Americans are, after all, a sentimental folk and when they get ready to wish somebody a "Merry Christmas," they do not care to be delayed in acting upon this praiseworthy impulse.

A Record of Political Events

Even the political activities of the American people may be reflected on the notations on the circuit layout charts. Once every four years the United States must go through the process of selecting candidates to run in the forthcoming presidential election. The cities in which the two major parties hold their national conventions must be provided with telephone facilities to take care of the requirements of the delegates and, to an even greater extent, with private line telegraph and teletypewriter circuits to meet the needs of the press. If the convention happens to be held in a city which does not normally have a considerable number of "spare" circuits, the Circuit Order Group is likely to spend many hours of anxious thought in preparing for the temporary but exceedingly urgent demand for telephone and telegraph facilities.

For similar reasons a presidential inauguration places a heavy tax on circuits into Washington and provision must be made for taking care of this one-day rush of private line telegraph, teletypewriter and long distance telephone traffic. Even after a president has been safely elected and inaugurated, his personal habits may have a marked bearing on the number and the difficulty of the problems which the Circuit Order Group is called upon to solve. If the Chief Executive usually stays in Washington, with short trips to a nearby summer camp, as does Mr. Hoover, the problem is relatively simple. But if he makes a practice of taking long railroad journeys at frequent intervals or spending his summer vacations first in one part of the country and then in another, the charts of the Long Lines Department must record the fact that additional telephone and telegraph circuits have been assigned to points along the presidential itinerary. Not only must there be sufficient telephone and telegraph facilities to keep the official party in touch with Washington, but once again private line telegraph and teletypewriter circuits must be provided for the use of newspapers and press associations. It sometimes becomes of momentous interest to the people of the United States to know whether, on any particular morning, their Chief Executive has fished with worms or with a fly—and whether he has caught anything. There are times, too, when they are vitally concerned in hearing that he has spent a good share of a summer afternoon sitting on one end of a log—with a British Prime Minister sitting on the other. For out of these presidential summer camps there come, over the private line telegraph and teletypewriter wires or by long distance telephone, not only items of news which are essentially trivial, but those which tell of events that may profoundly affect the history of the nation and of the world.

Strawberries and Sporting Events

The Circuit Order Group must have at least a working knowledge of scores and almost of hundreds of activities in which the American people engage or interests which hold their attention. Its members must, for example, know enough about agriculture to predict with measurable certainty when strawberries will begin to ripen on the eastern shore of Maryland. Strawberries are a perishable crop and must be sold and shipped in a hurry, once they begin to turn from green to red. This means urgent long distance calls between farmers and their market representatives, and these, in turn, involve more circuits—or trouble. So a group of additional facilities is set up each year to take care of this situation. Among the members of the Circuit Layout Group it is known as the Strawberry Layout.

Nor can the strategists on this important sector of the Bell System battle-line afford to become so absorbed in statecraft or in strawberries that they forget to study the sporting pages. When the warm days of April come and the bleachers echo to the cheers which greet Babe Ruth's first home run, every Big League city must have extra newspaper and press association private line telegraph and teletypewriter facilities. At World Series time, these demands are still further augmented in the two cities in which the championship is to be decided. There would be trouble, too, if some year the Circuit Layout Group were to forget that there are such things as the Indianapolis Speedway motor races, or the annual gridiron clashes between Harvard and Yale and other traditional rivals, or pugilistic encounters of major importance. Anything that makes news makes demands for communication facilities and consequent changes in telephone and telegraph layouts—if the news is big enough.

It requires but little imagination to see in these Long Lines circuit layout charts—some of them bearing the scars of long service, as does the big open-wire chart—an important contribution to contemporary Americana. Upon them are reflected the incidents and events which make up America's current history. Here, too, is recorded, in a never-ending succession of pencil lines, erasures, and still other pencil lines, the continuing growth of a great communication service that is playing a vitally important part in helping America to fulfill its destiny.

R. T. Barrett

Award of the John Fritz Medal to Dr. Michael I. Pupin

Editor's note:

The John Fritz Medal is the honor given jointly by four national engineering societies; the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. It was established in 1902 in honor of John Fritz, of Bethlehem, Pennsylvania, and is awarded not oftener than once a year for notable scientific or industrial achievement. The Board of Award is formed of sixteen men, four representatives from each of the four Societies.

On January 27, 1932, at a meeting of the American Institute of Electrical Engineers, this medal was presented to Dr. Michael I. Pupin, Professor Emeritus of Electro-Mechanics at Columbia University, New York City, whose loaded telephone line invention more than thirty years ago was an outstanding fundamental contribution to telephone engineering, and who is held in highest esteem as a member of the Bell System family.

At this meeting the address in regard to Dr. Pupin's achievements was made by Mr. Bancroft Gherardi, Vice-President and Chief Engineer of the American Telephone and Telegraph Company. It is printed below in full together with Dr. Pupin's response after the presentation of the medal.

Mr. Gherardi's Address

FIFTY-EIGHT years ago, late in the winter of 1874, a young Serbian landed at Castle Garden. He was without money or property, without friends or influence, and without knowledge of the language of this country. Many would say that he had nothing; but this would fail to recognize the things which he had. He had good health, character, ambition, a mind eager to find knowledge and to use it, and high ideals.

This evening I have been selected as the spokesman of four great engineering societies whose representatives are gathered here to pay a tribute of esteem and affection to him.

Limitations of time compel silence upon Dr. Pupin's early struggle for an education, and his studies at Columbia, Cambridge (England), and at the University of Berlin; except only this, that no one can read the account which he gives of this period of his life in his wonderful autobiography without being convinced that in the earlier influence of his mother and in the period in which he was getting his education, was laid the foundation upon which rest his many achievements during a long and varied career. From the time of his connection with the staff of Columbia University, the story of his life is a continuous record of contribution to our knowledge and our methods of thought. Of these only a few high spots can be mentioned this evening.

Perhaps because I am a telephone engineer, I am starting by referring to his invention of the loaded telephone line. For a number of years prior to Dr. Pupin's work which led to his inventions and patents on this subject, it was known that the addition of continuously distributed inductance to a telephone circuit would add to the transmission efficiency of the circuit, that is to say, would diminish the losses of the telephone current during its passage through the wires. It had been suggested that similar results should follow from the placing of inductance coils at intervals in the circuit. This had even been tried experimentally without favorable results.

By means of a beautiful mathematical investigation Dr. Pupin established the fact that it was not sufficient to place inductance at intervals in the circuit, but that the inductance must be designed with reference to the conditions of the circuit and must be uniformly spaced at intervals having a relationship to the shortest waves which it was desired to transmit. He confirmed the results of his mathematical investigations through a brilliant series of laboratory experiments and in addition he designed and demonstrated the advantages of the toroidal type of loading coil; a design which fundamentally has persisted even to the present time, although it dates from over thirty years ago.

Dr. Pupin's patents were acquired by the Bell Telephone System and from that day to this his inventions have played a fundamental part in long distance telephony. The time at which Dr. Pupin made these inventions was most opportune. They came just when telephone engineers were confronted with serious problems in the extension of long distance telephone service over greater and greater distances, and also when, due to the unfavorable effects of non-loaded telephone cables, very serious problems were arising in the planning of long distance lines. These problems were particularly difficult where the numbers of circuits required were so great that overhead open wire constructions presented formidable difficulties, and where the lines had to be brought into large cities.

As part of the mathematical investigation of the loading problem, Dr. Pupin developed a mathematical theory of certain forms of artificial lines or electrical networks. Such artificial lines today have numerous important applications in the communication art.

Dr. Pupin was the original discoverer of the electrically tuned circuit, that is, of the possibility of so proportioning the electrical characteristics of a circuit that it would respond energetically to any pre-determined alternating current frequency. The electrically tuned circuit is used today in every important branch of the electrical art, in telephony, in telegraphy, in power transmission, and last but not least, in radio systems. It was first used by him and then by others in the analyzing of alternating currents, that is to say, in their separation into the different frequencies of which they were composed.

In a way, Dr. Pupin was unfortunate in the time in which he made this invention. Electrically tuned circuits are used in every radio receiving set. At the time that he made the invention, however, the radio art was practically non-existent and for many years thereafter it was used only for incidental and specialized purposes. Today, however, practically every home contains an electrically tuned circuit in the radio receiving set, but Dr. Pupin's discovery was so far ahead of the development of radio and therefore of the general use of tuned circuits that few realize today that, if this contribution of Dr. Pupin's were to be removed from the radio systems of the present day, they would no longer function.

Immediately upon the discovery of the X-Ray, Dr. Pupin made two important contributions. He was the first to discover the phenomenon of secondary X-Ray radiation, that is, that when X-Rays strike on any matter, that matter becomes itself a source of X-Ray radiation. This fact was not only important in itself, but it contributed to many other scientific advances in X-Ray work. Dr. Pupin did much experimental work in X-Ray photography and he was, I believe, the first in this country to make an X-Ray picture with the aid of a florescent screen. The advantage of this method over those previously used was that it enormously shortened the time necessary for the photographic exposure and made it possible to take X-Ray pictures in many medical and surgical cases where, without a short exposure it would not be practicable to get an effective X-Ray picture.

Dr. Pupin was the first to suggest the use of an electrical rectifier in connection with the receiving of radio signals. While Dr. Pupin's original invention made use of an electrolytic type of rectifier cell, his invention was broad enough to cover the use of any type of rectifier element. Here again Dr.

Pupin was unfortunate in that his invention was so far ahead of the development of the radio art that it was many years after his work was done before there was any extensive opportunity to use practically this contribution.

Dr. Pupin has had an important part in the building up of the scientific and engineering departments of one of our greatest universities—Columbia University. He has not only contributed much in this way, but the graduates of Columbia University who studied under him have in many cases made distinguished records in the fields of science and engineering. Of the many, I shall only mention two—Dr. Robert A. Millikan and Gano Dunn, a Past President of the American Institute of Electrical Engineers. These and many others testify with the greatest enthusiasm to what they owe to Dr. Pupin's teaching and to his inspiration.

During the war, Dr. Pupin had an important part in starting the National Research Council. The purpose of the National Research Council as defined by President Wilson in his executive order with reference to it was: "stimulating research in mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare." Throughout the period of our participation in the war, Dr. Pupin devoted his abilities and his boundless energy to the vital problem of submarine detection.

No statement of Dr. Pupin's achievements, however brief, could omit the mention of his autobiography, itself a contribution to literature, to science, and to education and a wonderful study in the process of Americanization. From this book many native-born Americans can learn something of the spirit and aims of our country.

Dr. Pupin's honorary degrees, his membership of societies and his presidencies of them, his American and foreign decorations, medals and awards are too numerous to mention, but they testify to the judgment of others as to his personality and his work. In 1921 the American Institute of Electrical Engineers awarded to Dr. Pupin the Edison Medal, the highest honor which that Society could confer. Now three other great engineering societies, Civil, Mechanical and Mining have joined with the Electrical Engineers in awarding to him their great joint honor.

Dr. Pupin, I salute you:

An inventor who has made important contributions to the application of electromagnetism to the uses of man.

A scientist who has added important facts to our knowledge of science and contributed to scientific idealism.

An educator who not only has an enviable record as to those who have studied under him, but who has advanced the cause of education.

A citizen who has contributed much to this country.

An American who is proud of the country of his adoption, and of whom his country is proud.

Dr. Pupin's Response

As I have been sitting here and listening to the kind eulogies which my good friends dedicated to me this evening, I could not help recalling some of the memories of my boyhood days. I saw, as if in a vision, the familiar faces of several peasants of my native village who were my schoolmates over sixty years ago. I imagined them sitting in the front row here and dazzled by the brilliancy of this festive occasion they asked me: "Michael, tell us what saints and angels of heaven guided you on your way from the humble pasturelands of our tiny village to a place of honor in this glorious palace of the American engineers?" I answered: "Ask Mr. Gherardi to give you a Serbian translation of the speech which he dedicated to me this evening; that will answer your question better than I can answer it." I shall add only this: At every step of my uphill road I found generous encouragements in this blessed land. Above all I must mention here the generous spirit of my Alma Mater, Columbia College. The enjoyment of its scholarships, fellowships and research facilities helped me more than words can tell to make my modest contributions to science and engineering. Without this help I would not be with you this evening. The generous spirit of my Alma Mater was the same as that which prompted the John Fritz Medal Board of Award to confer this high honor upon me. I gratefully accept it, and I shall treasure it as a precious symbol of the generous spirit of this blessed land which always made me feel that life is worth living.

Permit me now to take up another line of thought. I have been informed that you expect me to bring you a message from the age of science in which I lived and toiled as an humble worker. That age is the Power Age and it sends you the following message:

Faraday's discovery of electromagnetic induction, a hundred years ago, is the closing event of a great epoch in the history of physical science and engineering. It is the epoch in which the power age was born.

Watt's invention of the steam engine marks the beginning of this epoch. It suggested to the genius of Carnot the immortal idea embodied in his well known law. This law defines what Carnot called the moving power of fire, that is of heat, a name which today is one of the greatest names in physical science.

Carnot's interpretation of the moving power of heat completed in 1824 the first great step in the evolution of the power age. The second great step was made when in 1820 Oersted discovered the magnetic force of moving electricity and a few years later Faraday discovered the electric force generated by moving magnetism. The law of action of these forces defined the moving power of electricity just as Carnot's law defined the moving power of heat. We know today that these two moving powers are the fundamental physical powers in the universe, and that their revelation was the greatest achievement ever recorded in the history of engineering sciences. It inaugurated, a hundred years ago, the power age. This age is the parent of our present civilization and the moving powers of heat and of electricity are the propelling powers in the physical evolution of this civilization.

Our civilization very often is called the machine civilization and what I call the power age often is called the age of machines. I don't like these names for the simple reason that machines are the creation of the hands of mortal man. They are transient, but the moving power of heat and the moving power of electricity are eternal; these powers are the immortal elements in the physical structure of our civilization.

Advancement of science during the power age, that is during the last hundred years, revealed that the same fundamental powers which are at work in the evolution of our civilization were also at work in the evolution of organic life ever since life appeared on this terrestrial globe and that they are also the only propelling powers in the evolution of the luminous stars. Radiations from these stars tell us that the moving powers of heat and of electricity are of celestial origin; they were brought to earth on the wings of solar radiation and remained dormant until the genius of Watt, Carnot, Oersted, Faraday, and Henry called them to the service of man. This service is the service of our central star to this tiny terrestrial globe; its mission on this earth recalls the mission of the celestial flame which, according to an ancient legend, the Titan Prometheus snatched from the radiant chariot of the sun god Helios and brought down to earth. The ancients believed that the mission of that celestial flame was to make the life of man similar to the life of the Olympian gods.

We believe that the mission of the moving powers of heat and of electricity, our most precious gifts from our central star, is to raise the life of man to Olympian heights. But has our civilization, the offspring of the power age, lived up to the lofty aim of this mission?

Two different pictures present themselves to our mental vision when we attempt to answer that question—two entirely different pictures. In one of the pictures I see the triumphant conquest of space by the automobile and the aeronautical art. I see the wonders of power distribution increasing a hundredfold the comforts and the creative power of man, and I am thrilled by the electric waves which sliding over wires or wandering through space convey on their wings speech and melody over continents and oceans to every nook and corner of this terrestrial globe. These are a few of the miracles of our power age by which the moving powers of heat and of electricity have displayed the magic of their celestial origin; they certainly have made the physical side of human life even more glorious than the life of the Olympian gods. This achievement of the power age is its greatest glory.

But the spiritual side of human life, exhibited by another picture, is far from edifying. In this second picture we see desolation on every side in the wake of the most deadly war which the world has ever seen. The world appears here standing on the verge of economic collapse, and yet vast armies and navies are devouring the meager remnants of the wealth of nations while millions of idle workers are starving. The most repulsive figures in this horrible picture are fear and hatred, which, like two ugly demons, are hovering on each side of the boundary lines between neighboring nations.

Banish these demons from the human heart and there will be no need of vast armies and navies to guard our security against hostile neighbors; there will be no hostile neighbors, and wars will become a dying memory only of former barbarous ages. But the celestial servants of our civilization, the moving powers of heat and of electricity, have not banished them.

Science admits that the magic of these two primordial powers cannot unaided purge the soul of man and eliminate the poisons which corrupt its spiritual life. Another moving power is sorely needed which can penetrate more deeply than the moving power of even the infinitely minute electrons into the depths of the human heart. This need was recognized nearly 2,000 years ago when our Saviour revealed the greatest moving power in the spiritual world and commanded us to love the Lord our God, and to love our neighbors as ourselves.

This was a message of the approaching power age in the spiritual world. But this age has not yet arrived; mankind has not yet yielded to the greatest moving power in the spiritual world, and without its aid the moving powers of heat and of electricity cannot contribute their full share to the evolution of the spiritual life of man.

Love of the eternal truth and of their work to reveal this truth for the good of mankind has guided the scientists and engineers to their great triumphs of science. These triumphs of love will persuade the reluctant world that the victorious triumph of the moving power of love which Christ discovered will be the greatest triumph of the power age.

Notes on Recent Occurrences

W. C. FORBES MADE A. T. & T. DIRECTOR

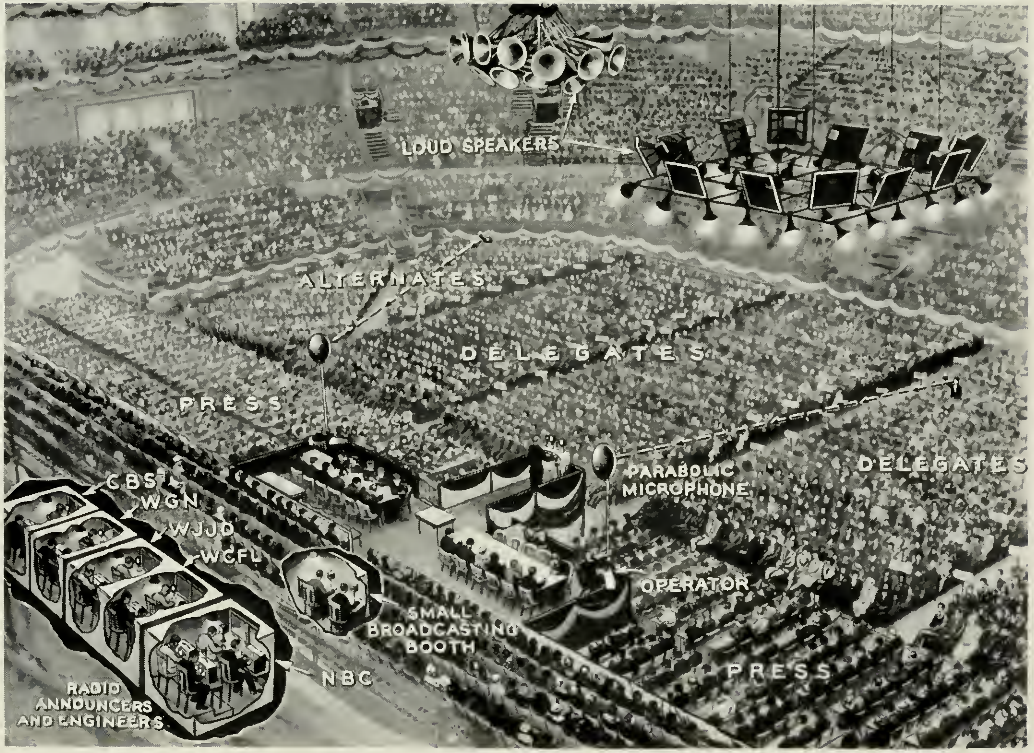
THE directors of the American Telephone and Telegraph Company at their meeting on February 17 accepted the resignation as a director of Jeremiah Smith, Jr. on account of ill health, and elected W. Cameron Forbes to succeed him. Mr. Forbes was formerly a director of the company and resigned to accept the position of Ambassador to Japan last June. He is now retiring from the diplomatic service.

THE ANNUAL MEETING

THE annual meeting of the stockholders of the American Telephone and Telegraph Company was held on Monday, March 29, 1932. The Board of Directors was unanimously re-elected. In all, 382,884 stockholders voted in person or by proxy 11,251,437 shares representing 60.3 per cent of the total stock outstanding.

SHIP-SHORE RATES ON ZONE BASIS

EFFECTIVE April 1, rates for ship-shore telephone conversations with transatlantic liners were placed on a zone basis. When the vessel is more than 500 nautical miles from the American Atlantic coast the charge is $18 for a three minute conversation and $6 for each additional minute. When the ship is 500 or less nautical miles off shore the charge is $9 for a three minute talk and $3 for each additional minute.



1932 Republican and Democratic Conventions.

Composite photograph of a section of the convention hall at Chicago showing seating arrangements of delegates, alternates and newspaper writers and arrangements for radio broadcasting. The two parabolic microphones were designed to pick up the voices of speakers from the floor. During the Democratic convention these were supplemented by a number of Western Electric lapel transmitters, carried to the speakers by floor pages. The box-like loud speakers are part of the permanent system in the stadium. The horns were installed especially for the conventions.

Bell Telephone Quarterly

A Medium of Suggestion and a Record of Progress

CONTENTS FOR JULY 1932

VOL. XI NO. 3

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES AND CANADA; SINGLE COPIES, 50 CENTS

Address all communications to

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

CONTRIBUTORS TO THIS ISSUE

G. K. McCORKLE

University of Kentucky, B.M.E., 1908. Entered Chicago Telephone Company, now Illinois Bell Telephone Company, in 1908. Occupied various positions in the Traffic Department, and became General Supervisor of Traffic in 1920. On the staff of the American Telephone and Telegraph Company, Department of Operation and Engineering, handling traffic results analysis, provisional estimate and toll service supervisory matters, 1924–1927. Traffic Results Engineer, 1927. General Commercial Manager, Chesapeake and Potomac group of Telephone Companies, 1927. General Manager for the company operating in Maryland, 1929. Vice President, Illinois Bell Telephone Company in general charge of public relations, 1930–.

ARTHUR L. FOX

Ohio State University, M.E., 1906. Entered Plant Department of New York Telephone Company same year in plant engineering work. Division Plant Engineer, Buffalo, 1909, Division Plant Engineer, Syracuse, 1912, Division Engineer, Albany, 1920. Transferred to Engineering Department as Engineer of Outside Plant 1925. Since 1927 Assistant Outside Plant Development Engineer in Department of Development and Research, American Telephone and Telegraph Company.

SYDNEY BONNEVILLE

McGill University, B.Sc., 1922. University course completed after returning from military service overseas. Immediately following graduation, entered the Engineering Department of The Bell Telephone Company of Canada. Occupied on general transmission problems until 1928. From 1928 to 1932 engaged in fundamental studies and engineering of the Trans-Canada Telephone System.

WALTER H. GRAHAM

Western Electric Company, New York, 1906; Philadelphia, 1911; New York, 1913. Chief Stores Manager, 1917. Distribution Engineer, 1926. Engaged in development of Distribution Methods.

CHARLES AUGUSTUS HEISS

Bloomsburg State Normal School, Bloomsburg, Pa.; Franklin and Marshall College; College of Political Science, George Washington University, B.A., 1908; University of Michigan, M.A., 1928; teacher 1898 to 1905; Examiner of Accounts, Interstate Commerce Commission, 1912–1913; entered the Accounting Department of the American Telephone and Telegraph Company May 1913; Comptroller, American Telephone and Telegraph Company, 1920–.

Communications and the National Conventions

INAUGURATING the second century of national conventions as instrumentalities in American political action, the two major parties have just concluded their 1932 meetings, both held in Chicago. Equally responsive to the demand for the special as well as the usual in their services, the electrical communication systems of the country—the local and long distance telephone, the telegraph and cable, radio broadcasting and telephotography,—have contributed each an important part in planning, preparing for and conducting these conventions, as well as in interpreting them to the public.

The political philosophy which underlies party conventions is bound in with communication. The convention proceedings are the first formal act in the party's campaign for votes, a campaign to be furthered during the next few months by every method of communication by which the public eye, ear or consciousness can be reached.

To use a trite, but in this case justifiable expression, "a modern miracle" was performed and repeated every moment of the two conventions. So comprehensive were the services of communication that any person in the United States, with access to a radio receiving set, might, if he chose, listen to every speech and hear on the instant every word spoken in debate. If he did not care to follow the proceedings, which sometimes lasted far into the night, his daily newspaper, issued perhaps a thousand miles from the convention city, would give him frequent reports of the convention activities, with photographs taken on the scene and transmitted by wire. If he wished to send a message to his own delegates or talk to them in person, the convention hall was equipped with telegraph and telephone service drawn to the last notch of efficiency. If his interest required contact out of convention hours, he would find the wire facilities at his call to penetrate hotel rooms, committee rooms and headquarters.

Many profound political developments in American history are readily traceable to the lack of adequate communication between different sections of the country in the early days of the republic. In those days communication with those at a distance meant just one thing—travel; travel in person or by messenger, on foot or horseback, in the lumbering coaches of the day, or by sea. When the nation was founded there was scarcely a single highway worthy of the name in the thirteen states. Main roads were deep in mud or dust and side roads were little better than trails. The traveler forded the small streams and was ferried across the large ones. These conditions had their influence in shaping the very form of the government itself. The provision in the constitution that presidential electors shall meet in their respective states was no doubt dictated, in part, by the difficulties of travel, otherwise the obvious arrangement would have been for the electors to meet in some central place. The plan adopted required a single messenger from each state to make the journey to the seat of government. The interval allowed between the casting of the votes and the inauguration of a president was due, probably, to the time necessary to collect the electoral ballots and complete the election. The time required to reach the capital was also the reason for the long interval between the election and induction into office of members of Congress, whence come the "lame duck" sessions. So important was the factor of travel that Alexander Hamilton in a scheme of government which he presented to the Federal Convention, proposing that senators be chosen for life and representatives for three years, wondered "if gentlemen could be induced to make a journey of six hundred miles to attend the national legislature." After the government was established improvements in transportation methods and facilities for travel came so slowly that to gather an assembly from all parts of the country would obviously have been a major operation in those early years, only to be undertaken for the most imperative reasons. A session of Congress, for which the members received compensation and mileage allowance, justified a long journey, but such a thing as a gathering of delegates in a brief meeting did not enter into the political program for almost half a century after the foundation of the government. Organized political action in the early days took the form, for the most part, of the caucus, and in national elections the Congressional caucus assumed the right of choosing presidential and vice presidential candidates and writing the party platforms.

Even after conventions were established as methods of party action, the time element, the season and communications were governing factors. Former Governor Alfred E. Smith comments on this in a recent magazine article. "I have often asked myself the question, without hope of a satisfactory answer," he wrote, "'Why is it necessary to hold the national convention in the month of June?' As I look for the answer, I find that years ago the delegates required several months to get to the convention and then back to their home towns. After the nomination nothing of much importance to the campaign could happen because there were no modern means of communication, there being no telephones, no rapid railroad transportation and no radio, no airplanes and no . . . transmission of photographs or the ever present motion picture and news reel."

The first party convention organized on a nation-wide basis was held just one hundred years ago to renominate President Andrew Jackson. As the place for this first convention Jackson chose Baltimore, which was connected to Washington by the newly constructed Baltimore & Ohio railroad, which offered the quickest means of communication then in existence anywhere in the country.

Two events of lasting importance opened the campaign of 1844. For the first time one of the parties named a "dark horse" for President and for the first time also, electrical communication entered the picture. At the time of the Whig convention, in May, the first telegraph line in America had been completed from Washington to a point about fifteen miles from Baltimore. When Henry Clay was nominated for president, newspaper reporters boarded a train, rode out to the point where work on the telegraph line was in progress and from there sent the announcement of Clay's nomination by telegraph to Washington, where it was received in the Supreme Court room of the Capitol by a waiting group of Whig leaders. This was the first telegraphic report of a national political nomination. When the Democrats met three weeks later, the line was finished and instruments were in place in the railroad station. Reporters hurrying from the convention hall to the station flashed to Washington the news of the nomination of Polk. This was so unexpected that some in the group of Democrats gathered in the Capitol refused to believe it. But the message was correct and the reply that went back, "Hurrah for James K. Polk!", was received in the Baltimore convention before the chairman had officially announced Polk's nomination.

The Republican convention of 1860, which nominated Abraham Lincoln, was the first of a long succession of conventions to be held in Chicago and is reported also to have been the first to which spectators were admitted. The sessions were held in a "wigwam," a wooden building constructed for the purpose. When Lincoln's nomination came, the result was proclaimed by firing a cannon from the roof of the wigwam, a form of "broadcast" in vogue at that time. Lincoln was in his law office in Springfield, Ill., when he received the telegram announcing his nomination. "There's a little woman over on Eighth Street ought to know about this," he said. Of course there were no telephones then. Lincoln walked home. Five months later, on election night, he sat in the little telegraph office in Springfield, receiving frequent news of the counting of the ballots. When the message came that New York had gone Republican he felt sure of his victory. Again he walked home. Mrs. Lincoln was waiting. "Well, Mary," he said, "I guess we're elected."

In 1860 the pony express service started and one of the earliest relays of riders who crossed the western plains and mountains carried the news of the nomination of Lincoln. The fastest trip ever made was by those who bore copies of Lincoln's inaugural address. The following year the telegraph was lifted over the mountains and the brief but exciting career of the pony express soon came to an end.

The Chicago convention of 1868, which nominated Grant and Colfax, was held in Crosby's Opera House. According to a newspaper account of this convention, a telegraph office was fitted up in the south proscenium box for the convenience of the Associated Press, whose reporter (only one, it seems) had a table in front of it. This is the first installation on record of special wires for the purpose of reporting a national convention, although at previous conventions the telegraph companies had always made arrangements to handle a larger than normal volume of traffic.

The telegraph, with its splendid service and facilities, still remains an important instrumentality for conducting the business of national conventions and supplying reports of their activities, particularly to the newspapers. But in later years the telephone and radio broadcasting have also become of major importance.

The first conventions held after the beginning of telephone service were those of 1880. The service at the time was local only. An item in a Chicago newspaper of May 26, 1880, a few days before the Republican convention, stated that "Just as the local executive committee had adjourned, somebody called through the telephone for Mr. Jesse Spaulding. He went to the instrument and was informed that the anti-Grant men wanted the Exposition Building to hold their indignation meeting in." Here was the first, so far as the records show, of the thousands of telephone messages which have gone into and out of convention committee rooms—messages which have had tremendous influence in shaping convention results.

The practice of admitting spectators, begun in the Chicago wigwam in 1860, had been continued in later conventions of both parties with a constantly greater demand on the part of the public for admittance. And, with the addition of new states to the union, the conventions themselves had grown larger. To accommodate this demand, larger and larger wigwams, "amphitheatres" or exposition halls were provided or requisitioned. The practical ultimate in such buildings was reached in the construction of the Coliseum in Chicago. Due to the limitations of the human voice, the size of this hall was just about the maximum for a place of public assembly. Five Republican conventions, the last in 1920, were held in this building.

In 1920 a new development perfected by Bell System engineers was demonstrated for the first time in a national convention. This was the public address system with the familiar loud speakers. With this system everyone in the big Coliseum could hear perfectly the proceedings on the platforms and from then on the conventions took on a new character. Since the public address system accommodated a vastly larger audience, recent conventions have been held in the largest halls in the country. No doubt the selection of Chicago in 1932 was partly due to the completion of the Chicago Stadium, which will seat about 22,000 persons. It appears that the size of halls of the future will be governed only by structural limitations. The problem of hearing is entirely solved.

The first transmission of an audible reproduction of convention proceedings to a distance took place in 1908 when, at the request of President Roosevelt, engineers of the Bell System installed in the Chicago Coliseum a set of four sensitive transmitters which were hung about ten feet above the heads of the delegates and a few feet in front of the platform. These were connected in a circuit running from Chicago to the White House in Washington. The president, with receivers clamped to his ears, was able to listen to the "keynote speech" of the temporary chairman, Henry Cabot Lodge, and to hear the cheering, which lasted forty-seven minutes, when his name was mentioned by the speaker. But Roosevelt was not a candidate that year and the next day Taft was nominated.

This was a service for one listener only, but by 1924, when the Republicans met in Cleveland and the Democrats in New York, radio communication had become an established service and chain broadcasting had been successfully developed. The first commercial broadcasting station, KDKA in Pittsburgh, had begun its career on election night in 1920 and its first program was the broadcast of election returns. Both 1924 conventions were broadcast over small chains covering the eastern and central parts of the country. The long drawn out proceedings of the Democratic meeting in Madison Square Garden, New York, were broadcast at great length and into the small hours of the morning. The almost endless repetition of the words, "Alabama casts twenty-four votes for Oscar W. Underwood," as ballot followed ballot in the long deadlock, was heard day after day by radio in so many homes that the expression began to take on the flavor of a tradition. By 1928 the chains broadcasting the convention had grown to sixty, in forty-three cities in all parts of the country. Chain broadcasting combines the services of the telephone lines and the local broadcasting facilities. The radio system operates the broadcasting service and the Bell System supplies the wire lines which connect the various stations throughout the country which make up the chains and which receive identical programs by means of these lines. During the 1932 conventions Bell wires linked 181 stations of the National Broadcasting Company and of the Columbia Broadcasting System with announcers' booths in the Chicago Stadium. The importance of these broadcasts is second only to the service of the newspapers, on which, of course, most Americans depend for the presentation and analysis of the news of the conventions.

The two conventions of 1924, the Republican in Cleveland and the Democratic in New York, also brought the first public demonstrations of the Bell System's newly developed method of transmitting pictures by wire. In a demonstration at Bell System headquarters, New York, on the afternoon of May 19, 1924, the first press telephotographs had been transmitted. By the time the Republican convention met on June 10 of that year this method had been fully tested between Cleveland and New York and throughout the convention pictures taken in Cleveland were regularly published the same day in the New York newspapers.

Telephone service constitutes the nerve network joining convention halls with committee rooms, campaign headquarters and the homes or offices of candidates and other interested persons in distant parts of the country. The first instance of special arrangements to provide continuous contact between a candidate and his headquarters was recorded twenty years ago when the home of Theodore Roosevelt in Oyster Bay, New York, was connected with the Congress Hotel in Chicago over a leased telephone circuit. This was in service a week before the Republican convention and enabled the former president to direct all details of his campaign. Later, however, he boarded a train and rushed to Chicago where he was on hand to deliver his famous Armageddon speech before the Progressive or "Bull Moose" convention, which followed his defeat in the Republican meeting. A recent magazine article says that Senator Penrose of Pennsylvania, who was prevented by ill health from attending the 1920 Republican convention, communicated frequently with the Pennsylvania delegation over the long distance telephone and consented to the switch of the Pennsylvania votes to Harding, breaking the deadlock in that memorable meeting.

As was pointed out by Mr. Arthur W. Page in his recent address before Lowell Institute, the ancient forms of communication "were an essential part of the machinery by which a small ruling class kept large populations in subjection. These communications were largely made up of the military and political information necessary for the conquerors to maintain this rule over the populace. Modern communication is chiefly useful so that large populations may know themselves, by constant intercourse, and thereby improve their economic status and their ability to govern themselves. The underlying purpose of the two systems is exactly the opposite. One gave inside news exclusively to the few. The other is to enable every one to have the same news at the same time and to have equal facilities for personal communication. One tended towards exclusive power, the other tends towards equalization of opportunity. Communications are now one of the great agencies of democracy."

The outline which we have just traced by means of a few references to history, serves to emphasize the contrast between the old and the modern in communications in their relation to political action in our own country and to show how the forces of reaction, which were strong in early days, have gradually, and in recent times, rapidly, yielded to the demand for complete, continuous and instant information and publicity concerning all matters of government and party action.

The physical means whereby the comprehensive systems of communication associated with national conventions are established and operated doubtless receive little consideration by a public accustomed to enjoy the benefits of science in so many fields, but the magnitude of the job makes the story impressive when the various agencies involved are marshalled in review. To obtain the results demanded by the public and by those participating in the two conventions in Chicago, required both the separate and the co-ordinated services of all forms of electrical communication.

There were several groups to be considered in the setup of communication facilities. First, those in the convention hall itself; second, the newspaper-reading public; third, the audience of many millions listening from radio receiving sets all over the country, and finally those who might desire individual communication service on matters connected with or growing out of the convention.

The Chicago Stadium, designed primarily for athletic contests, was transformed for the conventions into a vast auditorium. The speakers' stand which projected deep into the center was equipped with microphones both for the general broadcast and for the public address system within the hall. As the convention proceedings would be made up entirely of speeches and debate by speakers having every degree of voice quality and voice capacity, it was thought best to reinforce the public address system already in place in the Stadium, which was designed to be used by trained announcers. This was done by a special installation which practically doubled the capacity of the system and was so effective that those in any part of the hall, which is more than two hundred feet in length, were able to hear. To take care of a possible overflow crowd, an additional battery of amplifiers was installed in Union Park about two blocks from the Stadium.

The press stand stretching the full length of the floor on either side of the platform was crowded at each convention with more than seven hundred newspaper men and women from all over the country and some representing foreign papers. To quote a prominent newspaper writer in his description of the Republican convention, "a flood of news and feature matter was loosed on bolts of lightning in total six-day volume believed to be not less than five million words, filling daily as high as eight or ten pages of metropolitan newspapers." This, of course, included press dispatches covering preliminary news of the convention. No corresponding estimate of wordage on the Democratic meeting is available, but it was doubtless as great, or greater. There were several telegraph instruments working directly from the press section and the Associated Press had a teletypewriter working within a few feet of the rostrum. Four press associations maintained large workrooms in the Stadium close to the convention floor. Writers, working in relays, took notes in the convention and went to these workrooms where their stories were written and transmitted over telegraph or teletypewriter circuits to all parts of the country. On the lower floor of the Stadium were about fifty smaller workrooms used by Chicago newspapers and by special correspondents of papers in other cities. These workrooms were equipped with telephones, teletypewriters and telegraph instruments.

To care for telegraph, telephone and teletypewriter facilities for the press, the Illinois Bell Telephone Company set aside a special one hundred pair cable terminating in an American Telephone and Telegraph Company loop board installed in the basement of the Stadium. From this board branch cables were carried to the various workrooms of the press associations and individual newspapers and to the press section on the convention floor. The Western Union and Postal Telegraph companies also maintained large workrooms where they handled a heavy volume of press dispatches and private messages.

The Bell System's telephotograph service played a prominent part in telling the world the story of the two conventions in pictures. Four press picture services were daily users filing photographs for transmission to all parts of the country reached by this service. The Chicago telephotograph office, two miles from the Stadium, was a busy spot during the two conventions. Press photograph services worked feverishly in the race to take, develop and start on their way around the country over Bell System wires pictures of the convention actually in session. One of the press photo services supplying pictures to about six hundred newspapers in the United States and many more in foreign countries, established a temporary finishing plant across the street from the telephotograph office. Films of the first pictures taken in the convention after the sessions opened, were placed in an ambulance, obtained for the occasion, and rushed to the telephoto office under motorcycle police escort. Finishing equipment had been set up in the ambulance and the films were developed en route, ending the two mile trip six minutes after the pictures had been taken. Other press photograph services also used the telephotograph service liberally. Several pictures sent by wire to New York on the first day of the Republican convention were on steamships headed for Europe the same evening.

Perhaps the feature of greatest immediate interest to the largest section of the public was the arrangements for radio broadcasting. Extensive use was made of Bell System facilities both by the broadcasting companies and local Chicago stations. Above and back of the speakers' platform was a row of five glassed-in radio control booths operated by the National Broadcasting Company, Columbia Broadcasting System and three Chicago stations. In each booth occupied by announcers and radio engineers were microphones, telephones and control equipment. In addition to the microphones in front of the speakers' platform, the National Broadcasting Company had two parabolic microphones, one set up at each corner of the platform, to pick up speeches from any part of the floor, as well as to register the applause and demonstrations. These conventions were the first to use this type of microphone, which may be aimed or focused in any direction and is designed to pick up and amplify the voices of floor speakers. The Columbia System also had five special microphones in various locations around the hall.

At the Democratic meeting the first use for convention purposes was made of the new Western Electric lapel type microphone, developed by Bell Telephone Laboratories. Microphones of this type, suspended on long cords, were carried on the coats of pages. When a delegate spoke from the floor, a page placed himself so that the microphone would pick up the sound of the speaker's voice, carrying it clearly both to the convention and the radio audience.

All microphone locations were connected with the control booths by telephone so that announcers, directors and engineers were in constant communication. Telephone talking circuits also connected the control booths with the main Chicago studios of the broadcasting and chain systems and with their studios located below the platform, which were used for broadcasting informal talks by prominent men in the convention. Some of the broadcasters also operated temporary studios in the Congress Hotel for evening broadcasts and these studios were connected to the broadcasting stations by Bell wires.

To care for individual, public demand for service into and out of the convention hall, an attended public telephone station of twenty-eight booths was installed in the corridor of the Stadium to supplement the thirty-nine booths already permanently in service. Committee headquarters and candidates' headquarters in the hotels were supplied with individual telephones or private branch exchanges. One such private branch exchange utilized a three-position board with twenty central office trunks and seventy terminals.

The American Telephone and Telegraph Company, Long Lines Department, and the Illinois Bell Telephone Company made careful preparations for giving the services required by the national conventions. To such an extent has the telephone communication system developed, however, that these preparations consisted mostly in the proper arrangement of standard facilities, care in the selection of supervisory and operating personnel and care in handling details. The types of plant already in ordinary use were readily adaptable and standard traffic practices in every way suitable.

G. K. McCorkle

Some Recent Developments in Underground Conduit Construction in the Bell System

FEW users of the telephone have any conception of the myriad problems which are met in rendering the highly complex service of telephone communication. Infinite attention to details is essential to telephone progress. In this article a brief account is given of how the problems related to one particular detail were solved by careful attention and patient experimentation.

Hidden beneath the surface of the ground there exists in the Bell System over 600,000,000 lineal feet of underground duct. These miniature tunnels radiate in groups from the central offices or extend for miles across country along many of the toll cable routes. They are part of the underground system of conduit runs, which are provided as a ready means for the installation of underground cables and, when necessary, for their removal. While recent developments in the application of protective coatings on lead covered cable have made it possible to bury cables directly in the ground with a minimum of danger from sheath corrosion, such installations are generally restricted to those cases where there is little prospect of a second cable being required for a number of years.

The extension of underground construction of both conduit and buried types is continuing from year to year. Where these are employed instead of aerial construction it is usually because of economic reasons. In those cases where large aggregations of cable facilities are required, they can generally be supplied less expensively in the form of underground cable in conduit. In other cases, conduits may be employed because of physical conditions or where public improvements make underground construction preferable.

Excavating for underground construction is expensive, especially when it involves breaking through pavement, and the cost of restoring pavement is another considerable item. Accordingly, at the time the first underground cable is required along a given route, where additional cables will be frequently needed, it is customary to place sufficient duct facilities to care for the cable requirements over a period of years shown by engineering studies to be economical.

Many different types of conduit have been employed in the Bell System, and many other types used by other companies, both here and abroad, have been carefully investigated in arriving at our standard practice. This practice employs vitrified clay conduit, in either single or multiple duct units, for main line conduit runs with subsidiary or branch runs constructed of creosoted wood duct, fibre duct, vitrified clay sewer pipe or steel pipe. (See Figure 1.)

We are fortunate in the telephone field in being able to make use of multiple duct conduits. This type of construction is essentially less expensive than that employing single duct conduits, which are generally assembled into a conduit run with all of the joints staggered and the whole encased in concrete. It is because of the low voltages and currents employed in telephone cables that we have no occasion to fear an electrical breakdown from one cable to another in an adjacent duct, through the butted joint between multiple conduit sections.

With the multiple duct type of construction, as well as that of any other type, it is of course necessary to provide some form of union between longitudinally adjacent sections of conduit, that will maintain the alignment of the ducts and prevent the infiltration of silt and sand from the surrounding soil. It has been the practice in the past, with multiple duct conduit construction, to form the joint with cement mortar. A pat of mortar is first placed on the bottom of the trench where the joint will fall, a strip of cheesecloth is then wrapped around the conduits at their junction, to prevent mortar entering the ducts, and the joint is completed with mortar applied with a trowel to sides and top. It will be appreciated that the working conditions in a narrow trench are such as to make it difficult to apply the mortar in such a way as always to insure an intimate bond between mortar and tile at all points, or to have any means of checking the results obtained.

When the conduits are new, no difficulty is experienced in installing cables; but several years after the construction of an underground conduit system, the story may be entirely different. As is well recognized, water has a persistent way of working through tiny crevices and carrying with it particles of silt and sand, which are deposited where the flow of water is retarded. In an underground conduit system, over long periods of time, these accumulations are sometimes sufficient to require their removal before new cables can be installed. This may not be a particularly difficult operation, if the deposits are susceptible of removal by some one of a number of tools that can be dragged through the duct line. At times, however, it is impossible to get a line through the duct, from manhole to manhole, without first removing heavy deposits that may be completely blocking the duct. In such cases special tools must be employed on the entering end of jointed duct rods used for threading the ducts, and the process becomes slow and laborious. Of course, the soil conditions in different areas are quite different, and some soils are much more troublesome than others.

In very aggravated cases there may be no alternative but to resort to an excavation of some portion of the conduit run. This involves measuring with duct rods the distance from manhole to obstruction, laying this off on the surface of the ground, digging down to expose the conduit, breaking into it and clearing the obstruction. The conduit must then be repaired and the trench backfilled. This operation often involves in addition the breaking through and restoration of pavement, which adds considerably to the cost.

Of course, this infiltration of silt and sand could be prevented by providing a heavy monolithic concrete encasement for the conduit, but the expense of this method for general use in telephone practices would be prohibitive.

In studying the development needs of the Bell System, it appeared that, if an improvement could be effected in the type of joint employed with multiple clay conduit construction, appreciable savings could be made in the expense of preparing ducts for the installation of cable. Accordingly, arrangements were made with the Bell Telephone Laboratories to undertake studies with this end in view. It should be pointed out that the proposed objective was silt-proofness rather than waterproofness, in spite of the fact that the exclusion of all water unquestionably would be desirable, since much of the trouble experienced with underground cables is due to moisture reaching the conductors through openings which occasionally develop in the sheath. The objective was limited, however, because it is practically impossible to exclude water entirely from an underground conduit system, since it would be present often as the result of condensation if from no other cause.

The studies undertaken by the Laboratories canvassed the whole field of conduit construction, even to the consideration of materials other than vitrified clay, and to the use of vitrified clay conduit in more complex forms that might appear to facilitate making the joints silt-proof. Obviously, it was desirable that the solution of the problem should be accomplished without having the effect of increasing overall costs, and a number of possible solutions were eliminated on this basis.

One natural suggestion was the employment of some plastic form of material which might be applied with a fabric backing that could be wrapped around the conduit, overlapping the ends of two adjacent sections. Asphaltic compounds of different kinds were tried in this way, with some appearance of promise, but the results were very erratic and there was no way of determining at the time of construction how satisfactory a joint had been obtained. It developed also, in the case of some of the materials at least, that a rather precise technique was required in the preparation and handling of the material to provide a satisfactory joint even under laboratory conditions.

Previous attempts had been made in the field to mold a mortar collar around the conduit at the junction of adjacent sections, but efforts along this line did not result in fully satisfying the desired objectives.

One of the principal difficulties with all joints seemed to be to secure a proper union between the joining material and the conduit on the under side, where even visual inspection was out of the question. It was recognized that where cement mortar could be properly applied very satisfactory results were obtained, and it appeared that the solution might lie in the method of applying mortar so as to insure an intimate contact with the conduit.

The Bell Telephone Laboratories in following up this idea made some experiments in applying the mortar in the form of a poultice encased in cheesecloth, a method also previously tried unsuccessfully in the field, with the idea that the cheesecloth would assist in applying the mortar and in bringing it into close contact with the conduit, as well as helping to hold it there until set. The first efforts along these lines did not bring satisfactory results, because when a sufficient thickness of mortar was employed to insure adequate strength at the joint, there was encountered a tendency for the mortar to slump in the poultice and to resist any efforts to redistribute it by stroking the outside of the bandage. Then the happy thought suggested itself that an intermediate strip of cheesecloth in the center of the poultice might help matters, and this proved to be the case. A poultice, or to use a more descriptive term a mortar bandage, formed in this way, did not show any tendency for the mortar to slump and permitted the mortar to be worked

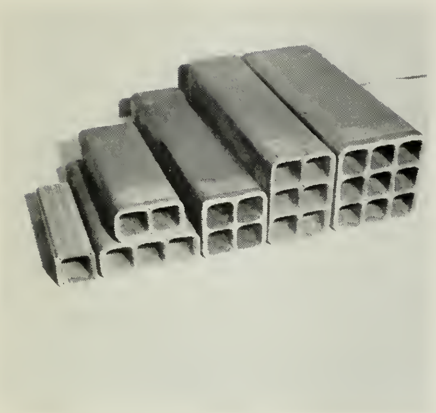


Fig. 1. Types of Vitrified Clay Conduit Used in the Telephone Plant.

Fig. 2. Partial View of Field Laboratory at Chester, New Jersey.

Fig. 3. View of One of the Flooding Trenches After a Test.

Fig. 4. Modified Standard Joints with Supporting Base, After Test.

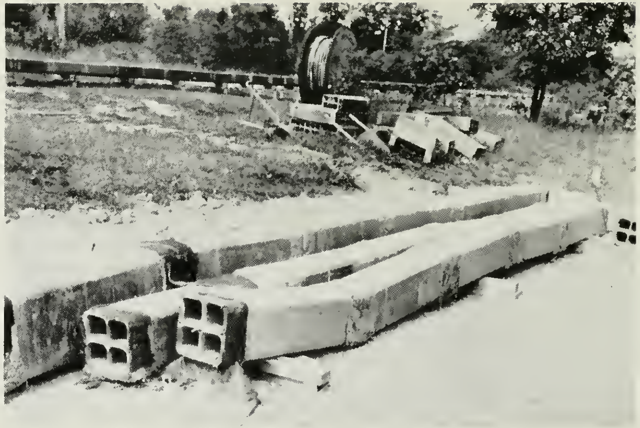


Fig. 5. Asphalt Bandage Joints After Test Showing Weakness of Structure Unsupported.

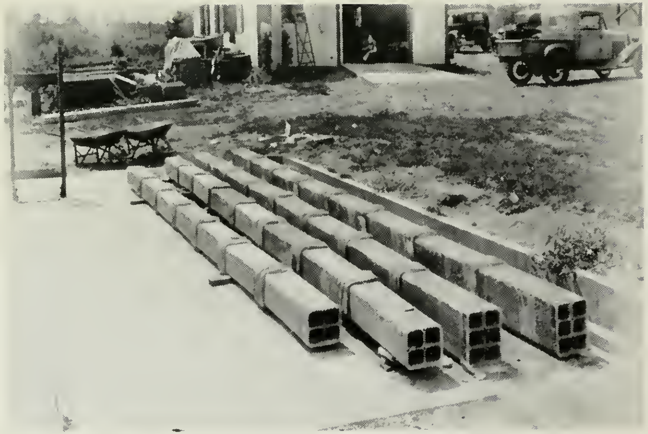


Fig. 6. Mortar Bandage Joints After Test Showing Strength Unsupported by Base.

Fig. 7. Asphalt Bandage Showing Failure of Joint from External Water Pressure.

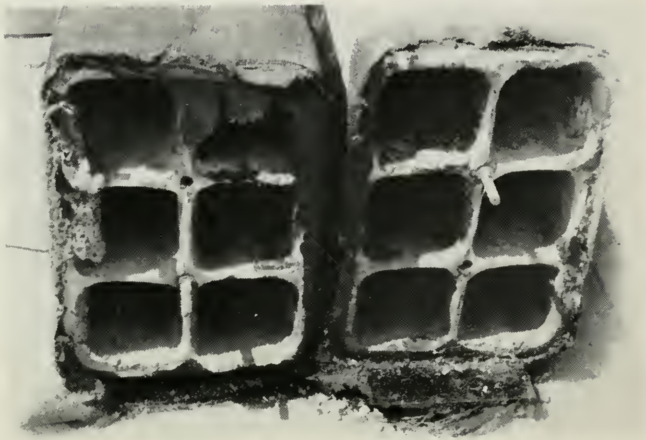


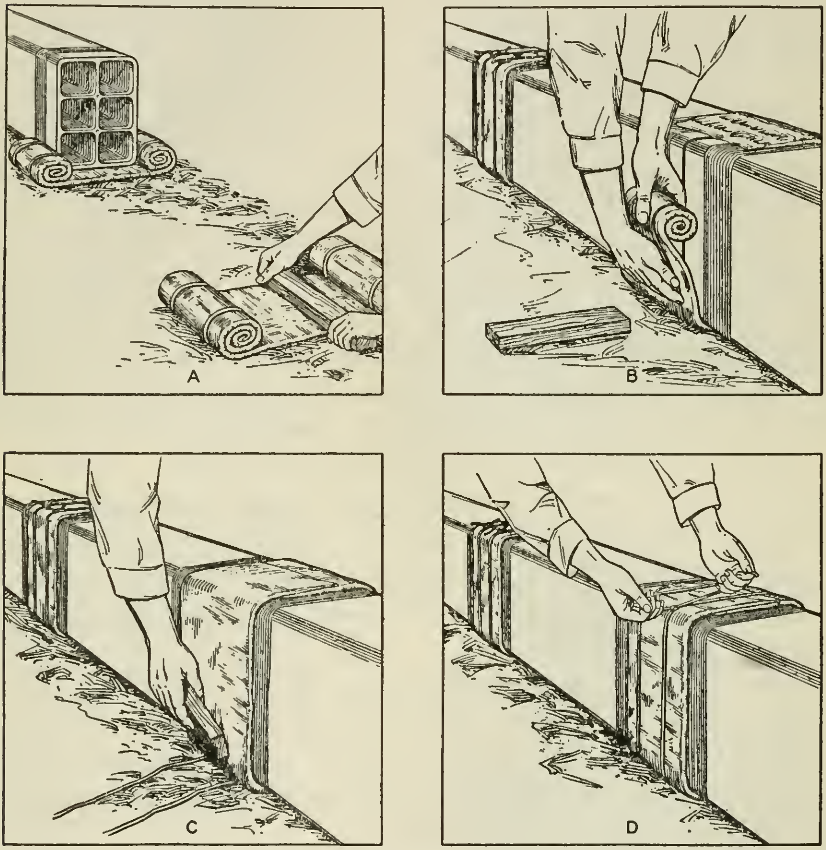
Fig. 8. Same Joint Shown in Fig. 7 Broken Open and Showing Obstructions in Duct.

into close contact with the conduit by stroking with a wooden block. Through further experimentation, the proper mesh of cheesecloth and the proper consistency of the mortar were determined, so that when the bandage is applied sufficient cement paste will flood through to insure a firm bond with the conduit. Close contact was further assured by tying the bandage in place with a cotton tape binding on each side of the joint. A joint of this kind, when tested under hydrostatic pressure, showed very encouraging results. In this form, however, it was evident that there was a tendency for the tapes to cut rather deeply into the bandage at the corners.

A substantial improvement was later added in the form of a paper strip, placed under the cheesecloth on the outer side of the bandage. As applied, this had the effect of distributing somewhat the pressure of the tape, thereby securing the desired contact on the bottom of the conduit, as well as on the sides and top, without tending to cut into the bandage at the corners. Two other advantages result from the use of paper. It assists the bandage in retaining an adequate supply of water for the setting process, which is so essential for strength, and it prevents paste from exuding through the cheesecloth on the outside surface, a condition which would make the bandage very disagreeable to handle.

The Laboratories' experiments were further extended to determine the best kind of cement to use, the best mix and its consistency, and the effect of certain admixtures to insure proper plasticity over a sufficient period of time to comply with working requirements in the field.

Part of the Laboratories' investigations and experiments were conducted at their indoor laboratories in New York, and during the progress of development they also supervised certain trial installations in the plants of operating companies. These facilities, however, were inadequate to permit properly conducting all of the experiments deemed necessary. In the first place indoor laboratory methods as applied to underground conduit construction cannot be made to properly simulate field conditions. On the other hand, due to the pressure attendent upon work in the field, where a large construction force is co-ordinating its efforts in the interest of economy, there is not the oppor-



METHOD OF APPLYING MORTAR BANDAGE.

tunity to stop and study the detailed operations, as is necessary in the development of improvements. Neither is it possible to apply any positive checks or make comparisons as to the results obtained with different methods. For these reasons a field laboratory was recently established near Chester, New

Jersey, laid out on such a scale as to provide conditions essentially similar to those encountered in actual practice. Among other provisions, concrete trenches were built in which conduit runs differently constructed might be tested through the flooding of the trench. (See Figures 2 and 3, facing page 220.)

These trenches were used for comparative tests on conduit joints made by four different methods. In each case a 20-foot length of conduit run was built up, 20 ducts in cross-section, consisting of 2 four-duct multiple units laid on top of 2 six-duct multiple units. In each case a dirt bottom was first laid in the concrete trench, the end sections of conduit were sealed with cement plugs, and one of these in the lower tier of each unit was tapped with a drain pipe extending out through the sealed end of the trench into a manhole where the seepage could be measured. After the laying of the tile and the completion of the joints, the trenches were backfilled with dirt and flooded. The water seeping into the ducts was caught as it emerged from the drain pipes and measured periodically over several months until stable results were obtained. The conduits were then dug out and raised to the surface, where the joints were broken down and examined for defects and the silt deposits studied.

One of the installations was of standard troweled joint construction, laid on a four-inch base of newly placed concrete to provide a firm and even bed for the conduit. Another installation employing a modification of the standard joint was also laid on a similar base, but in this case, in addition to the cheesecloth strip laid next to the conduit overlapping the opening at the junction of adjacent sections, a wider strip of cheesecloth was also employed outside of the mortar, which was applied with a trowel in the usual manner. (See Figure 4, facing page 220.) This outer strip of cheesecloth was drawn around the joint, and a trowel used to press the mortar against the conduit. In addition, the longitudinal joints between the multiple units themselves, and between them and the base, were carefully pointed up so as to make as nearly as possible a waterproof job.

Still another installation involved the use of an asphalt wrapping backed with burlap, the best of its kind as determined by previous experiments. (See Figure 5, facing page 221.) This was laid without a concrete base. The fourth installation employed the mortar bandage and also was placed without a concrete base. The lower units were joined with bandages in which the paper inserts were omitted. The four-duct units in the upper tier were joined with mortar bandages which included the paper strips. (See Figure 6, facing page 221.)

To briefly sum up the results of this comparison, it was found in these experiments that the standard troweled joint was not wholly effective in excluding water and silt. The modified standard joint proved superior to the standard, but still did not effectively seal the joints. The asphaltic wrapping proved to be unstable with a tendency to cold flow under pressure, with the result that the compound in many cases was squeezed in between the ends of the conduits. This not only resulted in openings in the joints but caused obstructions of asphaltic material to be formed in the ducts. Because of the nature of this material, it would be particularly objectionable in a duct line, due to its tendency to increase the friction on a cable being pulled into the duct. The mortar bandage joint without the paper insert, while superior to the other types mentioned, allowed a little leakage in a few of the joints; whereas the four-duct sections, joined with mortar bandages including paper inserts, were practically waterproof. (See Figures 7 and 8, facing page 221, and Figure 9, facing this page.)

The results of these experiments with the mortar bandages were so favorable that it was decided to recommend them for a general field trial throughout the Bell System. To adapt their use to field practice, however, it was necessary first to work out the technique of handling the various steps in the process of making and applying bandages. Cheesecloth, paper and tape, of the kinds found most suitable, were made available, cut to size for conduits of different dimensions; and arrangements

Fig. 9. Mortar Bandage Joint Broken Open. Intimate Contact Indicated by Scarification of Conduit Marked on the Bandage.

Fig. 10. Work Bench and Trays Designed to Facilitate the Making of Mortar Bandage Joints.

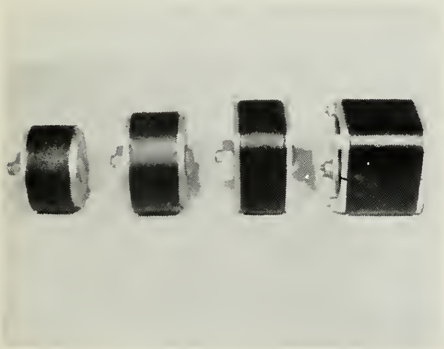


Fig. 11. Duct Plugs for Both Empty and Occupied Ducts.

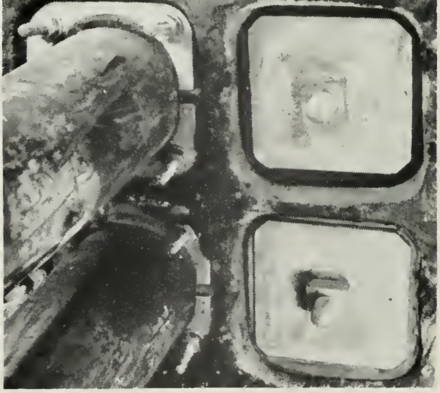


Fig. 12. Duct Plugs Installed in Central Office Vault.

were made so that the quantities of these materials necessary to complete a convenient number of joints would be furnished in a single package. A bench design suitable for the manufacture of the bandages had to be worked out, and trays provided in which the bandages could be readily assembled; several sizes of trays of course being required. (See Figure 10, facing page 224.)

It was also necessary to see that a field practice was established that would make use of the technique found to be most efficient in the mixing and testing of the mortar, the fabrication of the bandage, and its application to the conduit. Because the new method was something entirely different from the practice followed in the past, detailed instructions were prepared for the benefit of the conduit forces, outlining all of the essential points in the technique of performing the various operations. To still further facilitate the transmission of these ideas to the workmen actually performing the operations, an educational sound film was prepared, which illustrated and explained every move in the process and in addition demonstrated the unsatisfactory results that would follow certain variations from the procedure recommended.

In considering the benefits which it is expected to derive from the development of the mortar bandage joint, there is of course the saving that is anticipated in the cost of rodding ducts. It is also expected that the Operating Companies will find many cases where they can take advantage of the high strength provided with this form of joint to lay conduits without the concrete base often employed. As an example of the strength of these joints, beam tests, made on a two-duct multiple conduit laid flat and containing three joints, showed that in an unsupported span of six feet it was capable of sustaining a load of 1000 pounds. As affecting construction costs in general, it seems that the bandage joint also offers economies through the speeding up of the subway job, since it permits more rapid completion of those operations which are performed in the trench and which act as the bottleneck controlling the speed of the job as a whole. Following such operations, the trench may be immediately backfilled on completion of a bandage joint, whereas with a troweled joint the mortar should be allowed to take its initial set before backfilling. It is interesting to note also that the mortar bandage will permit the alignment of the conduit run in the trench without cracking the newly finished joint. This would not be possible with the ordinary troweled joint. The mortar bandage is also peculiarly adapted to the assembly of conduit into those special curved sections often required at central office entrances, or where ducts are splayed at the entrances to manholes. By the use of short sections of vitrified clay conduit, and with the choice of either straight or mitered ends, it is possible with the mortar bandage to build up variously curved sections with no abrupt offsets in the duct line, and to do most of this work above ground, where the working conditions are better.

It was previously pointed out that underground conduit systems could not readily be kept free from water and that, accordingly, in solving the silt problem efforts were not directed especially toward the exclusion of water. There are certain instances, however, where water does become so objectionable as to require special means of excluding it from parts of the conduit system. This is particularly true at central offices, where the entrance of not only water but gas may become quite troublesome at times. In such cases, it has been customary to seal the ducts at the entrance in various ways, none of which have proved entirely satisfactory. In order to solve this problem, arrangements were made with the Bell Telephone Laboratories to undertake its study as a separate project. As the result of their efforts, specially designed rubber duct plugs suitable for both vacant ducts and those occupied with cable have now been made available for field trial, after the initial trials indicated that they appeared in every way to meet the requirements. (See Figures 11 and 12, facing page 224.)

With the mortar bandage joint and the new duct plugs it is expected that it will be now possible to meet all reasonable requirements with respect to silt and gas as encountered in the underground plant of the Bell System and that those requirements with respect to water control outlined above can now be satisfactorily cared for.

A. L. Fox

The Trans-Canada Telephone System

Editor's Note:

The inauguration of the Trans-Canada Telephone System represents a notable achievement in the progress of telephone communication. It is of particular interest to readers of the BELL TELEPHONE QUARTERLY, *not only because the Bell Telephone Company of Canada is one of the seven separate telephone systems co-operating in the enterprise, but also because Bell System standard operating practices and routing instructions, as well as Bell System practices in transmission maintenance work, have been adopted as standard on this all-Canada transcontinental telephone line.*

THE formal opening of the Trans-Canada Telephone System on January 25, 1932, by Lord Bessborough, Governor-General of Canada, signalized the completion of one of the major telephone projects in Canada, a project which has necessitated the attention and co-operation of the seven larger telephone systems in Canada. The Trans-Canada Telephone System provides a group of long haul circuits entirely within the Dominion for the handling of Trans-Canada business. The system was also designed to co-ordinate with the general toll switching plan in the United States. Prior to the inauguration of the Trans-Canada System it was necessary to route the long haul toll business between Canadian points, to a large extent, over lines in the United States.

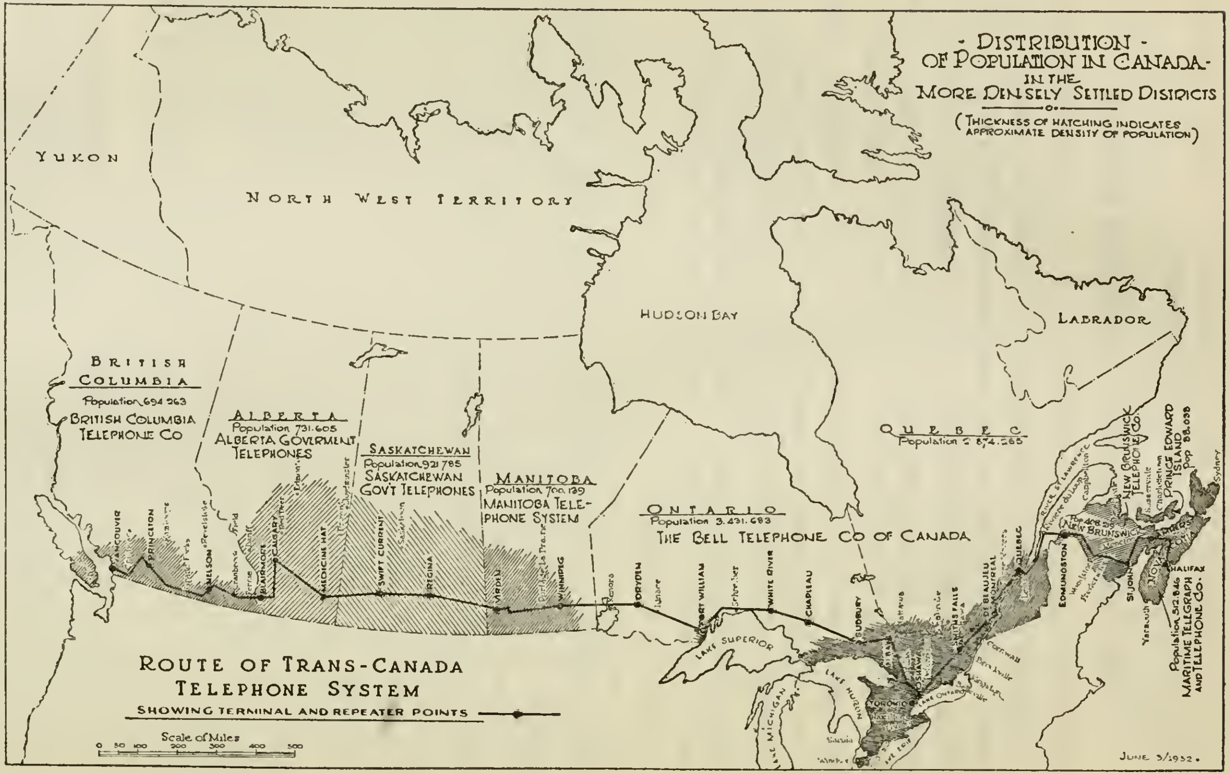
It is proposed in this article to describe the development of the Trans-Canada Telephone System, including an outline of the many interesting problems in circuit design and construction encountered during the engineering work. A historical sketch of the telephone business in Canada is first presented to assist in appreciating the situation as it existed from the standpoint of providing long haul facilities.

The Seven Canadian Telephone Systems

The main centres of population in Canada are located in four regions separated by long gaps of sparsely settled, rugged country. The Pacific region centres around Vancouver and includes the southwestern part of the province of British Columbia. The Western region is located in the southern part of the provinces of Alberta, Saskatchewan and Manitoba. The settled parts of Ontario and Quebec, centering about Toronto and Montreal respectively, compose the Central region, while the Maritime region takes in the provinces of Prince Edward Island, Nova Scotia and New Brunswick. These regions are located, roughly, 1300 miles apart, reckoning from the middle of one region to the middle of an adjacent region.

The evolution of the telephone business in the Dominion finally resulted in the formation of seven major and distinct telephone systems, which exist to this day. The names of the systems, from west to east, are the British Columbia Telephone Company in British Columbia, The Alberta Government Telephones in Alberta, The Saskatchewan Government Telephones in Saskatchewan, The Manitoba Telephone System in Manitoba, The Bell Telephone Company of Canada in Ontario and Quebec, The New Brunswick Telephone Company in New Brunswick and The Maritime Telegraph and Telephone Company in Nova Scotia and Prince Edward Island. These form the links of a chain of systems across Canada. Any scheme, therefore, involving Trans-Canada circuits would require the co-operation of all the major telephone systems.

Toll service at first was confined to each region without regional intercommunication. No outlet was available to the other regions until the advent of transcontinental service in the United States. Connections with the Bell System were established at this time and provided a means of communication be-


- DISTRIBUTION -
OF POPULATION IN CANADA-
IN THE
MORE DENSELY SETTLED DISTRICTS
(THICKNESS OF HATCHING INDICATES APPROXIMATE DENSITY OF POPULATION)
YUKON
NORTH WEST TERRITORY
HUDSON BAY
LABRADOR
BRITISH COLUMBIA
Population 694 263
BRITISH COLUMBIA TELEPHONE CO
ALBERTA
Population 731.605
ALBERTA GOVERMENT TELEPHONES
SASKATCHEWAN
Population 921 785
SASKATCHEWAN GOV'T TELEPHONES
MANITOBA
Population 700.139
MANITOBA TELEPHONE SYSTEM
ONTARIO
Population 3.431.683
THE BELL TELEPHONE CO OF CANADA
QUEBEC
NEW BRUNSWICK TELEPHONE CO.
PRINCE EDWARD ISLAND
Pop 88.038
Population 512.846
MARITIME TELEGRAPH AND TELEPHONE CO.
VANCOUVER
PRINCETON
NELSON
BLAIRMORE
CALGARY
MEDICINE HAT
SWIFT CURRENT
REGINA
VIRDEN
WINNIPEG
DRYDEN
FORT WILLIAM
WHITE RIVER
CHAPLEAU
SUDBURY
SMITHS FALLS
DE BEAUJEU
MONTREAL
QUEBEC
EDMUNDSTON
ST JOHN
HALIFAX
TORONTO
Sydney
LAKE SUPERIOR
LAKE HURON
LAKE MICHIGAN
LAKE ONTARIO
ROUTE OF TRANS-CANADA TELEPHONE SYSTEM
SHOWING TERMINAL AND REPEATER POINTS
Scale of Miles
0 50 100 200 300 400 500
JUNE 3/1932.

tween different sections of Canada at a time when direct circuits through the Dominion were not economically feasible.

The Telephone Association of Canada

It has already been mentioned that in order to provide service from coast to coast over Canadian lines, it would be necessary to enlist the active co-operation of the different telephone systems across Canada. This and other problems which required the assistance of a number of systems for their solution, resulted in the formation in 1921 of the Telephone Association of Canada. The association is composed of members representing the seven major telephone systems in the Dominion. The purposes of this association are "to protect telephone investment; to establish uniformity of construction, maintenance, operation and accounting; to disseminate useful information; to cultivate cordial relations and to do all things necessary to systematize, unify and render efficient telephone service in the Dominion of Canada."

One of the problems discussed by the Telephone Association of Canada at its first annual meeting, was the provision of Trans-Canada circuits. A committee was formed to investigate the possibility of providing such service. This committee presented its report at the second annual convention held in 1922. The report indicated difficulty in providing telephone facilities in three sections. In the West, the massive ranges of the Rocky Mountains presented a barrier some hundreds of miles in length, which it seemed almost impossible to span with poles and wire, either on roads or private right-of-way, in order to provide service. The only possibility which appeared feasible at that time was the use of one of the railway company's telegraph leads which were constructed on the railway right-of-way.

Between the Western and Central regions, lay a stretch of rocky country extending from Winnipeg to Sudbury, some 1000 miles in length. This country is very sparsely settled and here again, the only solution appeared to be the use of the railway company's pole lines. The third section, between Quebec and Saint John, required some four hundred miles of pole line through a part of the country practically uninhabited and where pole line construction would be very difficult.

Although further committees were formed at subsequent meetings to report on the Trans-Canada project, it was not until the annual convention in 1928 that it was decided the time was opportune for a complete study of the construction necessary to provide Trans-Canada facilities. At that meeting the Bell Telephone Company of Canada was requested to proceed with an engineering study to determine what additional facilities would be required to make available all-Canadian transcontinental service.

Continued progress was being made by the separate telephone systems in extending toll service in each region and between regions. By 1927 plans had been made to span the three gaps separating the regions and by the end of 1928 telephone circuits were in operation in each gap.

Trans-Canada Reports

The preliminary report was submitted to the Executive Committee of the Telephone Association of Canada in April, 1929, and outlined what progress had been made in the study. This report covered the circuit requirements, an estimate of revenue and some preliminary data on the route, transmission requirements, maintenance requirements and outside plant features.

The final report was presented to the Executive Committee at the annual convention held in September of 1929. One of the more important items covered in the report was an estimate of costs. More complete data were also made available on the pole route, transmission requirements, maintenance features and outside plant features. The reports were adopted at this meeting and it was decided to proceed with the project at the earliest possible date. Work was started in 1930 on the basis that each telephone system concerned would provide the facilities required in its own territory, thus bearing its share of the total cost.

The project was scheduled for completion in 1932, the circuit requirements being worked out so as to take care of the traffic in that year.

Traffic Data

A large amount of basic data was required before proceeding with the study of the Trans-Canada Telephone System. A questionnaire was therefore prepared requesting this information. Message figures were obtained for a number of years prior to 1929. These figures were used in preparing estimates of messages for the years from 1929 to 1932, which in turn formed a basis for determining the circuit requirements.

Arrangements were also made to obtain quarterly reports of messages for 1929 and subsequent years. These reports were used to make periodic checks of the estimates so that, if necessary, the circuit requirements could be revised.

The circuit layout was made as flexible as possible so that any large deviations from the estimates could be cared for by modifying the circuit layout. The original Trans-Canada study considered twelve circuits but actually only seven circuits were placed in operation.

Circuit Layout

It was necessary, before preparing the Trans-Canada reports, to define what circuits would be included in the study. This was governed by the following conditions which existed at the time the report was requested:

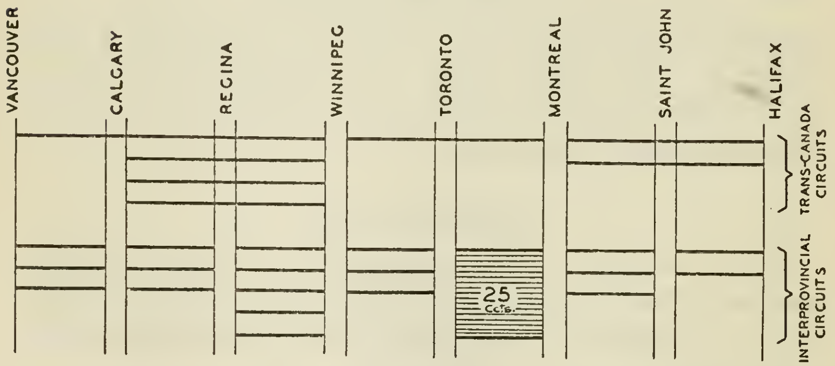
By 1927, no through telephone circuits had been established through the Rockies, the district between Sudbury and Winnipeg, and between Quebec and Saint John. However, as previously mentioned, plans were in course of preparation providing circuits in each of these gaps by the end of 1928. Although the amount of business was still limited it was felt that the provision of direct circuits, and therefore faster service, would soon stimulate further business. Later events proved that these premises were well founded.

In November, 1928, a circuit was established between Calgary and Vancouver, over the Canadian Pacific Railway Company's telegraph pole lines through the Rockies. In August, 1928, Sudbury and Winnipeg were joined together by a direct circuit on the Canadian Pacific Railway Company's telegraph pole line between these points. East of Quebec circuits were erected, partly on connecting company's lines and partly on a new line, and joined the New Brunswick Company's line at Edmundston. Two direct circuits were then made available in December, 1928, between Montreal and Saint John.

CIRCUIT LAYOUT

TRANS-CANADA TELEPHONE SYSTEM

JANUARY 1932



At the end of 1928, therefore, circuits were available between all adjacent provinces. These circuits functioned satisfactorily in providing telephone links between adjacent systems, but the two wire voice frequency type of telephone circuit has certain limitations which become apparent when attempts are made to make use of this type of facility for establishing very long telephone connections. The use of such circuits for long connections would also be unsatisfactory from the standpoint that frequent switches would be required.

In order to provide a suitable grade of transmission between all points in the various regions in Canada, and particularly, for those cases where very long telephone connections are involved, circuits with high inherent transmission stability and good transmission quality are required. As it is not feasible to provide direct circuits between all systems, the circuits must be suitable for interconnection by means of switches, in order to establish built-up connections.

As no specific plans were being made by the individual system to establish circuits between non-adjacent provinces and in view of the transmission requirements for the design of such circuits being more severe than those of much shorter length, it was decided that the Trans-Canada report would specify the circuit requirements between points separated by one or more provinces.

The following table shows the Trans-Canada circuits actually placed in operation and the number of circuit miles operating over carrier and voice frequency facilities.

Group	No. of Circuits Jan. 1932	Length of Group in Miles	Circuit Miles		
			In Carrier	In V. F.	Total
Winnipeg-Vancouver	1	1744	925	819	1744
Winnipeg-Calgary	3	925	1850	925	2775
Winnipeg-Montreal	1	1578	1247	331	1578
Montreal-Halifax	2	890	1244	536	1780
Total			5266	2611	7877

It will be noted that there are four groups of circuits with almost eight thousand circuit miles. About 67 per cent of the total circuit miles is in carrier, the remainder being in voice frequency and consisting mainly of open wire facilities.

In addition to the circuits tabulated above, the Trans-Canada plans embraced other long haul facilities which form an integral part of the project, since they act as main feeders for the Trans-Canada circuits. The more important of these facilities, which are shown below, were built with the Trans-Canada circuits in such cases where they were not already available;—

Group	No. of Ccts. Jan. 1932	Length of Group in Miles
Vancouver-Calgary	3	819
Calgary-Regina	3	507
Regina-Winnipeg	5	418
Winnipeg-Toronto	3	1278
Montreal-Saint John	3	622

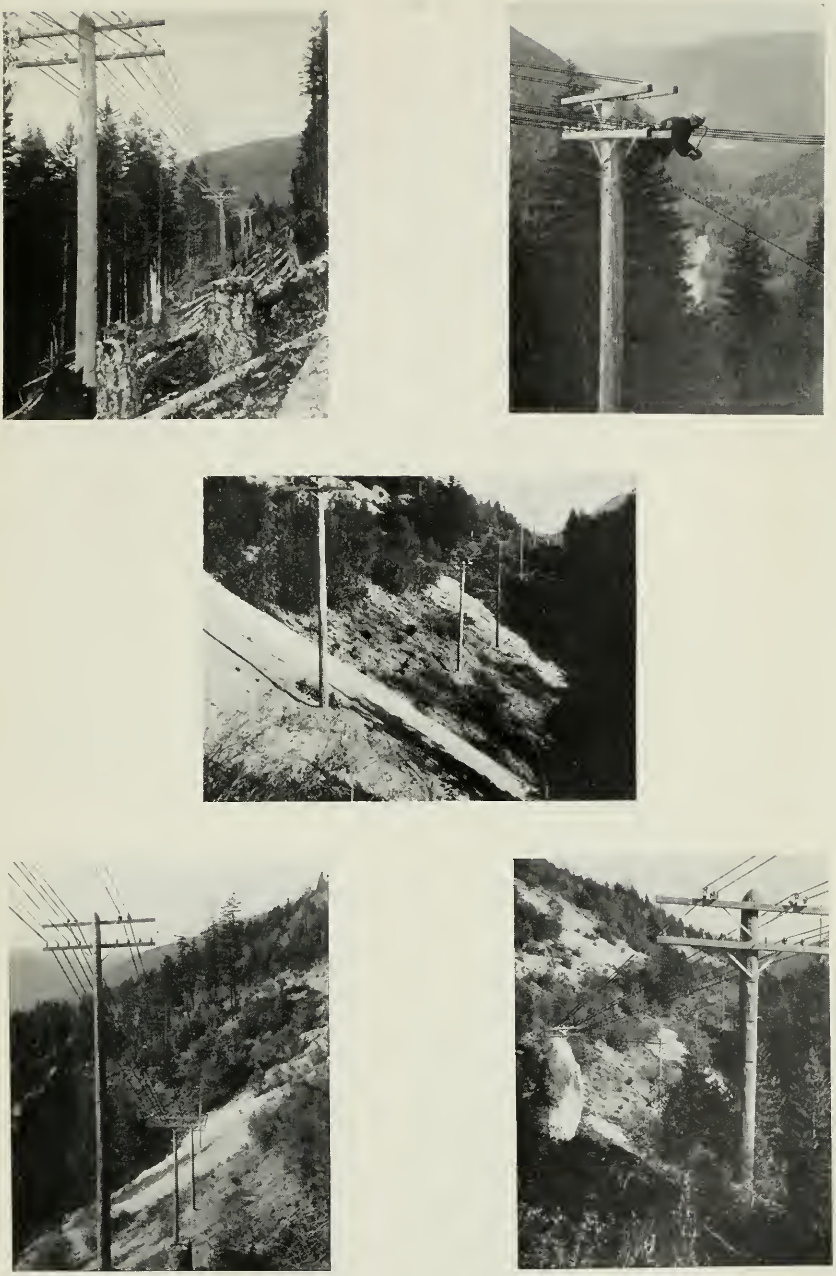
With this circuit layout taken in conjunction with the inter-provincial circuits, not more than two switches are required between any two of the main switching points in Canada.

Pole Route

The choice of a suitable pole route for the Trans-Canada circuits, involved a comprehensive survey of existing facilities. It has already been mentioned that at the time the report was undertaken circuits had been established between all adjacent provinces. The routes followed by these circuits were therefore used as a starting point in the survey.

In general, it was found that the existing routes were suitable or could be made suitable at a smaller cost than any other route, considering at the same time the intermediate requirements. The existing leads take the most direct route between the main switching centres, are comparatively free from power exposures and provide suitable locations for repeater points. Although complete rebuilding was required in many places and major changes necessary at other points the selection of any other route, in general, would have required a new and longer lead.

Two major exceptions were made. In the case of the route through British Columbia it was decided not to use the Cana-



Crossing the Mountains of British Columbia

The Trans-Canada Telephone System

Catenary Crossings

Stone-Boat for Stringing Wires

In British Columbia

In Alberta

In British Columbia

THE TRANS-CANADA TELEPHONE SYSTEM

dian Pacific Railway Company's lead, but to build a new lead about 150 miles south of the railway. It is expected that the choice of this route will result in improved service and it has the advantage that long lengths of cable are avoided, due to tunnels. Although the new route is nearly two hundred miles longer than the existing route, it passes through a settled district and can therefore be used to take care of circuits to intermediate points.

The other exception was between Brandon and Winnipeg for some 200 miles where it was decided to keep away from the main lead. The new lead is about 40 miles longer, but avoids the necessity of rebuilding an old lead with as many as eight crossarms in certain sections. A long power parallel near Winnipeg is also avoided.

The total length of the pole line is about 4200 miles, of which it was necessary to rebuild completely about 2000 miles and to carry out pole work for carrier transposing for some 1500 miles.

Transmission Design Features

The transmission requirements for the Trans-Canada circuits were engineered on the basis of meeting the limits recommended for the general toll switching plan. In view of the length of the Trans-Canada circuits many interesting transmission problems arose which are not normally encountered in designing the shorter haul facilities.

Transmission design requirements in respect to transmission equivalent, noise, crosstalk and distortion for both direct and switched connections indicated the desirability of restricting the length of the voice frequency circuits and using carrier systems for the longer circuits.

To obtain suitable transmission results it was necessary to provide the best available grade of outside plant facilities consisting of 165 copper wire on CS insulators at 8″ spacing. The use of 165 copper on CS insulators has the advantage of lower attenuation and of greater stability compared to the use of smaller gauge wire on ordinary toll insulators. With the larger gauge wire the fluctuations of equivalent are less with temperature and humidity changes. The improved glass insulators, moreover, effect a marked reduction in attenuation and in the variation of attenuation with weather conditions. Eight-inch spaced non-phantomed facilities were required in order to meet the cross-talk design limits for circuits of the type and length involved in the Trans-Canada System.

Certain limitations are imposed upon the number of carrier systems which can be operated in tandem. This resulted in the use of voice frequency facilities in a few cases where carrier was available. It is interesting to note the extent to which carrier was used; as previously noted, about 67 per cent of the circuit miles is in carrier.

The repeater points shown on the Trans-Canada route map have been so spaced that advantage is taken of the possibilities of the large gauge wire when erected on improved glass insulators at 8″ spacing.

Where carrier is involved line filters with a cut-off frequency of 5000 cycles have been used so that the circuits may be available for the transmission of programs when required.

In addition to the regular facilities, emergency assignments have been provided to take care of the carrier systems when failure occurs on the regular assignment. The emergency facilities are, in many cases, inferior to the regular assignment and in the design work, it was necessary to co-ordinate the carrier and voice frequency repeater points, both for the regular and emergency assignments of the carrier.

A 2-A automatic pilot channel regulator is now being installed on the Oshawa-Winnipeg carrier system (about 1250 miles), while the Calgary-Winnipeg system (about 925 miles) is already equipped. This regulator equipment will further improve the stability of the circuits. A number of observations made on the Oshawa-Winnipeg carrier system when equipped with the 1-A pilot channel showed that under certain conditions large variations amounting to as much as 13 or 14 db occurred between the hourly reading. With the 2-A system these variations will be compensated for automatically.

Outside Plant Construction

The major portion of the outside plant consists of open wire construction. Short toll entrance cables exist at repeater and terminal points, the total length amounting to about one per cent of the length of the pole line. There are two sections of toll cable, totaling 78 miles in length. One section of 34 miles is located between Toronto and Oshawa, the other section, 44 miles in length, is between De Beaujeu and Montreal.

In view of the importance of the Trans-Canada circuits, the number of circuits superposed on each open wire pair and the absence of alternate routes through Canada for over three quarters of the length of the line, careful consideration was given to the choice of open wire facilities. Copper line wire 165 mils in diameter is provided for a large part of the distance. This gauge has the advantage of greater mechanical strength and therefore more freedom from storm damage and other circuit troubles, compared to the lighter wire gauges.

It has already been pointed out that for transmission reasons it was decided to place the line wires at eight-inch spacing. This type of construction required a new system of transpositions in place of that which had hitherto been used. K-8 transpositions have been installed in the section between Winnipeg and Vancouver, and k-8 and k-10 transpositions in about half the line between Winnipeg and Halifax, the remainder being voice frequency or alternate arm transpositions.

The pole line was built to Class 1 requirements for heavy storm loaded areas. This provides the highest grade of pole line normally constructed for telephone purposes. For any new construction or reconstruction work western cedar poles were used west of Winnipeg and creosoted pine for pole work east of Winnipeg.

All toll entrance and intermediate cables have been carrier loaded suitable for the operation of "C" carrier telephone systems. As no loading system had been developed for eight-inch spaced conductors, it was necessary to modify the C4.1 and C4.8 systems to obtain the proper characteristics.

All joints on the open wire circuits used for carrier were soldered so as to reduce the possibility of high resistance unbalances. Transpositions were formed on the point side transposition bracket.

Transmission Maintenance

The maintenance of the Trans-Canada circuits has been the subject of careful study on account of the special conditions existing in Canada. It was appreciated that the maintenance of very long telephone circuits, in such a way as not to exceed the transmission variations contemplated in the design, would be far more difficult than the maintenance of the shorter circuits with which the different telephone systems in Canada had become familiar. Such difficulties were aggravated due to the fact that seven separate systems were involved, each system having, in general, different testing methods.

In order to co-ordinate the maintenance efforts and to assure the highest degree of efficiency and co-operation, so that satisfactory transmission could be maintained with a minimum of lost circuit time, suitable procedures and arrangements were adopted. The principal items in the plan are organization, intercommunicating facilities, instruction of maintenance personnel and the adoption of uniform transmission maintenance practices and testing equipment.

Each circuit in the system has a circuit control office located at one end, which is responsible for the satisfactory maintenance of the overall circuit or speech path, as distinguished from the physical plant required to provide it. The facilities themselves are divided into units with an office at one end responsible for the maintenance work on the toll plant within the limits of its section length. The unit may be made up of open wire, cable or carrier facilities, with or without intermediate repeaters. If there are intermediate repeater offices, they are assigned the responsibility of maintaining, under the direction of the circuit unit control office, a section of the unit. An organization of this type simplifies the maintenance problems and has the advantage of concentrating the supervisory personnel at a limited number of points.

The necessity for uniformity in the transmission maintenance work was clearly recognized. A special instruction course was held, at which the operating personnel was suitably trained in an understanding of their responsibilities and in the uniform interpretation and application of maintance practices. The Trans-Canada Telephone System adopted the standard practices of the Bell System in the United States for use in the transmission maintenance work, and these practices formed a basis for the instruction work at the course. Arrangements have been made to ensure that the transmission maintenance work is receiving uniform treatment throughout the system.

In order to provide suitable means for quickly testing the lines and apparatus, standard testing equipment has been provided at all repeater points and terminals, consisting of No. 5 toll test boards or their equivalent and 7-A or 7-B transmission test boards. In addition, portable testing equipment is located at strategic points and is used where it is necessary to make tests in the field.

As a check on how the maintenance work is being carried out, monthly reports of trouble are sent to the Chairman for all of the Trans-Canada circuits.

Organization

It was evident that an organization would be required to supervise and co-ordinate the work of constructing, maintaining and operating the Trans-Canada System. At a meeting of the Executive Committee of the Telephone Association of Canada, held in 1931, a Management Committee was formed. In addition to the Management Committee, there are several functional committees responsible to the chairman of the Management Committee. These committees maintain contact with all branches of telephone operation. Under the Management Committee a clearing house is operated which receives reports of Trans-Canada revenue and sees that it is properly apportioned between systems and the necessary settlements carried out. This saves the necessity of each telephone system having to effect separate settlements with all other systems.

Some of the more important work carried out by the functional committees might be mentioned. The adoption of Bell System standard operating practices and routing instructions has necessitated supplying all the systems with sufficient information to place these practices and instructions in effect. Basic traffic records are being maintained for use in determining circuit requirements. Service results have been checked in certain specific cases and it is expected to develop reports which will indicate the service results on a periodic basis.

Standard maintenance practices are now in effect. These practices are kept up to date and are supplemented from time to time to take care of special or local conditions. Service results are checked on a monthly basis by means of trouble reports which are prepared for all Trans-Canada circuits and some of the longer interprovincial circuits. New circuits and changes in existing circuits are authorized by circuit orders and the detailed make-up of the circuit is covered by circuit layout cards. The original transmission design work of the Trans-Canada Telephone System, the scheduling of construction work and the preparation of studies depending upon special requirements, have been some of the main functions of the Engineering Committee. The engineering of plant extensions requires periodic reviews of circuit requirements and the determination of the best method by which facilities can be provided to take care of such requirements.

Conclusion

The Trans-Canada Telephone System has progressed, from an embryo stage some ten years ago, to an actuality on January 25, 1932. The engineering and construction work has engaged the attention of the committees of the Trans-Canada System for the last three years. Results are now available for about three months' operation and these have been up to expectations. Excellent transmission has been demonstrated on the longest connections in Canada. The same close co-operation in the future which has been exhibited in the past between the major telephone systems in Canada would appear to assure the continued success of the Trans-Canada System.

Sydney Bonneville

The Western Electric Company as a Distributor to the Bell System

EVERY individual is a consumer, but the goods he consumes have usually been produced some distance from the point of consumption. For instance, a simple breakfast for an average family will probably include fruit from California, toast made from Minneapolis flour, bacon from Chicago, sugar from Cuba and coffee from Brazil. Production has in the main congregated in large metropolitan centers, and goods must be transported one or more times before they reach the consumer.

The general work of gathering commodities from world wide points, assorting, grading, selling, packing, shipping, transporting and storing until they are ready for the consumer in his own neighborhood, is commonly known as distribution.

Criticism has frequently been leveled at our modern distribution system because it sometimes happens that the cost of distribution is more than that of the goods distributed. Efforts have been made to eliminate the long string of so-called middlemen, but if goods are to be available to the consumer in his own vicinity, some one must accumulate them, assume the risk of deterioration and loss, carry investment, store, sell, extend credit, pack and ship the merchandise. Our experience in this country seems to prove that these functions can best be performed by people specializing in them, and manufacturers have usually found it desirable to let wholesalers perform this service. Regardless of whether these functions are assumed by the manufacturer, jobber or chain store, no way of eliminating the operations has yet been found and they remain a substantial element in the cost of living. According to the last census, one-eighth of all the people gainfully employed in the United States were engaged in wholesale and retail distribution.

The Bell System is a large consumer of merchandise. The maintenance and extension of its plant throughout the United States requires the use of tens of thousands of different articles. The problem of assembling in the proper place the wide variety of material required by the System does not differ materially from the general problem of distribution. It does differ from the general custom, however, in that through the distribution branch of the Western Electric Company, the Bell System has developed its own wholesaler which does for the System the work of the so-called middlemen.

This unusual arrangement came into being with the development of the supply contract between the operating telephone companies and the Western Electric Company. Under this contract the Western Electric Company agrees to manufacture or purchase material which the telephone company may reasonably require for its business, and to maintain distributing storerooms at points mutually agreed upon; also to receive, store, repair and reissue or otherwise dispose of, surplus material which has been removed from plant. This system was started in 1901 with the signing of the first supply contract by the Bell Telephone Company of Philadelphia (now the Bell Telephone Company of Pennsylvania), and was rapidly developed until at present there are distributing houses in thirty-two of the principal cities in the United States serving all the operating units of the Bell System.

Through these houses and the general departments with which their activities are co-ordinated, the Western Electric Company exercises all functions of the wholesaler; i.e., future demands are estimated, requirements are combined, contracts are made with suppliers for the amount of material required, or production in its own shops is authorized. The Distributing Houses purchase, store, carry investment, sell, extend credit, pack and ship as required by their customers. They carry in stock a large assortment of merchandise, including apparatus, cable and small switchboards of Western Electric manufacture;

wire, strand, crossarms, pole line hardware, electrical supplies, tools, paints, oils, janitor supplies, stationery and office supplies and numerous items of wide variety, even to china for restaurant use and a limited stock of medical and first aid supplies.

The plan whereby a number of separate corporations which collectively comprise a System in effect own their own wholesale source of supply is unusual, and has many advantages. By means of this arrangement the demands of all the companies comprising the Bell System are combined and purchased through a single purchasing agent, thereby securing the advantage of quantity purchases with a minimum purchasing expense.

The business is obtained without the maintenance of expensive selling organization and, since the customer's credit is established, there is no expense for a credit and collection department and no losses from bad debts.

For these reasons the Western Electric Company is free to devote its attention mainly to the control and adjustment of production and to refinement in methods and management, rather than to the usual problem of making sales. Since the corporations comprising the System could not individually get these advantages for themselves, the development of a Bell System distributor is clearly of economic advantage to the telephone companies and, assists them materially in their efforts to provide "the best possible service at the lowest possible cost."

The distributing system consists of general warehouses at Chicago, Ill., Kearny, N. J., and Baltimore, Md.; and distributing houses and repair shops in the following cities: Boston, New Haven, New York, Brooklyn, Newark, Philadelphia, Pittsburgh, Washington, Atlanta, Louisville, New Orleans, Jacksonville, Detroit, Cleveland, Cincinnati, Indianapolis, Chicago, Milwaukee, St. Louis, Kansas City, Oklahoma City, Dallas, Houston, Omaha, Minneapolis, Des Moines, Denver, Salt Lake City, San Francisco, Los Angeles, Seattle and Portland, Oregon.

The general warehouses located at the manufacturing plants are known as merchandise departments. They receive, pack, store and ship the products manufactured at those plants and conduct all commercial transactions incidental thereto. During the year 1931 the value of the goods sold by these departments averaged $670,000 per working day. In 1930 the corresponding figure was $855,000, and in 1929 it was in excess of $900,000 per working day. The packing and physical handling of merchandise in such quantities is an industrial operation of considerable magnitude, and has been the subject of engineering studies of broad scope. As a result of these studies, material handling equipment has been developed and storage buildings have been designed to fit the particular needs of the business.

The packing, physical handling and storage processes were analyzed in minute detail before the new warehouse recently completed at Kearny was designed. Equipment especially suited to the products was planned, and finally a building to house that particular equipment was erected. Since the products of the shops vary in size from small parts weighing a few ounces to articles which, when crated, weigh several thousand pounds, special equipment and special buildings greatly facilitate the movement of merchandise.

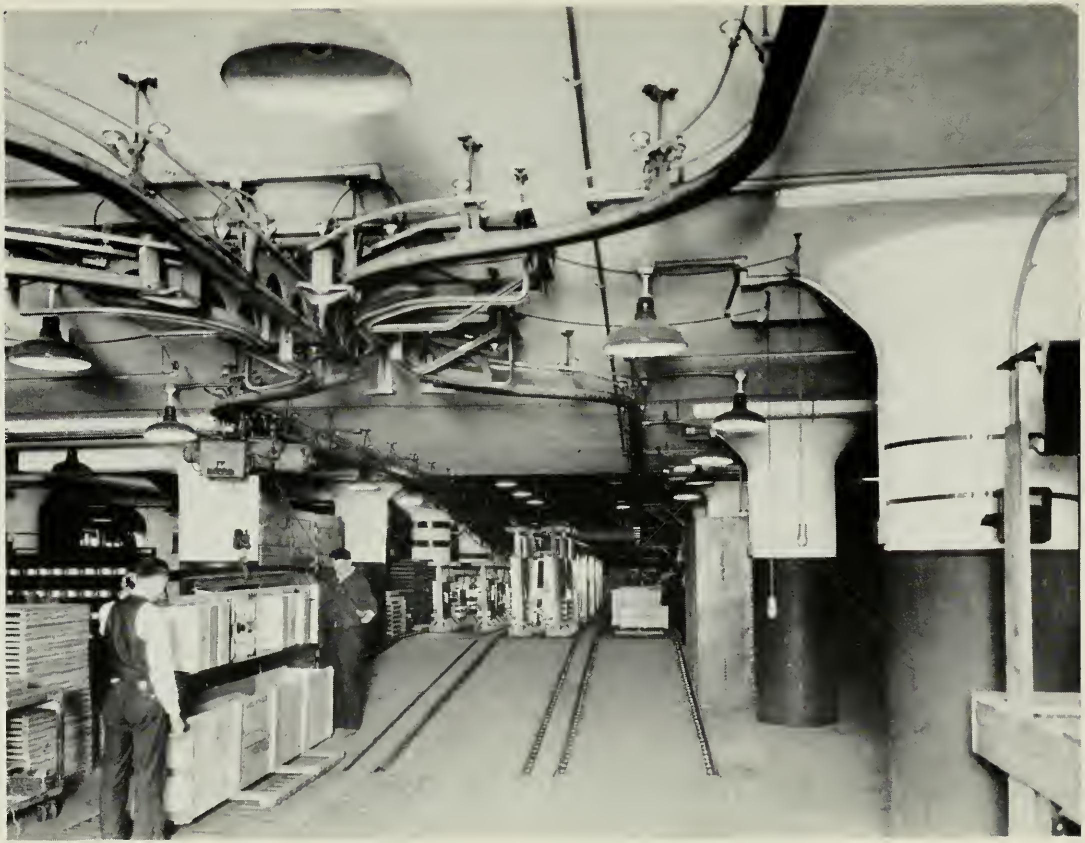
The systems installed are designed so that as material comes from the shop it is placed on moving conveyors, packed while in motion, as far as practicable, and transported to its proper place for storage without having been removed from the conveying system. The same system also takes outbound material by continuous moving processes from storage locations to checkers, packers, shippers, freight cars or motor trucks.

The Kearny warehouse is in two parts. One, a multi-story section with relatively low ceilings for the storage of material packed in small containers which can be economically handled on conveyors. The other, a special section with a ceiling height of approximately 50 feet, designed for operation with large cranes. Heavy and bulky material, piled to a height of approximately 35 feet, is stored in this section. The handling from conveyor to storage and from storage to freight car is done by electric cranes.

The packing department includes special machinery for cutting packing material to size, multiple nailing machines for the manufacture of cases, automatic sealing machines for cartons, and numerous other devices for reducing packing costs. Packing developments include also a study of packing materials and the standardization of material and methods best suited to the particular product. These studies on cartons and containers have reduced packing costs by more than $1,300,000 during the last five years. Fundamental studies are constantly being made to determine the quantities to be packed in both preliminary and final containers, so that the product may be moved through to ultimate destination at minimum expense from the System's standpoint.

In addition to the general range of commercial activities, a very important function of the merchandise departments is the scheduling of the factory output and its distribution among the various customers, so that the plans of the operating companies and of the Installation Department of the Western Electric Company will be co-ordinated.

The functions of the distributing houses are to receive the Telephone Companies' orders for merchandise, to see that the material is delivered when and where it is wanted, to carry on the commercial functions incidental to the purchase and sale of commodities and, through the distributing house shops, to repair and make available for reuse, material which has been temporarily removed from the telephone companies' plant. For various reasons, such as moves or changes in layout by subscribers, discontinuance of service, new developments and many other causes, apparatus is continually removed from



View at Entrance of New Merchandise Warehouse, Kearny, N. J.
Illustration shows material as it is received from the shop, starting along the packing conveyors.

View in Warehouse at Kearny, N. J., showing storage under cranes in building specially designed for that purpose.

plant. To facilitate the economical disposal and repair of such material, a properly equipped repair shop is a part of each house. When material is removed from plant and returned to the distributing house it is carefully examined, tested and classified, and that which can be repaired and for which there is demand is reconditioned and made available for reuse.

In general, the operating requirements which the repaired article must meet are furnished by the Bell Telephone Laboratories. Requirements on finish and appearance are usually specified by the Telephone Company. Constant studies by staff engineers, in co-operation with the shops, the Bell Telephone Laboratories, the American Telephone and Telegraph Company and Associated Companies, have resulted in the development of a standard technique for all shops. Machinery, tools and operating procedures are developed and standardized by a branch of the Sales Engineering Department which also supplies specifications and working instructions in practical form. The entire product is subjected to exacting inspection by skilled mechanics and the work is periodically checked by experts to insure complete compliance with the high standards of the company and the System.

Ordinarily, the object of a distributor is to make money, and the degree of accomplishment is shown by the rate of return on the capital invested. While it is important that the Western Electric Company's distributing business earn a reasonable return, the objective is not primarily to make money, but to have available when needed the material required by the Bell System for carrying on its operations.

Since the degree of accomplishment of such a purpose can not be measured by the rate of net return, it is necessary to have other means of determining the extent to which this function is fulfilled. This information is secured in various ways. The distributing houses are more than mere warehouses, they are contact points between the Western Electric Company and the telephone companies, and it is the duty of the managers to familiarize themselves with the telephone companies' problems and to have knowledge of their plans, as though they themselves were a part of the telephone company. It is their duty, also, to inform the operating companies as to what can be expected in the way of delivery, so that the plans of the latter can be intelligently made and carried out with the minimum of interruption.

Central office and large construction projects are co-ordinated from inception by what is known as the questionnaire system, whereby the plans of all departments affected are co-ordinated with the production schedules at the factory.

Ordinary daily deliveries from warehouse stock are coming to be more and more on pre-determined schedules established by the customers themselves. In most cases the telephone company's main garage is located immediately adjacent to the warehouse, and deliveries are made daily in accordance with the particular plan of distribution which the telephone company has in effect for deliveries in metropolitan areas. Under the Bell System plan for metropolitan distribution the service is practically immediate. It would be immediate if Western Electric stocks were never exhausted. Unfortunately, however, there are peaks in demand or delays in securing material which temporarily cause a shortage. Our experience has been that by diligent effort we can confine such shortages to a number not exceeding ¾ of 1 per cent of the items carried and we have, therefore, established as a standard that 99¼ per cent of the items carried in stock shall be on hand available for delivery at all times. Records are maintained so that those in charge of merchandising operations at the houses can at any moment check the actual performance against the standard.

When projects, additions or operations not on the questionnaire basis are to be started by the telephone companies, it is imperative that the material be available as needed or the work can not proceed. A shortage of material would have the same detrimental effect as shortage of workmen. Obviously, however, if material is made available at great expense or at unnecessarily large investment in merchandise, the cost of the material will be substantially increased, due to high cost of distribution. Good management, therefore, requires that service to customers, distribution expense and merchandise investment be continuously kept in proper relation to each other.

The correlation of these elements of the business has been the subject of much study and has resulted in two developments, viz., Standard Ordering Formulæ and the Bell System Quarterly Forecasting Plan. Each purchase of merchandise sets in motion a chain of operations, such as the determination of the proper amount to buy, the preparation and mailing of the actual order, inspection and transportation of material, its receipt and physical handling into storage, the making of reports and records, the approval and payment of invoice from supplier, etc. Each of these operations adds in some measure to distribution expense. If articles of small value are purchased too frequently, expense is incurred unnecessarily. On the other hand, carrying charges on merchandise are conservatively estimated at an annual cost of not less than 10 per cent of the value of the material, so that unnecessary expense is also incurred by needlessly large investment. Good merchandising, therefore, requires that the quantity specified on each purchase be determined by the relation between expense and carrying charges.

This has been the subject of engineering studies and formulæ have been published so that in each case the quantity of material which will cause the smallest sum total of expense and carrying charges can be readily determined. These formulæ show that the quantities purchased at a single time should be sufficient to last from a week to a year, depending on the movement and value of the article. The application of these formulæ at a typical house to each item in the normal assortment of high and low value items that comprise the merchandise investment showed that an investment equal to 47 days' sales from stock was the most economical quantity that could be carried. When a stock is once adjusted to the proper amount the merchandise investment can not be reduced further without loss, unless operating expenses are reduced simultaneously. There is, therefore, a necessity for unremitting attention to these problems. It should be noted in passing that control of merchandise investment can be had only by constant study by specialists, as stocks are based on estimated demands from a single customer and if the demands happen to be less than expected there is no other outlet—stocks can not be moved by bargain sales.

The Bell System Quarterly Forecasting Plan is a major effort to solve the service problem and reduce the cost of material. In brief, it is a plan for determining in advance the quantities of material which the System will require for carrying on its operations. Its foundation is the forecasting of demands for a relatively small number of principal items based on construction programs. It includes also the development of mathematical tables to show ratios of associated items of lesser importance to the principal items, and the development of what might be called experience tables which show the relation between many items of material and some factor of the business which causes their usage. The value of such a plan will be obvious from consideration of the following sequence of events.

Before material can be delivered operations must be financed, raw material secured, plant and machinery provided, workmen employed and trained, goods must be manufactured and transported to the points where needed. No deliveries can be made until all these processes have been completed. However, several months are required to complete these processes and when they are started the quantities that will be needed are not known—they must be estimated. If the estimates are too low, sufficient material will not be available. The shortage may be considerable and must be made up by

Western Electric Co. Distributing House, Boston, Mass.

View Showing Mechanical Equipment Used in Packing Department in the Hawthorne Warehouse.

manufacturing on an emergency or overtime basis at higher cost, or construction costs will be increased due to delay and changes in plans. Allocating that which is available causes additional expense and shipment by express frequently adds further to the charges. If the estimates are too high, surplus merchandise probably worth millions of dollars must be carried and stored. This expense is usually incurred by the manufacturer, but the carrying charges must sooner or later be absorbed in the cost of the article.

This development offers far-reaching possibilities for reduction in costs. For example, the houses have in stock a quantity of merchandise estimated to last approximately 50 days. If these stocks could be reduced to 49 days, or by a single day's usage, capital to the extent of $150,000 would be released for other purposes. A similar amount of capital would be released for every additional day's supply of merchandise that could be eliminated, but this is only at the houses. Basic stocks on hand at manufacturing sources are several times larger than operating stocks at distributing houses; so that if by more accurate knowledge of future requirements the quantity on hand is reduced by only a few days' supply, a very substantial amount of capital would be released for other uses.

In addition to its effect on service and investment, more accurate knowledge of demand will reduce first cost of the product itself, not only by reduction of emergency and overtime operations, but by the carrying on of the manufacturing operations on a more even schedule, thus reducing expense by avoiding frequent starting, stopping, changing from one product to another, turnover of workers, etc. The Bell System Forecasting Plan is the most fundamental and systematic effort that has yet been made to co-ordinate demand, production and distribution of merchandise for the Bell System.

The general subject of distribution expense is under continuous study. Since the functions performed are identical at all locations, studies and conclusions, when reached, are applicable to all. All the operations performed at the distributing houses have been studied in detail with three points in view; first, to see if any operations could be eliminated; second, to see if those which remained could be simplified; and third, to see if they could be performed by mechanical means.

Operating expenses at distributing houses are systematically studied and compared. The competition and rivalry arising from these comparisons has been the source of many improvements in methods and has produced economical results. The output of about 70 per cent of the employees at distributing houses is measured by a Standard Measurement Plan.

When new methods are originated they are usually tried at one location and development completed in actual use. When perfected they are introduced at all locations. Each distributing house is periodically inspected to insure that the quality of work conforms to the company's standard, that approved methods are followed, and that current rates of operating expenses are satisfactory. The routines, forms and equipment used at distributing houses have been standardized, so that when a change or improvement is made it can be introduced simultaneously at all locations.

During the past ten years the sales to companies comprising the Bell System have averaged $250,000,000 annually. A business of this magnitude, carried on in many separate cities throughout the United States, requires administrative methods developed for the peculiar nature of the business. In addition to those checks and tests which determine the extent to which the Western Electric Company fulfills its service functions, it is also necessary to have information showing the condition of the business at all times from an administration and financial point of view. Among other things, the volume of the business by the principal classifications of merchandise must be available; also exact knowledge of operating expenses divided into more than twenty classifications. The capital invested must be analyzed between merchandise, receivables, plant, cash and payables and, for purposes of control, the length of time the merchandise investment will last, or number of day's stock on hand, must be computed.

These factors are woven into an operating plan in the following manner: The probable sales for the following year are estimated in November, the estimates being based on the plans of the operating telephone companies. These estimates become the basis of an annual budget which includes the factors enumerated above. The budgets are carefully studied from all administrative angles and when approved constitute a master working plan. Reports are made monthly by each distributing house on forms similar to the budgets, and these monthly reports show where each house stands in the execution of the plan. By means of this system the business is always under control, though operations are carried on in many locations.

During the ten years prior to 1931 the growth was very rapid and caused many of the distributing houses to outgrow the premises in which they were located; consequently during that period it was necessary to provide entirely new buildings for the operation of distributing houses in eighteen different cities. In each case the buildings were designed to furnish good working conditions for employees, to provide for the particular needs of the business as developed by operating experience over a long period of years, and to be in keeping with their environment and the high standards of the Bell System.

In conclusion, it is worthy of note that this business is conducted by the distributor for the consumer. It has no viewpoint except the consumer's, and no policy except what is best for its customers. Although the business is obtained without competition, efforts to make distribution better and cheaper have been unceasing. While accurate costs among the wholesale trades are difficult to obtain, those that are available show that the Western Electric Company distribution costs are among the very lowest in the nation.

W. H. Graham

Budgets and Budgetary Control

An address delivered at the Annual Joint Meeting, sponsored by the Baltimore Chapter of the National Association of Cost Accountants and associated organizations, Baltimore, Md., March 22, 1932

WHEN our first parents were expelled from the Garden of Eden, they were told that "in the sweat of thy face shalt thou eat bread." Since then planning and provision for the future have been essential to the existence of the human race. Our best test of this is that the principle of evolution which we term the survival of the fittest has operated to remove speedily from the scene of action those individuals and tribes who took no thought for tomorrow and felt no responsibility for providing against future needs. At the same time, history records interesting examples of planning and foresight. We have the account of Joseph with his dream of seven lean cattle which devoured seven fat cattle—a dream which warned of famine to come and was heeded, with the result that the people stored up grain in the years of good harvests which tided them over the time of scarcity which followed. In these early stories, warnings as to the future came from dreams, from the utterance of oracles, or from other sources little more dependable. Prognosticators of business conditions and economic experts with their art were yet to come. Yet forecasts of our ancient ancestors, particularly when these were based upon sound interpretations of natural law and hard experience, were in some cases realized as is true today.

The period through which we are passing, characterized as it is by grave disturbances in economic conditions not only in the United States but throughout the entire world, has stirred many minds to search for the fundamental causes which have brought about such widespread maladjustment. It has also led many to search and to prescribe remedies therefor; remedies, some worse than our troubles, designed, if not to prevent entirely the wide swings between prosperity and depression hitherto characterizing the business cycle, at least to diminish their amplitude.

The problems both of diagnosis and of remedies are exceedingly complex. Many factors have contributed to bring about the present depression—the World War, our emphasis of production without the same emphasis on the problems of distribution and consumption, credit abuse, and so on—and even if we ever could reach a general agreement as to the real causes, it would be difficult to appraise their relative importance. In some cases it would not be easy to say with certainty what is cause and what is effect, and probably it is too much to expect the Master Builder to endow this generation with sufficient wisdom to solve all of the problems which now perplex us. Nevertheless, fallible and limited as we are, out of the serious study which is being given to correct our present troubles we shall make progress and some ideas of practical value will emerge to lift our economic order to higher levels.

In the literature which has so far appeared probably no single thought is expressed more frequently than the plea for more systematic and definite planning of our industrial and economic processes. On all sides there are suggestions and demands for forward programming to the end that the operation of business may be kept on a more even keel. As to just how this is to be done and the extent to which it should be carried, there is again no general agreement. We see it developed perhaps to its fullest extent in Soviet Russia where, proceeding from a revolution which broke down the existing economic order, an effort is under way to build a system in which all industrial and economic planning are functions of the State. Few indeed are the responsible Americans who would countenance a system so remote from our policy of individual liberty and initiative and the laissez faire policy on which our own economic progress has been based. There are, however, many outstanding business leaders as well as economists who believe that we must find means for more effective stabilization of industry and who are confident that more co-operative planning through trade associations, conferences of business leaders, national advisory boards, and particularly through industrial self-control, may be undertaken in ways which will be entirely consistent with the ideals of individualism which have always characterized our thought. Doubtless the only lasting solution to our problems must come from within our social, economic and industrial order. We have been too prone to pass our puzzling problems to government for political solution, or solution by mandate, yet no government is wiser than its people.

I have referred to these fundamental problems of our industrial and social order only because they seem to indicate clearly that the world today, perhaps more than ever before, has become concerned with the general subject of planning and programming, particularly in industry, and certainly within the limits of a particular business enterprise forecasting and budgeting offer the most effective means which have been devised for bringing about co-ordination of activity.

Again, the difficulties which we are now facing may well bring about re-examination of our methods of forecasting and planning. We are having impressed upon us through experience which has too often been bitter, the truth contained in an ancient saying—"No man liveth to himself alone." What man, what business, or even what nation is not at the present time affected in some measure by world conditions entirely beyond any single control. The moral to be derived from this experience seems clear. No business enterprise can safely chart its own course without at the same time giving most careful consideration to the probable effects of the currents and tides of general business which it is likely to encounter. Programs must be developed in the light not only of experience and prospects within the enterprise itself, but also from the viewpoint of the probable tendencies of those external factors which will affect future progress. To be sure, it is not always easy to determine the course of these factors, but to ignore them is folly. Such external data should be available in the formulation of judgments on which programs are to be based.

Briefly then, we have two general considerations in connection with business forecasting and planning which seem to be especially emphasized by the conditions of today—First, industry must in one way or another develop for itself, and from within, more definite methods of planning and programming its activities, and Second, consideration must be given to the probable trends of general business activity and more especially of those external factors which are most directly related to the activities of the particular enterprise concerned.

Turning now to the more specific phases of the subject of budgeting and budget control, let me state that I speak from experience gathered in the main in the telephone industry and I recognize that the problems of the telephone business differ somewhat at least from those of the ordinary unregulated business. I believe, however, that the philosophy which underlies our practices is sound in theory and is applicable to the broader field of budgetary practice.

What is "budgeting"? Is it as many regard it, a species of "black magic"? No, the undertaking is in no way mysterious. It is primarily the preparation of an overall management program through which the proposed future activities of an enterprise may be correlated and translated into terms of the income statement and balance sheet. The term "budget" is not an entirely satisfactory one for it may carry with it certain implications brought over from the governmental field. Governmental budgets from the point of sound principle should proceed from conservative estimates of revenues reasonably available and show activity and related expenditures planned accordingly, while commercial or business budgets should, to serve their real purpose, be plans or programs prescribing an orderly development of the business or industry under consideration. Budgets approached from the viewpoint of governmental procedure, are always subject to the danger that the items of expenditures included therein be looked upon as appropriations definitely made for specific purposes and therefore to be spent, or again as bogeys which have been set up as standards of accomplishment. Any over-expenditure therefore brings risk of censure to those responsible. Of course, in any business enterprise, definite appropriations to be spent for certain particular activities have their proper place. So, too, do standards by which achievement may be measured, and these standards when set in advance furnish an incentive which may well result in increased individual effort and in a higher degree of team work. To use the commercial or business budget, however, solely for these purposes definitely defeats its end.

Why should a business enterprise budget or plan its course? The answer to this question is also a simple one. Planning is necessary because the modern economic system with its related social order is highly dynamic in character. What we usually call the economic machine is, in effect, a living organism. Conditions in the sphere of economic life are constantly in a state of flux. Change is ever in progress in markets, in sources of supply, in prices, in business organization, in methods of production and distribution, in habits of consumption—to name only a few of the elements of economic existence which every business man recognizes. And behind the outward and visible change in such elements as these, a process of modification is continually taking place in economic relationships, in ethical standards, in political beliefs, in social customs, morals, and ideals, and in all those fundamental and frequently intangible forces which wield an influence over the destinies of the human race and all of its institutions. Moreover, these changes do not occur in a steady uniform flow. On the contrary, they come and go, they vary in intensity and in radius; they may be continuous, discontinuous, or periodic. In the case of any business institution, the objective of budgeting is to forecast these prospective changes, to appraise their probable importance, and to translate them into estimates, plans and policies relating to the future operations of the particular enterprise.

Budgeting programs should be made up in the light of the best available information at the time of preparation. They cannot, and should not, be regarded as strait-jackets within which the business is confined. Conditions change monthly, and even daily. Few indeed were the programs for last year, prepared let us say in the closing days of 1930, which did not require very substantial revisions during 1931. Clearly, in times like these planning or programming is more than ever needful but programs must be flexible and subject to continual readjustment. To be sure, the times are unusual, but in a sense all times are unusual. We never have lived and it is safe to say we never will live in a static world. How then can we plan or program most effectively? It seems to me that the answer is that it must be a continuous process, inseparable from the current operations of the business. The budget provides a means from time to time of taking stock, of bringing together anew the programs of the various departments of a business in order that they may be reviewed, revised if necessary, and coordinated so that the enterprise may be kept on an even keel and that expenses may be regulated in accordance with the probable overall results of operation. Approval of a budget or a program thus gives each of the various departments in the business assurance that its own particular program appears to be sound and may be undertaken. However, as time goes on, factors hitherto matters of estimate become matters of knowledge. Changes in the price levels of commodities, movements upward or downward in general business, the discovery that previous views of revenue or of the cost of certain activities no longer prevail—any of these factors may raise question as to the desirability of modification of programs under which the company is currently proceeding. Summed up, continuous planning or programming subject to review as frequently as internal or external conditions warrant, appears to offer the best possible means of assuring that operations are kept well coordinated and that all departments are working harmoniously toward a common goal—this in brief is budgeting.

As to the form of budget or planning procedure best adapted to meet the idea of continuous programming, there are varying ideas. In the main there are two general types—"long term" and "short term" planning:

The line of demarcation between the two types may not be especially well defined; and of course the differentiation between them will tend to vary among different types of business enterprises. In general, "long term" planning may be described as comprising those processes of intelligent prevision which are necessary, first, for reaching sound conclusions in respect of such matters as the fundamental, rational status of an industry in economic society and the average level, or rate of growth, of business volume which is consistent with that status; and second, for the development of progressive business policies which are in tune with prospective economic and social trends. "Short term" planning, on the other hand, comprises those processes which are necessary for the determination and appraisal of the prospective changes in the economic and social order which are likely to be fleeting in character, and for the formulation of those temporary plans and practices best adapted to adjusting the particular business to these transitory conditions. Respecting "short term" planning, there has in recent years been a tendency on the part of some companies to provide that the budget be revised quarterly, each time an additional three-month period being added, thus furnishing a program which is continuously twelve months in advance. The Bell System telephone companies have adopted a somewhat different method which I shall later describe.

Whatever machinery is set up, however, it would seem that under no budget philosophy which is soundly conceived should programs be prepared, say, for a calendar year and then be forgotten, except for comparisons with actual results, until the time recurs for a new program to be outlined, for this practice of comparing actual results with prior estimates to measure accomplishment is of little value. The true measure of the degree of efficiency and economy with which work has been done can be obtained only through carefully devised unit cost methods. In other words, costs must be related to units of work actually performed rather than to the volume of work which it was expected would be done.

Let us assume, for example, that the budget is prepared for a twelve-month period, that the estimate is broken down on a monthly basis, and that comparisons are made each month between the budget figures and actual results. An overrun of an expense item for the early months of the period may be due to the fact that the program is proceeding more rapidly than was planned, in which event it may be expected that expenses for later months will show a corresponding falling off from the budget figures. On the other hand, such an overrun may occur when the program is proceeding as originally expected and may be due to the fact that the original estimates of cost were too low. Again, overall results may be running very close to those estimated although there has been a slippage in the program which has been offset by higher costs of the work done. Clearly, in the latter event the experience gained as to actual costs might warrant reconsideration of the program even though for the elapsed period overall results seems to be running very near those estimated. Budget comparisons with actual results are of little or no value until they have been analyzed in the light of the actual progress of work and such an analysis may be expected to be of aid only in determining whether or not the program continues to be a sound one. Budget comparisons to be of value must look toward the future and their real worth lies in the light which they may throw on programs of work still ahead.

So much for the general philosophy underlying the use of the budget as an aid to the administration of any business enterprise. Let me now sketch briefly the methods and practices followed by Bell System telephone companies developed as the result of an experience of about twenty-five years in budget making. The Bell System comprises the American Telephone and Telegraph Company and twenty-four Associated Telephone Companies furnishing local and toll service within their own particular areas. The American Company is the parent organization, owning and operating the long distance telephone lines which connect the lines of the Associated Companies. It carries on research and development work for all of the System companies, not only along technical lines devoted to the advancement of the art of telephony but also in fields, such as accounting and statistical methods, operating methods, commercial methods, etc., where fundamental work, the results of which will be of value throughout the System, may more efficiently and economically be undertaken at a central point than at many places. A large staff organization, comprising over 7,000 persons, when the personnel in its laboratories is included, is maintained for this work and its services are at the disposal of the Associated Companies for advice and assistance on any problems which may arise. The American Company also does most of the financing necessary to provide for the growth of the System. The manufacturing of telephone apparatus is carried on for the System by the Western Electric Company which also acts as purchasing agent for the telephone companies.

The type of organization in each of the Associated Companies is functional, the work of the companies being handled by nine different departments. The traffic department, for example, has the responsibility for the handling of calls, the commercial department for business relations with users of the service, the plant department for the construction and maintenance of the properties, the engineering department for the planning for plant extension and the determination of the type of plant to be built, and so on, each department being charged with its own particular function. Obviously, organizations of the type and size of the telephone companies can operate with a high degree of efficiency only if there is constant co-ordination of departmental efforts, not only in the current operations of the business but also in the preparation of plans for the future. Careful "long term" planning for the future with us has particular importance because we must continually be adding new plant. Most industries in times of depression can entirely suspend their growth; telephone companies cannot. Even in 1931, gross expenditures for construction and replacements aggregated nearly $400,000,000 while net additions to plant amounted to about $150,000,000. We sell service rather than goods, and with the extension of service there must be extension of plant facilities, even though other plant may not for the time being be fully used. Furthermore, it is of the highest importance that our new construction be planned wisely, not only to meet present needs but with a view to probable requirements for a considerable period in the future. For each important city there is accordingly maintained what is termed a fundamental "long term" plan, forecasting for some years ahead not only the probable growth in population and in requirements for telephone service but also in such matters as the probable geographical trend of business and residential sections. These plans, kept under frequent review, furnish the background for a long range program into which may be fitted the solution of such problems as the desirable location and size of central office buildings, the location of principal conduit and cable runs, etc. Similar fundamental plans are made regionally, outlining the probable future growth of toll traffic and developing a basis for handling the installation of cables, whether underground or aerial, in a manner which will be consistent with the long range view.

Thus there is back of our budget practice a great deal of systematic planning and fundamental research not translated at the moment into precise estimates of cost or even into definite work schedules but all contributing to give assurance that those projects under present consideration, when finally undertaken, will be so planned and engineered that they will form an orderly part of a comprehensive program looking some years into the future; a program designed to provide that there be no more facilities than are needed and no less than are required.

The "short term" budget or program, which in our business bears the name "provisional estimate," is prepared by each company annually in the late fall and covers the three following calendar years. It comprises estimates of the cost of plant to be added and that to be displaced in each year, of the number of telephones to be installed and those to be removed, of the revenues that will be obtained from the various types of service, and of expenses by main classification of accounts, arriving finally at an estimate of the net earnings and of the ratio of such earnings to the average plant in service. It also furnishes an estimate of cash requirements and resources for the year immediately following and estimates of the quantities of certain of the more important types of material and equipment which will be needed. The schedules of the various companies showing the amount of new money which will be required are consolidated to determine the total cash needs of the System, while those showing the quantities of material and equipment which will probably be needed furnish the information required for the determination of a manufacturing and purchasing program for the Western Electric Company.

So far as the first year of the provisional estimate is concerned, expenditures included therein are based on rather detailed estimates of the cost of carrying out specific programs, while for the last two years, except for large construction projects which must be scheduled well in advance, the figures are based to a considerable extent on projections of past experience modified by business judgment and by consideration of those factors which might cause appreciable changes in the general level of operation during the years in question. In some cases, companies may carry their estimates through for five years in advance. However, in the case of all estimates covering periods longer than those for which programs have been rather definitely worked out and scheduled, it is desirable to avoid attempting to obtain what engineers term "spurious accuracy." Since so many factors in the situation are subject to change as time advances, it is futile to seek refinement of detail. For most items, broad judgments as to trends and overall considerations will not only furnish adequate estimates as a basis for proceeding but will save expense and a great amount of unnecessary routine work.

In the preparation of estimates of the growth in number of telephones and of toll usage, together with revenues to be derived therefrom—factors which, of course, have a direct influence on work programs—it is necessary to formulate an opinion as to the probable trend of general business. The difficulty of forecasting movements of general business is, of course, particularly marked at times like the present when economic conditions in this country are complicated not only by its own economic problems but by the political problems of Europe and Asia. However, even under these conditions, we feel that such judgments should nevertheless be formulated in the light of the best information currently available rather than to rely upon a spirit of either blind optimism or hopeless pessimism. The statistical organization in each company therefore aims to keep in touch with current tendencies in general business within its own respective territory, while the statisticians of the American Company maintain contacts with many other lines of business and are continually studying conditions for the country as a whole. Indices which serve as measurements of current economic activity have been maintained for many years and are under continual observation for the light which they may throw on the future. Certainly at the moment there is particular need for being on the alert to sense changes in general economic conditions, and the times emphasize the requirement that programs be kept flexible and subject to change as additional knowledge becomes available.

The adjustment of our budget program to changed conditions is met through periodic reviews of our programs at intervals during the year. The estimates for 1932 were prepared late in 1931 and were accompanied by an estimate of the various items by months for the first four months of 1932. As of May 1 the companies, with four months' experience behind them, will review and revise the figures both for the current year and for the year 1933. This review will be accompanied by another view by months for the next four-month period. The same process will be repeated as of September 1. In the preparation of these new views, revenue estimates are reconsidered, work programs are carefully reviewed, and the new view on receiving executive approval practically supplants the original estimate. Monthly comparisons of actual results with those estimated cover only the period since the latest review was compiled and are made from the viewpoint of throwing light on probable future performance.

In the preparation of reviews, the executives who have approved the original program will naturally seek explanation as to the causes for important changes therein. This gives them many items of useful information. Once the changes have been approved, however, the new view, as has been stated, supplants the earlier one. Thus we have what amounts to a continuing program, and our budget processes are tied into the day-to-day operation of the business. Programming is indispensable and should go on even without a budget. The budget, however, provides an effective means for bringing together all of the departmental programs that they may be co-ordinated and adjusted in the light of revenue estimates and the probable overall results of operation. Briefly, the budget should be a tool of administration. It should provide a way in which programs may be controlled and not a mold into which a business is to be fitted. It should be a chart showing the course on which the business is proceeding, but also one which may be varied from as new knowledge becomes available.

I have referred to the present widespread interest in the subject of better industrial planning largely because of our experiences under present economic conditions. During the past fifty years this country has passed through one of the greatest industrial and scientific periods of all times. It was our expression of a desire for a better world, a higher standard of living. This epoch of our history drew to industrial and scientific pursuits some of the greatest minds of that period. Why? Because men love power and ability to achieve and will be drawn to the particular movement or activity which, for the time being, gives them the greatest opportunity to those ends. Scientific and industrial achievement in this period made possible the aeroplane, the automobile and tractor, the great steamships, the far reaching telephone and telegraph systems, the radio for communication and broadcast, the almost unlimited extension of the use of electricity for light, heat and power, the electric train, the largest of factories and industrial plants, and so on to mention only a few aspects of our material progress. In man's conquest of nature through science, he has revealed great secrets and with these he has organized the production and distribution of material necessities, comforts and luxuries of life into larger units. In this quest for improvement many things were rendered obsolete before we really had an opportunity to become acquainted with them.

In the United States alone during 1930 upwards of $200,000,000 was spent by research laboratories for industrial research of one type or another. Add to this sum the enormous sums expended by laboratories for medical, social, governmental and other research to improve living conditions generally. Truly scientific research is one answer to our progress.

What does it mean for the future? Well, first, that we are not yet ready to fold up our tents and quit. It means great potential resources. It means far reaching changes in our social, economic and industrial life. It means that we can no longer isolate ourselves, that we cannot exist unaffected by what is happening in other lands. It means also that eventually there must come a common language for communication, a common currency as a medium of exchange, more uniform customs and standards of living, and through these and other changes will come better understanding, and differences and prejudices between nations should disappear and strife and warfare will be less possible. A new and finer world is in the making. Yet all of our progress has not been an unmixed blessing. There are definite evidences in our present economic situation that we have emphasized production and the tools of production and have overlooked some important aspects of the problems of distribution and consumption—decisive factors in our economic structure. Production without consumption may well prove a curse rather than a blessing. We have granaries filled with grain but not consuming power, we have the finest factories but at present no demand for their product. There is plenty of labor but no demand for its product, and with no demand for its product labor cannot buy. We have ahead the definite task of readjustment. Recognition must be given to the great increase that has taken place in recent years in the tempo of industrial and economic development, with changes compressed within a decade today that are as profound as those which were spread through a century or more before the alliance between science and business. This does not indicate that we should consciously attempt to retard the pace of progress, and have less new inventions and new technical processes, but rather that we should adjust and keep adjusted our economic processes and economic behavior to our new plane of progress.

An important aspect of this problem is that of providing as far as possible continuous employment for the worker in industry. In times like these when millions are unemployed, private charity and action by local and state governments must be depended on to prevent suffering and to relieve distress. Such measures, however, are but palliatives. The only cure for idleness is productive employment, and it is only through providing work that we can insure the maintenance throughout our population of these qualities of responsibility and self-respect which are essential to the social well-being of the nation. There is much evidence that business leaders are recognizing more clearly than ever before their responsibilities in this direction, and are searching for plans which will provide for a greater degree of stabilization of employment. One constructive suggestion to this end may be helpful. Just as reserves are accumulated in prosperous years from which investors may benefit in years of adversity, so too we should come to provide reserves in prosperous years which may be drawn upon to provide work for or relief to employees during ebbs in the business tide.

What I have said is a constructive and not a destructive criticism of our industrial and economic order. Most of our present troubles are definitely the aftermath of the World War and will in due time pass by. Our troubles are, however, accentuated by the accelerated production ability of recent years as yet not fully co-ordinated with adequate processes of distribution and consumption, and also by some unwise use of our credit facilities. We have, however, already made progress in these matters when comparison is made with our not so distant past. In the depression of the early nineties and again in 1907 we had well advanced processes of production, and we also had the same hectic conditions of unemployment, business and bank failures, and all the ills usually associated with such periods. The records and memories of those and earlier periods, however, do not reveal the same social and economic consciousness existing today, directed to keep the hardship and other ill effects of such periods at their minimum, nor the same universal interest in finding the cause of the trouble and the appropriate remedies therefor. Happily, too, we have today the means and the will to alleviate the adverse conditions confronting many of our people. As evidence, one need only to pick up a morning newspaper and there read of conferences of every description on the unemployment situation; conferences on correction and avoidance of business depressions; of efforts by community chests, welfare organizations and individuals to relieve suffering and distress; of bequests for hospitals; of cooperative efforts on the part of the employer and the employed to find a right solution of their differences; of efforts to eliminate waste and inefficiency; of efforts to improve our banking and credit processes; and of efforts to improve our taxation and governmental structure. When in history and in what country has such an effort based on voluntary and individual action been made?

The task of further adjusting and keeping adjusted our economic processes and our economic behavior to our new plane of progress is one in which we can all have a part, the engineer, the industrial leader, the scientist, the statesman, the banker, and not least of all the accountant with his understanding of business processes. It is a task which commands the finest type of mind, brains of the calibre which during the past fifty years led to our present productive ability. Industrial planning to be really effective must for the future consider these problems as fundamental and concern itself with a proper solution, if we are to continue as a great nation and a progressive people. The task comprises in part a proper viewpoint, more co-operation within industry, and greater industrial self-control, or self-government in business, rather than greater participation of government in business.

Is it too much to hope that with proper vision our budgeting or planning systems, designed to give proper recognition to these factors and then efficiently operated, will make not only increasingly valuable contributions to the financial success of business enterprises, but will also indirectly further the stability of our social and political institutions?

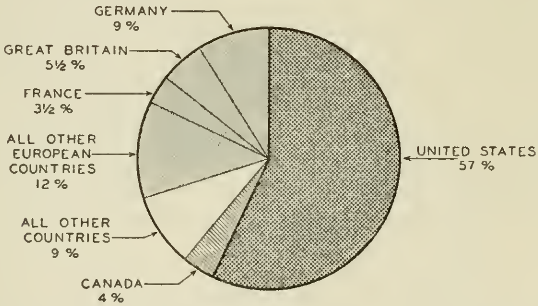
C. A. Heiss

World's Telephone Statistics

January 1, 1931

EACH year the Chief Statistician's Division of the American Telephone and Telegraph Company makes a comprehensive statistical survey of the number of telephones connected to the telephone systems of the world. With the gradual extension of international communication by radio-telephone, the data provided by this survey become increasingly interesting and significant. Every effort is made to secure accurate figures. Detailed questionnaires are sent to all the various tele-

DISTRIBUTION OF THE WORLD'S TELEPHONES
January 1, 1931



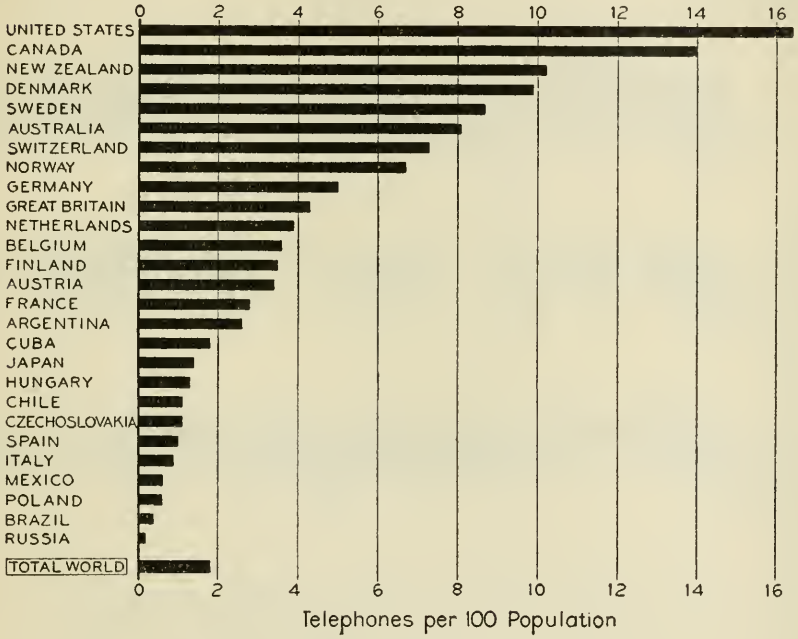
phone and telegraph administrations and systems throughout the world and, in the relatively few cases where authoritative data are lacking, careful estimates are made based on the records of previous years.

The survey for January 1, 1931 was recently completed. On that date there were 35,336,467 telephones in the world; of these, about 57 per cent, or 20,201,576 telephones, were in the United States. More than 99 per cent of these 20,201,576 telephones were either owned by, or connected to, the Bell System. Europe had 10,589,222 telephones, or about 30 per cent of the world's total; while the remaining 4,545,669 telephones

—13 per cent—were distributed among the countries of Asia, Africa, South America, Oceania and the parts of North America outside of the United States.

Despite the adverse economic conditions which generally prevailed throughout the world, there were 865,729 instruments added to the world's telephone systems during 1930. The increase in the United States was 133,553 telephones. Of the total telephones in the world, 10,860,000 instruments, or

TELEPHONES PER 100 POPULATION
January 1, 1931



about 31 per cent, were of the automatic or "dial" type. More than 50 per cent of these were in the United States.

As in other years, the results of the survey have been issued in the form of a printed bulletin from which the accompanying tables and charts have been taken.

Comparative Telephone Development of Countries

There were no significant changes during 1930 in the relative

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES

January 1, 1931

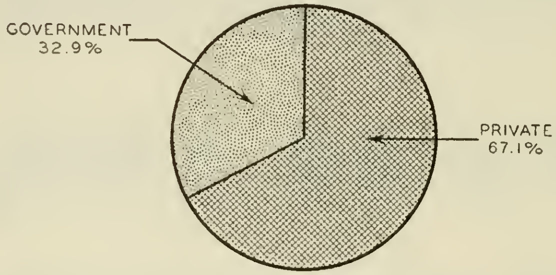
	Number of Telephones					
	Government Systems	Private Companies	Total	Percent of Total World	Telephones per 100 Population	Increase in Number of Telephones During 1930
NORTH AMERICA:						
United States	......	20,201,576	20,201,576	57.17%	16.4	133,553
Canada	241,309	1,161,552	1,402,861	3.97%	14.0	2,875
Central America	11,893	13,376	25,269	.07%	0.4	638
Mexico	1,427	90,632	92,059	.26%	0.6	10,364
West Indies:						
Cuba	485	67,991	68,476	.20%	1.8	− 8,341
Porto Rico	602	11,776	12,378	.04%	0.8	118
Other W. I. Places*	8,222	13,531	21,753	.06%	0.3	1,198
Other No. Am. Places*	100	11,829	11,929	.03%	3.3	520
Total	264,038	21,572,263	21,836,301	61.80%	13.0	140,925
EUROPE:						
Austria	233,912	......	233,912	.66%	3.4	11,676
Belgium	292,633	......	292,633	.83%	3.6	32,960
Bulgaria*	19,000	......	19,000	.05%	0.3	500
Czechoslovakia	147,028	17,451	164,479	.47%	1.1	6,772
Denmark (March 31, 1931)	13,593	340,722	354,315	1.00%	9.9	12,516
Finland	1,642	126,500	128,142	.36%	3.5	6,078
France	1,153,560	......	1,153,560	3.26%	2.8	97,526
Germany	3,248,854	......	3,248,854	9.19%	5.0	66,549
Great Britain and No. Ireland	1,996,897	......	1,996,897	5.65%	4.3	110,171
Greece	12,800	......	12,800	.04%	0.2	1,000*
Hungary	115,273	......	115,273	.33%	1.3	13,960
Irish Free State (March 31, 1931)	30,601	......	30,601	.09%	1.0	2,609
Italy (June 30, 1930)	......	381,992	381,992	1.08%	0.9	48,935
Jugo-Slavia*	70,000	......	70,000	.20%	0.5	3,000
Latvia (March 31, 1931)	51,530	......	51,530	.15%	2.7	9,341
Netherlands	306,554	......	306,554	.87%	3.9	22,121
Norway (June 30, 1930)	115,164	77,400*	192,564	.54%	6.7	4,326
Poland	108,683	90,696	199,379	.56%	0.6	13,277
Portugal	7,803	28,963	36,766	.10%	0.6	2,208
Roumania	......	49,809	49,809	.14%	0.3	......
Russia (October 1, 1930)¶	377,586	......	377,586	1.07%	0.2	46,334
Spain	......	222,382	222,382	.63%	1.0	37,840
Sweden	534,722	1,670	536,392	1.52%	8.7	27,331
Switzerland	297,930	......	297,930	.84%	7.3	29,216
Other Places in Europe*	99,507	16,365	115,872	.33%	1.4	2,905
Total	9,235,272	1,353,950	10,589,222	29.96%	2.0	609,151

SOUTH AMERICA:						
Argentina*	......	303,000	303,000	.86%	2.6	23,000
Bolivia	......	2,333	2,333	.01%	0.1	– 174
Brazil*	674	162,000	162,674	.46%	0.4	3,000
Chile	......	48,687	48,687	.13%	1.1	3,448
Colombia	2,500*	26,888	29,388	.08%	0.3	1,016
Ecuador	1,500	2,700	4,200	.01%	0.2	50
Paraguay	185	1,905	2,090	.01%	0.2	120
Peru	......	13,745	13,745	.04%	0.2	446
Uruguay	......	29,356	29,356	.08%	1.6	334
Venezuela	591	20,931	21,522	.06%	0.7	1,672
Other So. Am. Places*	2,830	......	2,830	.01%	0.5	62
Total	8,280	611,545	619,825	1.75%	0.7	32,974
ASIA:						
British India*	22,000	35,000	57,000	.17%	0.02	100
China	84,000	69,000	153,000	.43%	0.03	– 3,000
Japan (March 31, 1931)	913,157	......	913,157	2.58%	1.4	47,641
Other Places in Asia*	108,881	17,502	126,383	.36%	0.1	3,792
Total	1,128,038	121,502	1,249,540	3.54%	0.1	48,533
AFRICA:						
Egypt*	46,000	......	46,000	.13%	0.2	1,000
Union of South Africa†	112,900	......	112,900	.32%	1.4	3,963
Other Places in Africa*	86,871	1,320	88,191	.25%	0.1	5,854
Total	245,771	1,320	247,091	.70%	0.2	10,817
OCEANIA:						
Australia§	520,169	......	520,169	1.47%	8.1	14,615
Dutch East Indies	49,447	4,598	54,045	.15%	0.1	951
Hawaii	......	25,104	25,104	.07%	6.6	738
New Zealand†	164,739	......	164,739	.47%	10.2	3,698
Philippine Islands	6,000*	20,017	26,017	.08%	0.2	3,113
Other Places in Oceania*	3,638	776	4,414	.01%	0.2	214
Total	743,993	50,495	794,488	2.25%	1.0	23,329
TOTAL WORLD	11,625,392	23,711,075	35,336,467‡	100.00%	1.8	865,729

* Partly estimated.
† March 31, 1931.
‡ Includes approximately 10,860,000 automatic or "Dial" telephones, of which more than 50% are in the United States.
§ June 30, 1930.
¶ U. S. S. R., including Siberia and Associated Republics.

standing of the principal countries in point of telephone development. The United States, with 16.4 telephones per 100 inhabitants, has the largest number of telephones in relation to population. Canada was the next best developed country, telephonically speaking, with 14.0 telephones per 100 population; then follow in order, New Zealand with 10.2, Denmark with 9.9, Sweden with 8.7 and Australia with 8.1 telephones per 100 population, respectively. The service in the United States is operated exclusively by private companies, and in Canada about 79 per cent of the telephones are privately owned

OWNERSHIP OF THE WORLD'S TELEPHONES
January 1, 1931



and operated. Germany, with more telephones than any other country except the United States, had only 5.0 telephones per 100 population or less than one-third the development provided by the telephone companies in the United States. Great Britain had a development of 4.3; this ratio is above that found in France, which had 2.8 telephones for each 100 inhabitants. Argentina continues to be the best developed country in South America, with 2.6 telephones per 100 population. Japan, the best developed country in Asia, had 1.4 telephones per 100 population, a ratio duplicated by the Union of South Africa, which is the leading country of Africa in point of telephone density. The relative telephone development of the principal countries of the world is shown on the chart on page 275.

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES

January 1, 1931

Country	Service Operated by (See Note)	Number of Telephones: In Communities of 50,000 Population and Over	Number of Telephones: In Communities of less than 50,000 Population	Telephones per 100 Population: In Communities of 50,000 Population and Over	Telephones per 100 Population: In Communities of less than 50,000 Population
Australia (June 30, 1930)*	G.	295,165	225,004	9.0	7.1
Austria	G.	176,153	57,759	7.5	1.3
Belgium	G.	203,106	89,527	6.1	1.9
Canada	P. G.	730,000	672,861	23.7	9.7
Czechoslovakia	P. G.	65,543	98,936	4.1	0.8
Denmark	P. G.	158,910	192,400	17.5	7.2
Finland	P. G.	48,156	79,986	10.4	2.5
France	G.	676,125	477,435	7.5	1.5
Germany	G.	1,978,418	1,270,436	8.8	3.0
Great Britain and No. Ireland†	G.	1,432,700	588,900	5.7	2.8
Hungary	G.	85,675	29,598	4.9	0.4
Japan (March 31, 1931)	G.	548,762	364,395	3.5	0.7
Netherlands	G.	202,228	104,326	6.4	2.2
New Zealand (March 31, 1931)	G.	63,742	97,997	12.2	9.2
Norway (June 30, 1930)	P. G.	65,931	126,633	16.1	5.1
Poland	P. G.	111,500	87,879	2.9	0.3
Spain	P.	137,327	85,055	3.2	0.5
Sweden	G.	215,441	320,951	21.7	6.2
Switzerland	G.	130,809	167,121	15.5	5.2
Union of South Africa	G.	59,060	52,840	6.3	0.7
United States	P.	11,152,076	9,049,500	22.6	12.2

Note: P. indicates telephone service operated by private companies, G. by the Government, and P. G. by both private companies and the Government. See first table.

* Partly estimated.

† March 31, 1931.

Telephones in Large and Small Communities

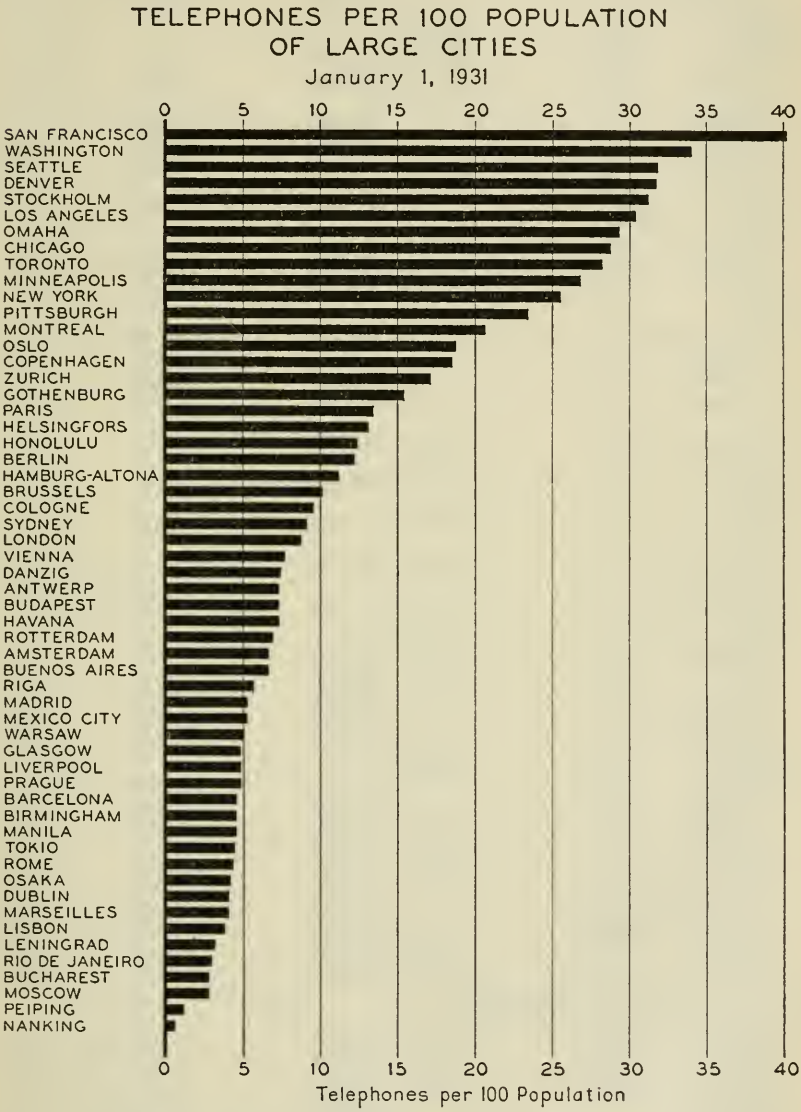
The table on "Telephone Development of Large and Small Communities," has a particular interest in that it indicates the extent to which telephone service is distributed between urban centers and the less populated areas. Examination of this table shows that in the case of the principal foreign countries, telephone facilities are restricted largely to the cities. Thus, in Germany there were only 3.0 telephones per 100 inhabitants in communities of less than 50,000 population, as against a development of 8.8 in communities of over 50,000 population. In Great Britain, we find a development in the less populated sections of 2.8, and in France a corresponding figure of 1.5. On the other hand, New Zealand, a small country with few large cities, reported a ratio of 9.2 telephones in communities of less than 50,000 population.

In the United States, however, the situation is radically different from European conditions. Our ratio of 12.2 telephones per 100 population in communities of less than 50,000 inhabitants reflects a high degree of development in the less densely populated sections—so high, in fact, that with the exception of Canada, no other country *as a whole* has a better telephone development than the smaller places in the United States.

Telephones in Large Cities

The relative telephone development of large cities throughout the world is shown on the accompanying chart. Of the twelve cities heading the list, ten are in the United States. San Francisco had the best development with 40.2 telephones per 100 population. Washington with 34.0, Seattle with 31.8, and Denver with 31.7 telephones per 100 population, respectively, are next in order. Then follows Stockholm with a development of 31.2 telephones per 100 population. The capital cities of France, Germany and Great Britain occupy relatively low positions on the chart. Thus Paris is eighteenth, Berlin twenty-first, and London twenty-sixth, with developments of

13.4, 12.2 and 8.7 telephones per 100 population, respectively. The accompanying table, "Telephone Development of Large



Cities," indicates even more strikingly the relative superiority of the American cities as regards telephone service. The aver-

TELEPHONE DEVELOPMENT OF LARGE CITIES
January 1, 1931

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINA:			
Buenos Aires	2,486,000	163,057	6.6
AUSTRALIA:			
Adelaide	324,000	30,422	9.4
Brisbane	313,000	24,868	7.9
Melbourne	1,015,000	95,117	9.4
Sydney	1,254,000	114,630	9.1
AUSTRIA:			
Graz	165,000	9,469	5.7
Vienna	2,020,000	155,128	7.7
BELGIUM:			
Antwerp	519,000	37,795	7.3
Brussels	948,000	95,632	10.1
Liege	424,000	20,669	4.9
BRAZIL (June 30, 1931):			
Rio de Janeiro	1,600,000	47,000	2.9
CANADA:			
Montreal	950,000	195,976	20.6
Ottawa	184,300	38,883	21.1
Toronto	735,500	207,218	28.2
CHINA:			
Hong Kong	500,000	12,100	2.4
Nanking	570,000	2,910	0.5
Peiping	1,200,000	13,000*	1.1
Shanghai	1,200,000	35,432	3.0
CUBA:			
Havana	685,000	49,801	7.3
CZECHOSLOVAKIA:			
Prague	850,000	40,571	4.8
DANZIG:			
Free City of	235,000	17,534	7.5
DENMARK:			
Copenhagen	771,000	142,323	18.5
FINLAND:			
Helsingfors	255,000	33,384	13.1
FRANCE:			
Bordeaux	266,000	21,013	7.9
Lille	210,000	15,116	7.2
Lyons	592,000	29,946	5.1
Marseilles	677,000	27,080	4.0
Paris	2,980,000	400,528	13.4
GERMANY:			
Berlin	4,325,000	525,689	12.2
Breslau	617,000	44,546	7.2
Cologne	737,000	70,045	9.5
Dresden	633,000	63,278	10.0
Dortmund	535,000	23,941	4.5
Essen	648,000	30,495	4.7
Frankfort-on-Main	625,000	68,405	10.9
Hamburg-Altona	1,605,000	179,435	11.2
Leipzig	710,000	71,003	10.0
Munich	740,000	77,642	10.5
GREAT BRITAIN AND NORTHERN IRELAND (March 31, 1931):			
Belfast	415,000	16,060	3.9
Birmingham	1,168,000	52,502	4.5
Bristol	410,000	18,740	4.6
Edinburgh	439,000	28,468	6.5
Glasgow	1,176,000	56,100	4.8
Leeds	506,000	21,751	4.3
Liverpool	1,178,000	56,185	4.8
London	8,210,000	712,493	8.7
Manchester	1,091,000	61,152	5.6
Newcastle	468,000	18,418	3.9
Sheffield	512,000	18,708	3.7
HAWAII:			
Honolulu	139,000	17,273	12.4
HUNGARY:			
Budapest	1,005,000	73,768	7.3
Szeged	135,000	2,452	1.8

TELEPHONE DEVELOPMENT OF LARGE CITIES (Concluded)

January 1, 1931

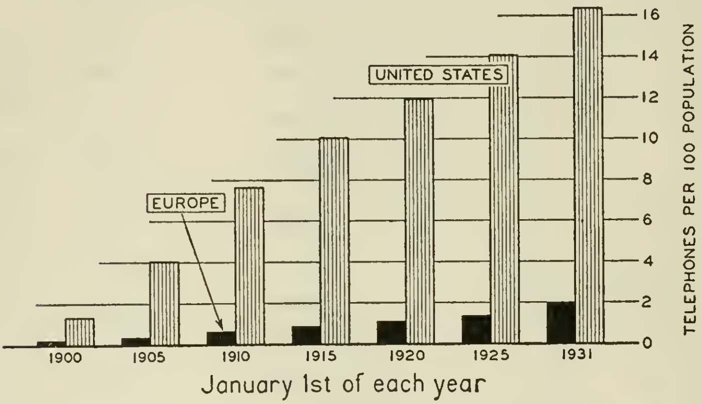
Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
IRISH FREE STATE (March 31, 1931):			
Dublin	412,000	16,338	4.0
ITALY:			
Genoa (January 1, 1930)	628,000	22,516	3.6
Milan	928,000	68,253	7.4
Rome (January 1, 1930)	950,000	40,393	4.3
JAPAN (March 31, 1931):			
Kobe	788,000	29,562	3.8
Kyoto	815,000	34,196	4.2
Nagoya	907,000	28,748	3.2
Osaka	2,454,000	101,478	4.1
Tokio	3,410,000	151,000	4.4
LATVIA (March 31, 1931):			
Riga	385,000	21,677	5.6
MEXICO:			
Mexico City	955,000	49,334	5.2
NETHERLANDS:			
Amsterdam	752,000	49,670	6.6
Haarlem	148,000	10,051	6.8
Rotterdam	598,000	41,510	6.9
The Hague	472,000	43,476	9.2
NEW ZEALAND (March 31, 1931):			
Auckland	207,000	21,759	10.5
NORWAY (June 30, 1930):			
Oslo	252,000	47,064	18.7
PHILIPPINE ISLANDS:			
Manila	380,000	17,199	4.5
POLAND:			
Lodz	836,000	13,699	1.6
Warsaw	1,116,000	56,332	5.0
PORTUGAL:			
Lisbon	590,000	21,837	3.7
ROUMANIA:			
Bucharest	630,000	17,103	2.7
RUSSIA (October 1, 1930):			
Leningrad	2,228,000	68,255	3.1
Moscow	2,780,000	74,391	2.7
SPAIN:			
Barcelona	850,000	38,104	4.5
Madrid	815,000	42,218	5.2
SWEDEN:			
Gothenburg	244,000	37,588	15.4
Malmö	128,000	18,735	14.6
Stockholm	428,000	133,441	31.2
SWITZERLAND:			
Basel	147,000	22,885	15.6
Berne	112,000	18,562	16.6
Geneva	143,000	21,956	15.4
Zurich	250,000	42,750	17.1
UNITED STATES:†			
New York	7,014,900	1,786,270	25.5
Chicago	3,424,000	981,325	28.7
Los Angeles	1,320,000	401,887	30.4
Total 8 cities over 1,000,000 population	19,602,800	4,875,830	24.9
Pittsburgh	987,300	231,435	23.4
Milwaukee	725,100	158,003	21.8
San Francisco	653,300	262,470	40.2
Washington	508,500	172,998	34.0
Total 10 cities with 500,000 to 1,000,000 population	6,927,700	1,605,282	23.2
Minneapolis	497,600	133,477	26.8
Seattle	403,900	128,447	31.8
Denver	290,100	91,965	31.7
Omaha	228,800	67,102	29.3
Total 34 cities with 200,000 to 500,000 population	10,228,400	2,204,289	21.6
Total 52 cities with more than 200,000 population	36,758,900	8,685,401	23.6

* Partly estimated.

† There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups and the development of certain representative cities within each of such groups.

age development of all cities (fifty-two) in this country with more than 200,000 population was 23.6, a figure which exceeds that for any single large foreign city except Stockholm and Toronto. Chicago, with its 981,325 telephones, had a development of 28.7, while the corresponding figure for New York, with 1,786,270 telephones, was 25.5. Yet Chicago had less than 5 per cent, and New York less than 9 per cent, of the total number of telephone instruments in the United States. London, on the other hand, had 712,493 telephones, or about 36 per cent of all the instruments in Great Britain; Paris, with 400,528 telephones, had 35 per cent of all the instruments in France. More than one fourth of all the telephones in Germany were located in the cities of Berlin, Hamburg-Altona, Leipzig and Munich. These figures, in other words, bring out still more emphatically the fact that in foreign countries telephone facilities are largely concentrated in the urban areas, despite the cognate fact that even these cities are less generously provided with telephone service than are American cities.

TELEPHONE DEVELOPMENT
IN THE UNITED STATES AND EUROPE



Notes on Recent Occurrences

BELL SYSTEM PUBLICITY CONFERENCES

ON March 15 and 16 the Publicity Managers of the Eastern Group of Associated Companies of the Bell System met in New York for a conference on matters pertaining to advertising and public relations, and on March 22 and 23 a similar meeting was held in Chicago attended by representatives of the Western Companies. The two conferences were conducted by Arthur W. Page, Vice President of the American Telephone and Telegraph Company.

LONG DISTANCE HEADQUARTERS MOVED

THE general and division offices of the Long Lines Department of the American Telephone and Telegraph Company have been moved from scattered offices to the Department's newly finished headquarters in the Long Distance Building at 32 Sixth Avenue, New York, which now houses about 5,500 people.

Thirty-two Sixth Avenue, known as 24 Walker Street before it was remodelled and doubled in size, is the largest long distance center in the world. It is the crossroads of all main trunk routes of the Bell System in the Northeast. It has direct telephone circuits to many important cities in the United States, Canada and Cuba, and to the switching points for Mexico. All calls from North America for Europe, South America, the Far East and ships at sea, are handled in this building.

In addition to all the telephone lines passing through it, the Long Distance Building is the principal nerve center for the great radio chains. Here is located the control room for the nation-wide hook-ups furnished to the broadcasting companies.

The building also houses the Bell System's largest teletypewriter exchange. All private wires furnished by the Bell System from New York to distant cities, whether by telephone, teletypewriter or telegraph, are brought through the building.

The construction activities just completed involved the erection of two new buildings, merging with the original building. The project involved changing the old twenty-four story building to a twenty-eight story building covering the entire block between Sixth Avenue and Church Street and between Walker and Lispenard Streets, or nearly twice the ground occupied by the old building. The new building rests on islands consisting of reinforced concrete mats.

It was necessary to relocate some 200 telephone cables in a new cable vault and to move cables here and there throughout the building. On account of the necessity for maintaining uninterrupted service, these alterations produced complicated and difficult problems.

One feature of the new structure makes it unique. This is a truss 90 feet long and weighing 52 tons, suspended 450 feet above the street level. This truss, together with a cantilever arrangement, supports four floors above the old building. The arrangement was necessary because the foundation and framework of the old building were not designed to support the extra weight which these four floors would impose.

In addition to the numerous switchboards, test boards and other equipment connected with telephone and telegraph operations, the new structure contains an assembly room seating 500, three cafeterias, complete medical department and rest and recreation facilities. Another feature is a dormitory for the use of operators coming off duty at late hours.

The original structure was erected in 1912. Seven floors were added in 1917, which provided space for local exchange equipment as well as toll. Today long distance facilities occupy the equivalent of nearly thirty floors of the old building.

The Long Distance Building in its new form was designed by Voorhees, Gmelin and Walker. Marc Eidlitz and Son, Inc., were the contractors.

JOINT N. E. L. A.—BELL SYSTEM SUBCOMMITTEES MEET

THE semi-annual meeting of Division One of the Joint Subcommittee on Development and Research of the National Electric Light Association and the Bell System was held at 195 Broadway, New York, on May 18, 1932. R. G. McCurdy, Bell System chairman of the division, presided. Other officers of the division included W. F. Davidson and H. E. Kent, division chairman and secretary, respectively, for the N. E. L. A., and R. A. Shetzline and P. W. Blye, division vice chairman and secretary, respectively, for the Bell System.

Division One is charged with the joint development work having to do with noise frequency co-ordination, and the discussion at this meeting was confined to this subject. Progress reports were presented by the five Project Committees of the division on the work of the past six months on the study of noise induction in toll and local lines, on the evaluation of noise, on the wave shape of power systems, and on the use of selective devices in noise-frequency problems.

The semi-annual meeting of Division Two of the Joint Subcommittee on Development and Research, on Low Frequency and Structural Co-ordination, was held at N. E. L. A. headquarters on May 19. The meeting was presided over by the joint chairman, A. E. Silver representing the N. E. L. A. and H. S. Warren representing the Bell System. Drafts of the progress reports of the ten project committees were presented for technical discussion. As a result of this discussion, the progress reports will be revised and presented to the Joint Subcommittee at their next meeting.

ACADEMIC HONORS FOR BELL SYSTEM MEN

F. B. JEWETT, Vice-President of the American Telephone and Telegraph Company and Vice-President of Bell Telephone Laboratories, Inc., has received the honorary degree of Doctor of Laws from Miami University, Oxford, Ohio.

Sergius P. Grace, Assistant Vice-President of Bell Telephone Laboratories, Inc., and well-known for his popular lectures on the science of communication, has received the honorary degree of Doctor of Laws from Notre Dame University, and the honorary degree of Doctor of Engineering from the University of Michigan.

Gustaf W. Elmen, inventor of the magnetic alloys permalloy and perminvar, and in charge of the Bell Telephone Laboratories' research in magnetic materials, has received the honorary degree of Doctor of Engineering from his alma mater, the University of Nebraska.

OVERSEAS TELEPHONE SERVICE TO SOUTH AFRICA

REGULAR radio-telephone service between North American telephones and South Africa began on June 1. Conversations are handled through the transatlantic radio telephone stations of the American Telephone and Telegraph Company, working with the British Post Office stations in England, where the calls are switched to the London-Cape Town radio circuit. The total length of the circuit from New York to Cape Town is about 9,500 miles.

The radio stations in Africa are owned by the Overseas Communication Company of South Africa. The transmitter is at Klipheuval, the receiver at Milnerton, both about forty miles from Cape Town. Territory reached by the service includes, besides Cape Town, the towns of DeAar, Port Elizabeth and other nearby points. All Bell System telephones in the United States are within the scope of the service, together with Bell-connecting telephones in Canada, Cuba and Mexico.

At the beginning the daily service period is from 3:30 a.m. to 8:30 a.m., New York daylight saving time, corresponding to 9:30 a.m. to 2:30 p.m. in Cape Town. Later it is hoped to extend these hours. A three-minute conversation between New York and Cape Town costs $45, with $15 for each minute of overtime.

The opening of this service marked the first major extension of commercial telephone service to Africa from the United States. Both links in the connection are radio circuits. Previously a single African city, Ceuta in Spanish Morocco, could be connected with North America over cables spanning the Straits of Gibraltar and land wire links to the radio terminals in Great Britain.

SHIP-TO-SHORE TELEPHONE EXTENDED TO SIX GERMAN SHIPS

ON JUNE 7, commercial ship-to-shore telephone service was extended to the S. S. *Bremen* from the radio stations of the American Telephone and Telegraph Company, located at Forked River, N. J., and Ocean Gate, N. J. The *Bremen* was the second German liner to be included in the service, as the S. S. *Deutschland* was added to the vessels so equipped on her voyage from New York early in May. Service to the *Europa, Albert Ballin, Hamburg,* and *New York* was subsequently placed in operation. Apparatus on these liners is owned and operated by D. E. B. I. G., the German radio operating company.

As in the case of the other transatlantic liners having ship-to-shore connections with North America, these ships while at sea will be able to reach all Bell System telephones in the United States, as well as those connecting with the System in Canada, Mexico, and Cuba. The same schedule of charges will prevail, namely, $9 for a three-minute call to New York and vicinity while within 500 miles of that port, and $18 when connections are established when the vessel is further out at sea.

MR. CHARLESWORTH ELECTED PRESIDENT OF A. I. E. E.

HARRY PRESCOTT CHARLESWORTH, Vice-President of Bell Telephone Laboratories, Inc., has been elected President of the American Institute of Electrical Engineers. Announcement of the election was made on June 20 at the annual convention of the Institute in Cleveland.

THE LARGEST TELETYPEWRITER EXCHANGE. (See page 317.)

Bell Telephone Quarterly

A Medium of Suggestion
and a Record of Progress

CONTENTS FOR OCTOBER 1932

VOL. XI NO. 4

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES; SINGLE COPIES, 50 CENTS

Address all communications to

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

CONTRIBUTORS TO THIS ISSUE

CHARLES H. FETTER

Pennsylvania State College, B.S., 1917; 1917–1919 Western Electric Company, New York; 1922–1928 American Telephone and Telegraph Company, Development and Research Department, engaged in transmission work; 1928 entered employ of Electrical Research Products, Inc.; 1928–1929 engaged in development of sound recording system; 1929–1931 spent 21 months in England in connection with talking picture studios in England and France.

A. B. CLARK

University of Michigan, B.E.E., 1911; American Telephone and Telegraph Company, 1911–. Toll Transmission Engineer in Department of Development and Research, 1928–. Mr. Clark's work has been largely concerned with toll telephone and telegraph systems.

KINGSLAND T. ROOD

Dartmouth College, B.A., 1918. After leaving the Army, entered the Long Lines Commercial Department, American Telephone and Telegraph Company, New York City, as a member of the Commercial Engineer's section, 1920. Transferred in 1921 to the staff of the Long Lines Magazine, which had just started publication; during the next eight years was successively Assistant Editor, Associate Editor, Managing Editor and Editor. Also assisted in Long Lines publicity work. Publicity Manager, Long Lines Department, 1928–.

HUGH D. BENDER

Ohio State University, B.E.E., 1917. Entered Engineering Department of the American Telephone and Telegraph Company the same year, working on outside plant construction practices and methods. U. S. Army 1918. Department of Development and Research 1919–, engaged in outside plant development problems, since 1921 on tool standardization and development.

HARRY R. WHITE

Massachusetts Institute of Technology, S.B., 1901. Instructor, Engineering Laboratories, Massachusetts Institute of Technology, 1901 to 1903. Mechanical Engineer, Harrison Brothers and Company, Inc., Philadelphia, 1903 to 1909. Mechanical stoker design, Parker Boiler Company, Philadelphia, 1909 to 1910. Since 1910 Engineer, American Telephone and Telegraph Company.

ROBERT L. TOMBLEN

Bates College, A.B., 1914. Worcester Polytechnic Institute, B.S., 1917. Commercial Engineer's Division of the Operation and Engineering Department, American Telephone and Telegraph Company, 1919–1929. Chief Statistician's organization 1929–.

GEORGE C. SOUTHWORTH

Grove City College, B.S., 1914; Yale, Ph.D., 1923; Grove City College, Sc.D. (Hon.), 1931; Assistant Physicist, Bureau of Standards, 1917–1918; Instructor, Yale University, 1918–1923; Information Department, American Telephone and Telegraph Company, 1923–1924; Department of Development and Research, 1924–; Member of the International Radio Telegraph Conference, Washington, 1927. Mr. Southworth's work in the Bell System has been concerned chiefly with the development of short-wave radio telephony.

A New Way of Splitting Seconds

FROM the earliest recorded history of man we have seen evidence of human interest in all sorts of athletic sports. Track and field events were popular in the days of ancient Greece and our present Olympic Games originated there centuries ago. Not only has man always been interested in the purely competitive angle of racing events, but in recent years he has become more and more interested in the performance of the individual with respect to time, in addition to his performance against a suitable competitor. On this basis national and world records have been established in order to classify the performance of the individual in terms of an invariable quantity such as time, where a contestant may compare his own performance either with that of some one who preceded his athletic activities, possibly by years or with other contestants in different localities.

In dealing with this so-called invariable quantity, time, the ordinary method employed of timing a race has been by means of a stop watch. Until several years ago stop watches giving time to a precision of one-fifth second were used, but more recently tenth-second stop watches have been universally employed. In track work, for example, the competitors are started by the firing of a gun. The timers are usually located near the finish line of the race in order to time the finish properly. The timer operates a stop watch at the flash of the gun when the race is started, and operates it again as the runner crosses the finish line. This procedure inherently contains the possibility of three errors; (1) it is practically impossible for a human being to operate a stop watch coincident with the firing of the gun because of the human reaction time involved; (2) it is extremely difficult for a timer to operate his stop watch at the finish of the race coincident with the man crossing the line, and while this error is probably less than the starting error because the timer has an opportunity to anticipate the finish, it is still very much in evidence; (3) the watch itself by virtue of being built for a precision of a tenth of a second would register the nearest tenth when the timer has operated it. In addition there is likely to be an accumulative error in a stop watch depending upon its adjusted rate as a time piece.

In addition to the question of time performance, judging a race is by no means a simple problem. In a close finish it may be very difficult to decide not only who is first, but also the order of finish of, for example, the first five. A runner may be blanketed by another competitor so that the judge is confused as to which runner he is called upon to judge. As a matter of fact in an important meet not long ago a man who ran second was not placed at all because of the human error in observation.

This state of affairs in regard to track events has been known to exist for some years. Four or five years ago Mr. Gustavus T. Kirby, Chairman of the Advisory Committee of the Intercollegiate Association of Amateur Athletes of America (I. C. A. A. A. A.), who has been interested in amateur sport activities for many years, conceived the idea of photographing the finish of a race in order to determine the proper position of the contestants. He included in this the idea of somehow photographing the time of the contestants as well, and in 1931 he used a motion picture camera which photographed both the finish of the race and the face of an ordinary stop watch. The scheme which he used was that of starting the stop watch before the race was started and recording on the motion picture film a flash of light operated by a contact in the starter's gun. By subtracting the readings on the photograph of the stop watch at the beginning from those of the finish of a race the time could be determined to the nearest tenth of a second.

In the summer of 1931 several individuals at Electrical Research Products were discussing the possibilities of applying to the problem in some way Bell System technical knowledge of precision timing work. This was done in complete ignorance of any progress which had been made along this line and, strangely enough, the same conclusion was reached that was found by Mr. Kirby and his associates, namely, that the only satisfactory method by which a race could be timed and judged was through the use of a high speed motion picture camera arranged to photograph both the performance and the time. Obviously this process would provide a permanent record of each event, which would be of value.

Through a fortunate occurrence in endeavoring to investigate the situation these individuals met Mr. Kirby and discussed the problem with him. They were extremely interested to learn of his activity along this line but felt that the company could make a very important contribution to the improvement of timing apparatus, in that it could build a frequency standard that would permit timing if necessary to one one-hundredth or even to one one-thousandth of a second. The need for such precision in timing in a foot race becomes evident when it is realized that in the faster races, including races as long as a half mile or a mile, a man may run a yard at the finish in a tenth of a second. After discussing this matter with Mr. Kirby, work was begun to develop suitable apparatus for experimental use at the I. C. A. A. A. A. and the Olympic Games in 1932 for which permission had already been granted.

Before design of the apparatus was begun, at least on a model basis, several preliminary requirements as to its operation were established; (1) it was decided that for this use a precision of .01 second would be satisfactory, as such timing is accurate to within three or four inches in the position of the runner; (2) use of the photographic method appeared absolutely essential; (3) it was considered desirable to devise a means of photographing the reading of the clock at the finish of the race to show the actual time of the runner. This meant that the clock must be reset to zero before the start of the race and be started practically instantaneously with the firing of the gun. The Bell Telephone Laboratories were asked to design a tuning fork generator and a motor driven clock mechanism which would meet these requirements.

In the development of this system it was decided to make two clocks, one associated with the camera in which the time and the finish of the runner could be photographed adjacently on the same film, and another clock which would be started in the same manner as the first but so arranged as to be hand stopped so that one of the timers could use this precision clock as a sort of "glorified" stop watch, by means of which the time, except for human error at the finish, could be read to the hundredth of a second immediately following the race.

The system which has been developed consists primarily of a 200 cycle tuning fork generator which drives a synchronous motor at a speed of ten revolutions per second. The motor shaft is connected to a clock mechanism by means of a magnetic clutch so arranged that the clock dials, which are normally reset to zero and stationary, are set in motion when the starter's pistol is fired.

In designing the clock work itself some consideration was taken of the type of record to be obtained. First of all it was decided to use a standard 16 mm. camera which takes 128 pictures per second. Inasmuch as most of the picture area in the 16 mm. film must be devoted to the action of the contestants, it was decided to use three rotating dials and a fixed hair line in order to obtain the time on the film in the largest possible characters. By the use of rotating dials it was necessary to photograph only a small segment of the entire dial arrangement. Three concentric dials were used. The inner dial rotates at one revolution per second and has one hundred divisions on it. The middle dial rotates at one revolution per minute with sixty divisions, and the outer dial rotates at one

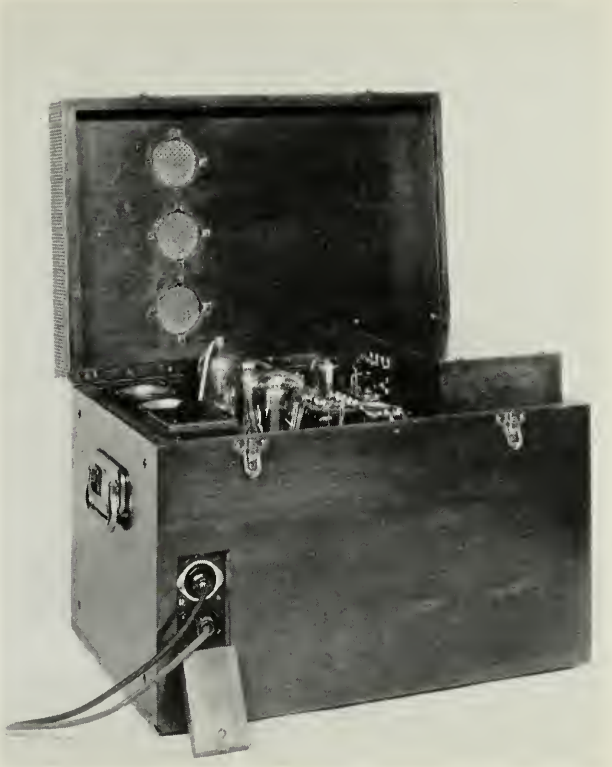


Figure 1

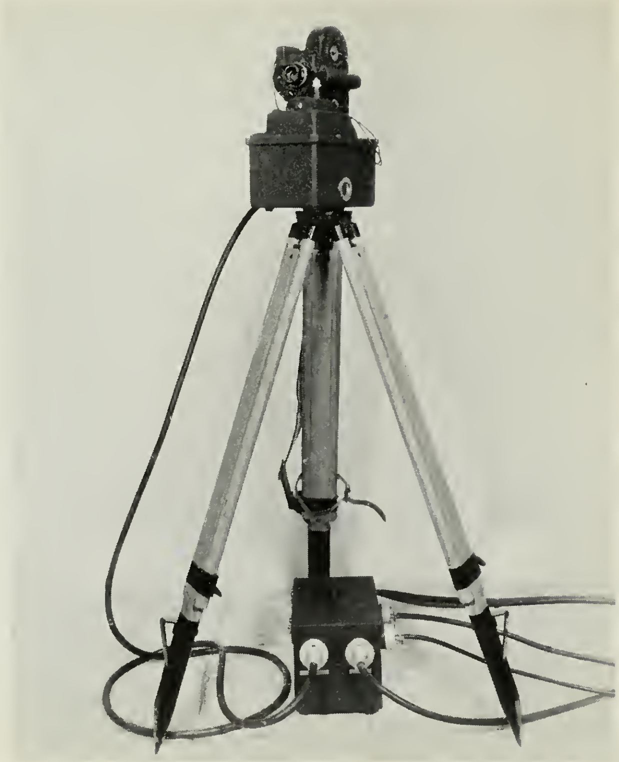
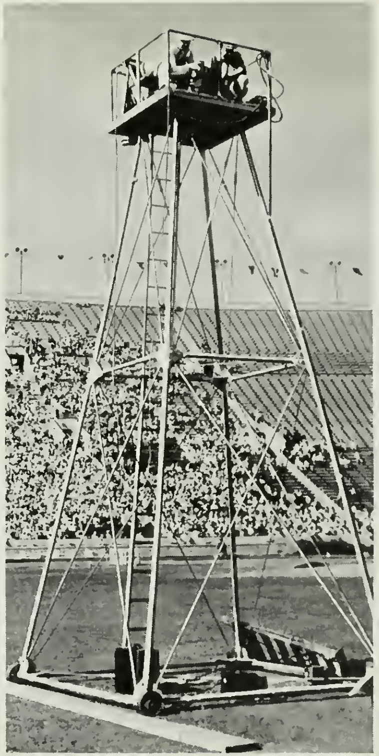


Figure 2

FIGURE 3

FIGURE 4



Xth Olympiad Committee, Official Photograph.

FIGURE 6

FIGURE 5

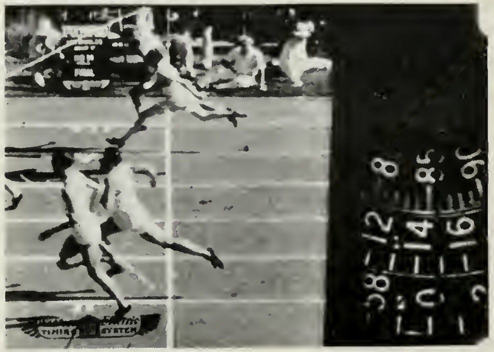


FIGURE 9

revolution per hour with sixty divisions. Thus minutes, seconds and one hundredth seconds can be conveniently read.

Figure 1 shows a photograph of the 200 cycle generator used in this model and Figure 2 shows an assembly view of the camera, clock and a control box designed to provide the necessary power. The whole system is operated from alternating current of 110 volts. The optical system provided to photograph the clock dials can be seen at the left rear end of the main camera lens assembly.

This system was first tried out at the Columbia-Syracuse track meet at Baker Field, New York, on May 14, 1932. Figure 3 shows the first race to have been timed with this system. It was the 100 yard dash in which the time as shown to the nearest hundredth of a second was 10.26 seconds. At the Princeton-Cornell meet at Princeton on May 21, 1932, the system was successfully demonstrated and on June 19, 1932 the apparatus was sent on the Intercollegiate special train which ran from New York to Berkeley, California, for demonstration at the I. C. A. A. A. A. meet there on July 1 and 2.

An example of the results obtained at Berkeley is illustrated in Figure 4, which shows Carr of Pennsylvania winning the 440 yard dash in 46.99 seconds. Even though the camera operates at such high speed, all of the final events on Saturday, July 2, were recorded on less than 60 feet of film. This, of course, is because the camera is operated only as the runners cross the finish line.

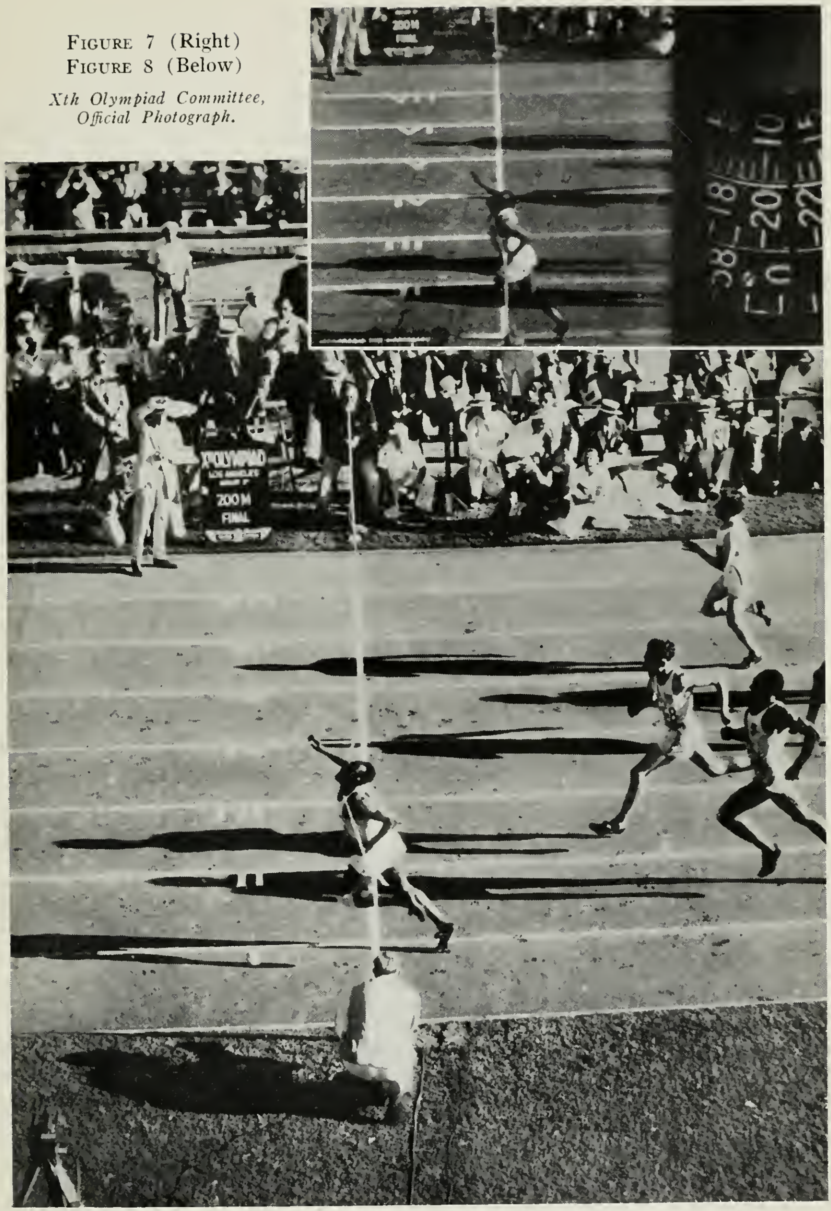
At Palo Alto on July 15 and 16 the American Olympic tryouts were held and photographs were obtained of the finish of every heat and final at those tryouts. As an example of how difficult it is to judge a race, Figure 5 shows the finish of the 100 meter final at these tryouts. Metcalf finished first in a time of 10.62 seconds, but there were at least four runners who were not more than a yard or so behind him. Such a grouping of runners shows how difficult it is to judge a close race by eye alone. Note that the camera position is above the finish line as well as in line with it so that it becomes less difficult to judge properly the finish. At Palo Alto on July 16 the film was shown to the American Olympic Committee and great interest in the timing system used was expressed. As a matter of fact, the committee confirmed one of its own decisions through the showing of the pictures and reversed the fourth and fifth positions in one event because of the camera evidence.

From July 31 to August 7 inclusive this apparatus was in use at the Xth Olympiad held at the Olympic Stadium in Los Angeles, California. A few days prior to the opening of the games some of the pictures taken at Palo Alto were shown to the Olympic Committee, and based upon that evidence the following status was given the timing system: (1) it would be used officially for judging, (2) the hand stopped clock associated with the system would be used as one of the timers of which there were five, (3) it would be used officially for timing the Decathlon.

The camera clock was located 60 feet back from the finish line and on top of a 25 foot steel tower as shown in Figure 6. Throughout the Olympics every trial, semi-final and final was timed. Figure 7 shows Tolan breaking the world's record in the 200 meter run with a camera-recorded time of 21.12 seconds. His official time for this race was 21.2 seconds. Figure 8 is interesting because it shows one of the official photographs taken from the top of the judges' stand for this same race. In the lower left-hand corner can be seen the hand-stopped clock and the timer who is operating it is kneeling in the immediate foreground. Figure 9 (facing p. 297) shows Lord Burleigh of England in fifth place of the 110 meter hurdles. This illustrates how the time of each contestant can be determined as well as that of the winner. This picture is also particularly interesting because it was in this race that Finlay of Great Britain was awarded third place, reversing the decision of the judges who had awarded it to Keller of the United States, before the pictures were seen. The foot of the winner

FIGURE 7 (Right)
FIGURE 8 (Below)

Xth Olympiad Committee, Official Photograph.



Cleveland Air Races

3 Kilometer Speed Record

Major James Doolittle

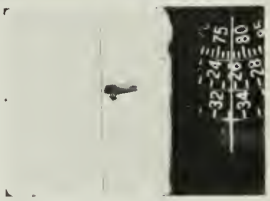
Average Speed (Four Consecutive Trials) 294.90 Mi. per Hr.

RACE 2

← Start 30: 14.10
Finish 30: 37.30 →
Time 23.20 sec.
Speed 289.32 MPH

RACE 3

Start 33: 25.78 →
← Finish 33: 48.09
Time 22.31 sec.
Speed 300.86 MPH



RACE 4

← Start 35: 42.10
Finish 36: 05.35 →
Time 23.25 sec.
Speed 288.70 MPH

RACE 5

Start 39: 58.42 →
← Finish 40: 20.74
Time 22.32 sec.
Speed 300.73 MPH

FIGURE 10

is just visible at the left side of the picture and Finlay is running in lane 3. Keller of the United States is running in lane 7, the farthest one from the camera. Two other decisions of a minor nature were reversed by the judges after seeing the pictures.

As an example of how the official times compared with the recorded photographed time, figures are given below for some of the Olympic finals:

Race	Official Time	Camera Time	Difference—Official Time Used as Reference
100 Meter Run	10.3	10.38	+.08
110 Meter Hurdle	14.6	14.57	−.03
200 Meter Run	21.2	21.12	−.08
400 Meter Run	46.2	46.28	+.08
400 Meter Hurdle	51.8	51.67	−.13
800 Meter Run	1:49.8	1:49.70	−.10

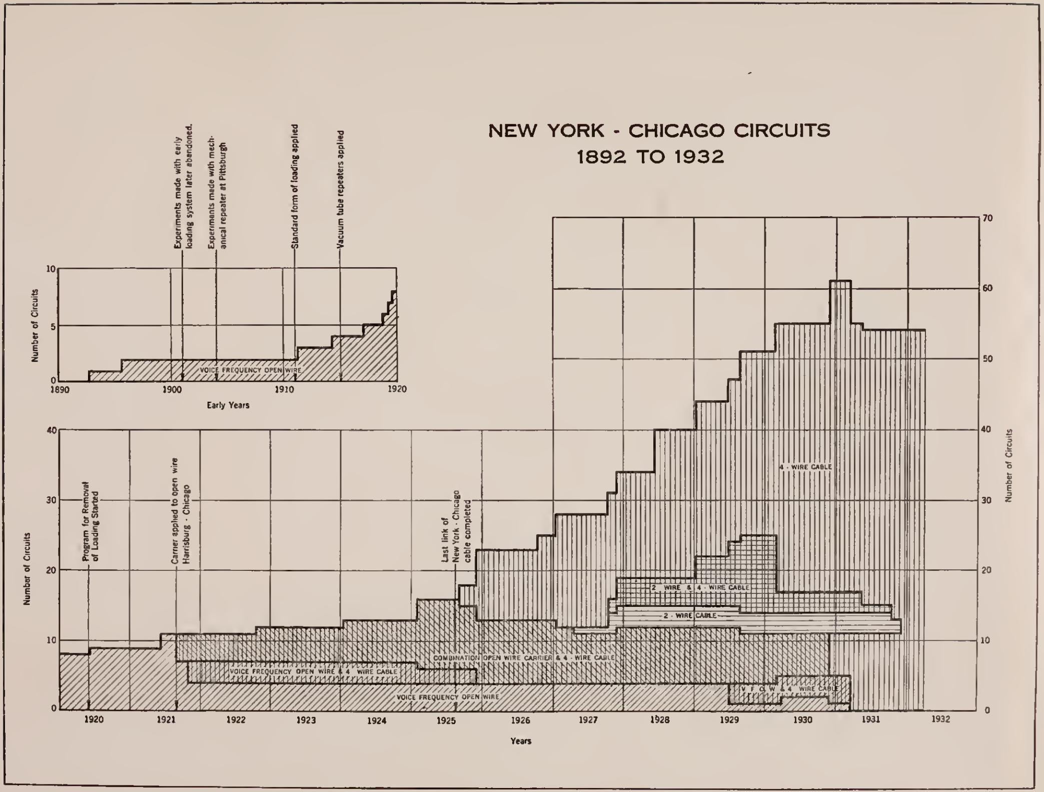
At a meeting of the International Amateur Athletic Federation after the games were over, this body in an official report praised the use of the timing system and recommended that hundredth-second timing be adopted as a world standard. It also officially invited us to time the Olympic Games to be held in Berlin in 1936.

While at the Olympic Games in California Mrs. Amelia Earhart Putnam, having seen and heard of this method of timing, stated that it should certainly be used for airplane races. As a result of this statement the National Aeronautic Association was approached and through the courtesy of Dr. Lewis and other members of the Contest Committee the apparatus was used in collaboration with the official timing means at the Cleveland Air Races from August 28 to September 5 inclusive. In order to time a straightaway airplane speed trial, it was necessary of course to have two camera clocks operating in synchronism from one generator, one to photograph the beginning, a second to photograph the finish of the race. The second camera was obtained and modified and two camera operated clocks were used at Cleveland. All of the straightaway races in which there was any indication that a speed record might be broken were photographed.

Figure 10 shows Major Doolittle breaking the world's record for land planes over a 3 kilometer course. These pictures are not, of course, official but it is interesting to note that the official average speed made by Major Doolittle as determined by the official method was 294.48 miles per hour, while the speed determined by the camera clock was 294.90 miles per hour.

C. H. FETTER

EDITOR'S NOTE: *Mr. Fetter has been active in the development of electrical timing systems, and was in charge of the field experiments conducted by Electrical Research Products, Inc., at the recent Olympic Games and at other sports events.*



NEW YORK - CHICAGO CIRCUITS
1892 TO 1932
Experiments made with early loading system later abandoned.
Experiments made with mechanical repeater at Pittsburgh
Standard form of loading applied
Vacuum tube repeaters applied
Number of Circuits
VOICE FREQUENCY OPEN WIRE
Early Years
Program for Removal of Loading Started
Carrier applied to open wire Harrisburg - Chicago
Last link of New York - Chicago cable completed
4 - WIRE CABLE
2 WIRE & 4 - WIRE CABLE
2 - WIRE CABLE
COMBINATION OPEN WIRE CARRIER & 4 - WIRE CABLE
VOICE FREQUENCY OPEN WIRE & 4 WIRE CABLE
V F O W & 4 WIRE CABLE
Years

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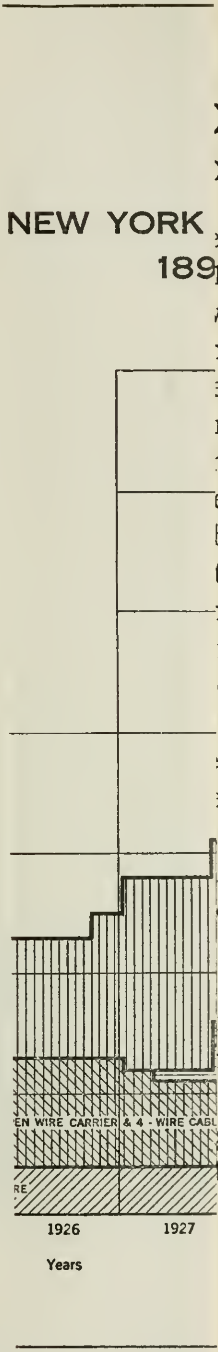

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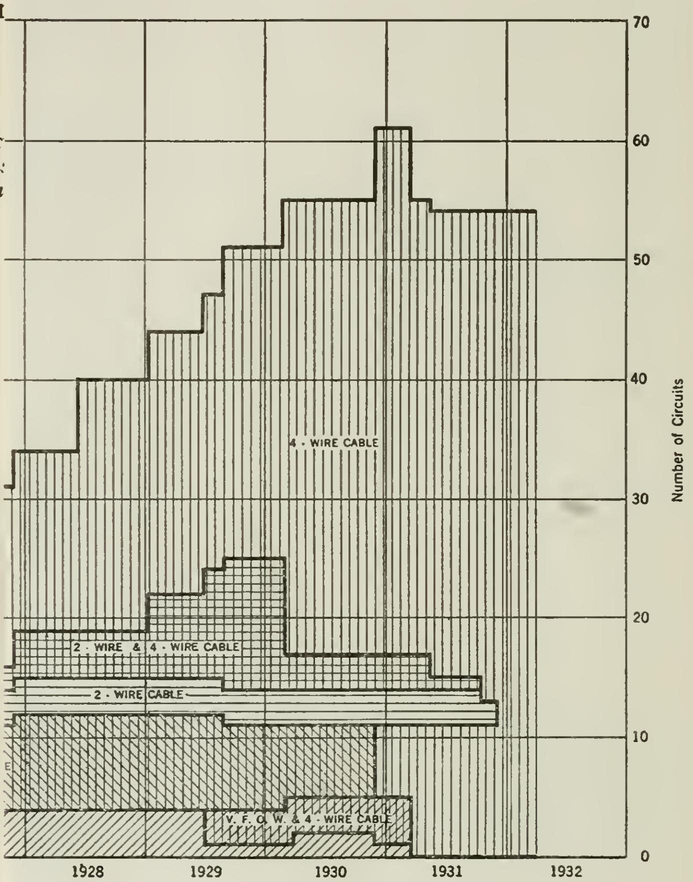


New York-Chicago Telephone Circuits: Forty Years of Growth and Progress

FORTY years ago telephone service between New York and Chicago was inaugurated. On October 18, 1892, at the official opening, Alexander Graham Bell at New York conversed with William H. Hubbard at Chicago, whom he had last seen sixteen years before at the Philadelphia Centennial where Hubbard assisted Bell in exhibiting the first telephone.

Great changes have taken place since 1892. The telephone circuits between New York and Chicago have increased manyfold and the physical make-up of the circuits has been greatly altered. With the aid of the accompanying chart it is interesting to retrace the steps, observing the growth which has taken place as well as the changes in the transmission art. Many very important developments in long distance transmission are reflected in this history.

Prior to the construction of the line between New York and Chicago, which was about 950 miles long,[1] 500 miles was about the limit of distance for telephone transmission. To make transmission possible over the practically doubled distance, a pair of copper wires 165 mils in diameter and each weighing 435 pounds to the mile was strung, these wires being more than four times the weight of conductors generally used for telephone service up to that time. Great pains were taken to avoid insertion of lengths of cable in the line since, without amplifiers and loading, such cables would have had a very detrimental effect. Accurate means for measuring the transmission loss of such a line were not available at that time. Probably the overall loss of this line was about 35 decibels, which means that the line delivered at the distant end a little

[1] Shortest cable route is now 862 miles long.

less than one-thirtieth of one per cent of the voice power applied at the sending end. This compares with about 9 decibels for the present New York-Chicago circuits which deliver at the distant end about one-eighth of the voice power applied at the sending end, i.e., the present circuits deliver speech about 400 times as strong. Conversations were, however, readily possible over the original New York-Chicago circuit, between telephones near the main offices in the two cities, the results being considered so satisfactory that additional wires were ordered to be strung immediately. An additional open-wire circuit was soon made available, but the number of through New York-Chicago circuits was not further increased until about 1911. Other circuits were strung, however, which, although normally terminated at an intermediate point, such as Pittsburgh, were connected together from time to time and used for handling business between New York and Chicago.

In 1901 a system of "loading" was applied to the 165-mil New York-Chicago circuits. In accordance with this system, inductance coils were connected serially in the line at intervals of about 2½ miles. When these loading coils were first installed, transmission was materially improved and very favorable comments were received from the users of the service. Then, lightning and atmospheric moisture began to cause trouble. The troubles caused by lightning were soon overcome, but the moisture resulted in serious leakage difficulties, which gradually became worse as more dirt collected at the leakage points. These could not be overcome without radical changes, so that the loading coils were removed from the two New York-Chicago circuits in 1903. Work was continued on the loading method and, as a result, about 1904 loading began to be applied as a regular engineering proposition to lighter gauge open wires, particularly wires 104 mils in diameter, for which circuits the leakage effects were relatively less serious. The loading coils were spaced about 8 miles apart, which spacing remained standard for all future open-wire loading.

Alexander Graham Bell at the Opening of the First New York-Chicago Telephone Line.

While none of these loaded 104-mil circuits went into service as direct New York-Chicago circuits, some were provided as way circuits which were no doubt connected together from time to time to handle New York-Chicago business.

At about the same time that this early work on loading was in progress, other work was also in progress on developing the "phantoming" method. In this method balanced transformers are connected to the terminals of two similar circuits constituting a "phantom" group. By making connections to the mid-points of the line windings of these transformers, an additional circuit called a "phantom" is obtained. Thus a 50 per cent increase in the number of circuits is obtained without stringing additional wires. After overcoming various troubles, not the least of which was the tendency of the circuits to cross-talk unduly into each other, this phantoming method became successful and came into large use on open-wire lines.

In 1904 a telephone repeater using mechanical elements was installed at Pittsburgh and operated on one of the New York-Chicago circuits. The mechanical element consisted of the equivalent of a telephone receiver placed in front of a transmitter. The telephone receiver was actuated by the weak currents from the line, thus causing the carbon grains in the transmitter to be agitated and, therefore, introduce variable resistance in series with a battery. The effect of this was to produce an alternating current roughly resembling the current received from the line in its wave form and, under favorable conditions of adjustment of the device, considerably stronger. Although, in the years which followed, mechanical repeaters were worked more or less regularly on the New York-Chicago circuits and under favorable conditions effected a distinct improvement, the repeater experiments were on the whole not particularly successful, in part due to imperfections in the repeater elements and in part due to incomplete knowledge of the requirements, both of the lines and of the repeater elements, essential to the obtaining of successful two-way operation as called for in telephone conversations. However, these experiments helped to point the way toward the modern highly successful telephone repeater.

By 1911 the leakage difficulties encountered in loading 165-mil wires had been sufficiently reduced so that the direct New York-Chicago circuits were again loaded. The phantoming method had also been developed in conjunction with the loading method to the point where it became possible to phantom the circuits and load the phantom circuits as well as the physical circuits. With this new setup the overall loss was reduced to about 20 decibels, so that about one per cent of the power applied to the sending end reached the distant end. During very good weather the lines performed even better than this but during rainy weather, however, the results were not so good, although, except under very extreme conditions, the transmission was improved as compared with the earlier non-loaded condition.

The vacuum tube telephone repeater was demonstrated as a great success on January 25, 1915, when service was officially opened between San Francisco and New York, via Chicago. Not only had the repeater element problem been largely solved but much knowledge had been gained of the line conditions necessary for successful two-way operation. To obtain the required line conditions it was necessary to reload the lines with coils of great electrical stability, very accurately spaced, so that the lines were made very uniform. One of the repeater stations was located at Pittsburgh and repeaters were placed at this point for use on the New York-Chicago circuits. By this time another line from New York to Chicago was also in service via Buffalo and repeaters were placed at Buffalo also. Adding these repeaters to the New York-Chicago circuits made a very distinct improvement. During good weather these loaded and repeatered circuits were operated at a loss of about 10 decibels, giving results comparable to the present circuits in volume. These New York-Chicago circuits were, however, materially inferior to the present-day circuits in clearness of transmission.

During the years which followed the application of repeaters the number of circuits between New York and Chicago increased rapidly, so that about nine were in service in 1920 when the next important transmission improvement occurred. This improvement consisted in removing the loading coils and introducing about twice as many repeaters of a more refined type. A non-loaded open-wire line transmits clearer speech than the same line after loading although without repeaters its volume efficiency is materially lower, particularly during good weather when the loaded circuit is at its best. Consequently, before highly efficient repeaters were available, applying loading to the New York-Chicago circuits gave best results. However, after the repeater had been improved it proved better to remove the loading coils and thus obtain the better clearness of transmission since the repeaters easily overcame the added loss. In fact, due largely to the higher velocity at which speech waves travel over non-loaded as compared with loaded circuits, the repeaters were able to reduce the overall or net losses of the circuits without loading below those formerly obtainable when the circuits were loaded and repeatered.

Removing the loading from the open wires made it possible to apply the carrier transmission method which at that time had been developed to the point where fairly successful results were being secured. The carrier transmission method consists in utilizing bands of frequency above the normal range of frequencies employed for voice transmission, the various frequency bands being separated from each other by means of electrical filters. Thus more communication channels are obtained without stringing more wires. Carrier first came into use on the New York-Chicago circuits during 1921.

About this same time the art of long distance cable transmission had also been developed to the point where cable became suitable for comparatively long distance telephone connections, offering advantages in reliability and economy, particularly for large groups of circuits. Cable naturally grew from the East, where traffic was heaviest. As the cable replaced the open wires in the Eastern section of the country, combination circuits came into use in the New York-Chicago group, some of these consisting of voice-frequency open wire and cable, others open-wire carrier and cable.

Finally in 1925 the long distance cable was completed between New York and Chicago. In this cable system all of the telephone circuits were obtained by voice-frequency methods using loaded and phantomed circuits. With such circuits a new problem had been found serious due to the comparatively low velocity, which tended to produce pronounced and troublesome echo effects.[2] To reduce this echo difficulty required development of a device called an echo suppressor in which relays actuated by the voice currents block one direction of transmission in a circuit while the voice currents pass in the other direction, thus blocking the echo. The use of cables also brought about an increase in the line loss so that nineteen repeaters were required on the circuits against three on the non-loaded open-wire circuits. This increased loss also introduced another serious problem, that of maintaining the overall efficiency constant. Cable circuits, while kept dry by a lead sheath, remain exposed to temperature variations which cause large changes in their efficiency. If the New York-Chicago cable circuits had been set up simply with the required repeaters but without means for overcoming the transmission variations, service could not have been given for more than a few hours before the circuits would have become useless, either the received currents fading completely out or, if the temperature change happened to be in the other direction, intolerable echo effects or singing taking place. Automatic transmission regulators, therefore, were employed. About

[2] Voice waves travel about 20,000 miles per second over cable circuits of the type now used for long distances. This compares with about 130,000 miles per second for non-loaded cable circuits and about 50,000 and 180,000 miles per second, respectively, for loaded and non-loaded open-wire circuits.

every second or third repeater station is a transmission regulator station in which the repeater gains are moved up and down automatically, thus overcoming the transmission variations.

In long distance cables two types of circuits are provided, four-wire and two-wire. The four-wire or two-path circuit has important advantages in facilitating two-way operation over long distances. During the years which followed the introduction of the first four-wire cable circuits between New York and Chicago, the growth of circuits was largely taken care of by adding more and more of these four-wire circuits. About 1927 some combination circuits were set up, consisting in part of two-wire and in part of four-wire cable circuits. Some other circuits entirely two-wire were also set up. While these circuits gave good results for terminal business, it became clear as the art developed that it would be advantageous to simplify the system by making all long cable circuits alike. At about the same time it also appeared desirable to discontinue the use of open-wires in this circuit group. Thus we have today the whole New York-Chicago group of circuits of a single type, four-wire cable.

It is interesting to compare the present four-wire cable circuits with the original open-wire circuit. Each one of the wires comprising the four-wire circuit weighs 20.5 pounds per wire mile, so that all four wires weigh 82 pounds[3] as compared to 870 pounds for the two wires which comprised the open-wire circuit. Loading coils are employed on the cable circuits spaced 6,000 feet apart while the original open-wire line contained no loading. The cable circuits contain repeaters spaced about fifty miles apart so that on the circuits between New York and Chicago nineteen repeaters are required. The original open-wire line, of course, contained no repeaters. While more complicated, the cable circuits are so designed that in addition to delivering much louder and clearer speech they

[3] If the phantom is allowed for, the weight of copper per circuit becomes only 55 pounds.

do this with much more consistency and freedom from disturbances than did the early open wires.

Thus we have seen an evolution from open wire to cable in which the open wires were first provided on a non-loaded basis, then loaded, then repeatered, and finally restored to a non-loaded basis with more refined repeaters. We have seen open wire gradually superseded by cable even though carrier entered and made it possible to obtain more economical open-wire circuits. At the present time these cable circuits are worked on a voice-frequency basis as was the original open-wire circuit. Developments are now under way which in the future promise other changes. While we do not know what all these changes will be, it now appears quite probable that New York-Chicago cable circuits will some day be obtained by carrier methods and that the wires will be non-loaded and non-phantomed. Thus, in so far as the line proper is concerned, we may return to the simplest form of transmission path, since even more refined vacuum tube amplifiers, electrical filters and other electrical instrumentalities and methods bid fair to make it possible to do a better job without the aid of the loading and phantoming methods.

Acknowledgment

Acknowledgment is made of considerable assistance in preparing this article rendered by many telephone workers and in particular by Mr. L. L. Bouton and Miss M. Darville of the American Telephone and Telegraph Company's Department of Development and Research, and Mr. J. P. Satterthwaite of the Long Lines Department.

A. B. Clark

New York's Long Distance Building

AMONG the more recent visitors to the new Long Lines Headquarters building at 32 Sixth Avenue, New York, was a group representing the British Society of Mechanical Engineers. Upon arriving in the Long Distance Building they were split up into small parties, one of which went to the Telephotograph Room as its first port of call. There an employee described the processes of transmitting pictures over telephone wires, illustrating his talk by demonstrations of the synchronizing equipment, photoelectric cell and light valve. After listening closely to the explanation one of the guests turned to a colleague: "I say, Doctor," he remarked, "this is really extraordinarily ingenious."

* * *

That was a fairly conservative expression of what most visitors feel on journeying through this twenty-eight story wonderland of modern communication aids. Most of these visitors come from non-technical walks of life. At first they are particularly impressed by the features which the layman can readily appreciate. They are told that the two new portions of the building, rising on each side of the former structure, are supported by mats or rafts of concrete reinforced with steel. They learn that the four stories recently added to the older building do not rest upon it at all, but are suspended above it by means of a huge truss and cantilever system.

They admire the lobby, with its symbolic ceiling decorations of outline glass mosaic, and the auditorium on the main floor. They speed up and down the 450 feet of the building's height in the most modern passenger elevators, operating at a speed of 800 feet a minute. They may peer admiringly into one of the half-dozen recreation rooms, designed with an eye to comfort and good taste, which are provided for operators during their rest periods. A well-equipped medical unit and a dormitory for operators who come off duty late at night occasion exclamations of admiration. The cafeterias and dining room, the well appointed kitchens, sculleries and bake shops are complete down to the various ceiling treatments for the purpose of deadening sound. Upon entering any of the operating rooms, particularly on hot, humid days in summer, visitors immediately notice the difference in temperature and humidity brought about by the air conditioning system which serves these rooms. Brows and palms which upon entering were dewed with perspiration within two or three minutes become cool and dry.

* * *

While the building is only one part of the entire long distance plant, it is a truly representative part. As visitors go from floor to floor, passing through operating, test and control rooms, practically all glimpse the fact that behind this assemblage of complex apparatus there is a definite and far-reaching purpose. If they can formulate an idea of the immensity of the task of furnishing long distance telephone service to the nation, of the enormous amount of equipment involved and the highly specialized craftmanship required on the part of employees, it is all that can be expected. Telephone men and women will, however, want to go further and inquire into the significance of the building as a part of the Bell System, and its even greater importance as a keystone of the country's long distance wire structure. It is the purpose of this article therefore to attempt to weave the outstanding facts about the building into a comprehensible pattern.

* * *

When the certificate of incorporation of the American Telephone and Telegraph Company was filed at Albany on February 28, 1885, it included this statement: "And it is further declared and certified that the general route of the lines of this association, in addition to those hereinbefore described or designated, will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said state, and in each and every other of the United States, and in Canada and Mexico, and also by cable and other appropriate means with the rest of the known world, as may hereafter become necessary or desirable. . . ."

Making allowance for the division of traffic between the parent company and the Associated Companies, this statement might well be used as a summary of the purposes of the Long Lines Department. Ever since the department first took definite form in 1900 as the "Department of Long Distance Lines," the providing of long distance telephone message service has been its chief function. From time to time other services have been developed, notably Private Wire Telephone and Telegraph Services, the Telephotograph, the Radio Program Supply, and most recently Teletypewriter Exchange Service. Important as some of these services have already become or are destined to become, the fact remains that the major Long Lines activity is its long distance telephone service. Of the total Long Lines telephone message traffic, approximately 40 per cent originates in, terminates in or passes through the new Long Distance Building in New York City.

To supply the backbone routes of the Bell System's long distance network, the Long Lines Department operates a system of lines interconnecting all sections of the country. Five transcontinental lines cross the plains and the Rockies to form connecting links between the Pacific and Atlantic Coasts. Radio circuits to England, South America, Bermuda and Hawaii extend the talking range from United States telephones more than half way around the world. Similar connections afford service with a dozen liners while at sea.

The wire mileage in the Long Lines plant totals more than 6,000,000 miles. Of this amount, nearly 1,000,000 miles is in aerial wire, and more than 5,000,000 miles is in cable, both aerial and underground. Measured in terms of sheath mileage, the Long Lines toll cable totals about 15,000 miles. It should be kept in mind that this trunk system can only operate in conjunction with the plant of the local companies. Each call that passes over it begins and ends over Associated Companies' lines and equipment, or those of connecting companies.

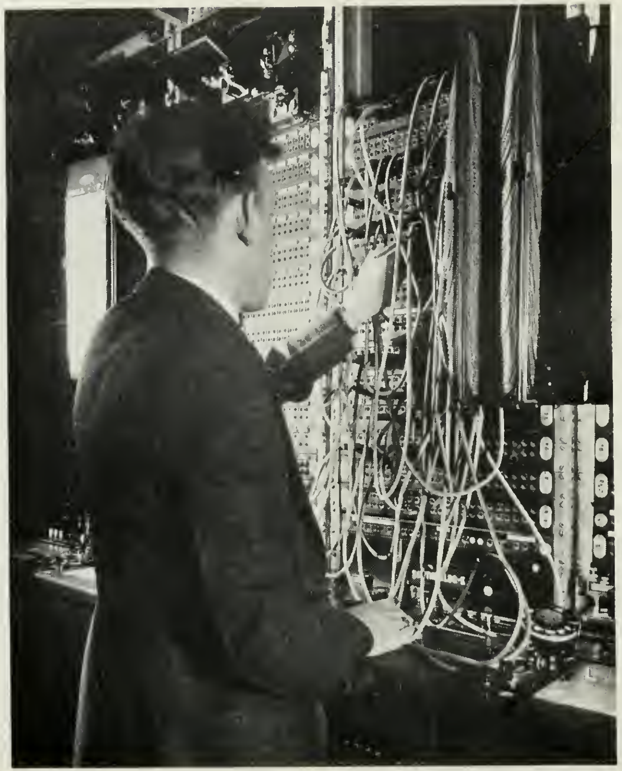
With the foregoing paragraphs as a background it is possible to bring the Long Distance Building into more definite focus. It is natural that the great majority of long distance circuits should have at least one terminal in one of the larger cities. New York City is not only the financial center of the country, and the headquarters of many of the leading industries, but also the hub of the great press association wire systems, and of the major broadcasting networks. This explains in part why 3,000 of the almost 10,000 telephone circuits provided for Long Lines use terminate in New York City. A further explanation is to be found in the fact that the metropolis forms a natural communications gateway through which flows a preponderance of the telephone traffic between New England and the remaining forty-two states.

In addition to the circuits which terminate in Manhattan—actually, of course, in the Long Distance Building—there is an additional number of circuits which pass through the building but have their terminals in other cities. Such circuits are the New Haven-Washington circuits, or the Boston-Chicago, the Poughkeepsie-Philadelphia, for instance.

Through the walls of a huge cable vault beneath street level in the building, some 200 cables weave their way underground to a variety of destinations. For example, certain "loop cables" go only to local exchanges. Toll cables, however, proceed to the limits of Manhattan Island, then beneath rivers or the harbor before taking their widely separated ways.

Some remain underground for long journeys, as do the New York-Boston and New York-Washington cables. Others alternately take underground and aerial paths through urban

A Long-distance Switchboard.



A Test-board Expert Keeps Watch for Telephone Circuit Troubles.

A Circuit Patrolman Adjusts Radio Telephone Circuits.

regions and open country respectively. This is the traveling technique of the New York-Chicago cables, for instance.

These practically stormproof voiceways have pushed farther and farther afield during recent years. Today the underground and aerial cable network reaches from Maine to South Carolina, and from the Atlantic seaboard to Northern Wisconsin, Texas and Nebraska. Omaha and Cisco, Texas, are at present the western outposts in the toll cable system.

Still others of the toll cables leaving the Long Distance Building are destined to "fan" their hundreds of pairs of wires into open wire lines radiating to scores of destinations. Out of that swirl of cables, each scarcely larger than a man's wrist, go some 3,000 direct circuits. They range in length from 40 to 3,000 miles and reach approximately 360 cities. The operators in the building complete about 90 per cent of New York's originating traffic over these direct circuits. Traffic to other points is handled by using one of these circuits and asking the distant operator to connect it with a circuit to the desired point. This, of course, makes possible a connection between New York and any other place in the country.

* * *

Having briefly sketched the fortunes of the cables after they leave the Long Distance Building, the time has come to consider the manifold activities which they bring about within the structure. A wholesale idea of their influence can be gained from the fact that on each of 15 floors one or more special phases of the communication art may be seen in action.

Rising from the vault on their way through the building the cables reach "distributing frames" on various floors and promptly lose their identity as lead-sheathed, insulated bundles of copper strands. For there the wires come out into the open to form a perfect maze as they are paired off this way and that, and dispatched in smaller, cloth-covered bundles to a primary testboard where tests can be made and any transmission faults remedied.

The next port of call for the office cable's burden of wires is the phantoming and compositing equipment. This amounts to a fork in the communications road, so to speak. Since many of the pairs of wires are carrying telegraph messages and telephone conversations simultaneously, it is plain that something must be done to separate the two in order that various patrons may receive the particular messages intended for them. Onlookers cannot actually see this magic performed, but they can follow down first one road and then the other for perhaps a new appreciation of electrical sleight-of-hand. Telegraph circuits, for instance, after they have been sidetracked, pass successively through a telegraph line board, telegraph repeaters, an intermediate telegraph board and finally through a telegraph service board. They then return to cables which connect with the offices of brokers, press associations and other subscribers whose business requirements involve the use of this type of communication service.

The telephone signals, having parted company with the telegraph circuits, also submit to a variety of tests, amplifications and general examination in passing through special equipment on the way to the toll switchboards, or to the offices of subscribers who have special leased wires for telephone service.

As a matter of interest it should be mentioned here that the phantoming and compositing equipment referred to above not only separates the direct current telegraph from the voice frequency telephone circuits, but derives "phantom" or extra circuits from the wires. Other methods of obtaining several telephone or telegraph channels from one or two pairs of wires are also employed. It is common practice, for example, for the modern technician with his special equipment to make four pairs of wires yield six telephone circuits or thirty-six telegraph circuits or various other combinations of telephone and telegraph circuits.

* * *

The visitor at 32 Sixth Avenue may be unaware of the progress of electrical events around him as just outlined, but certain of the results will be apparent to him. In the testrooms he glimpses what appear to be acres of complicated equipment, some of it ceiling-high, and learns that here is where the "circuit patrolmen" or "trouble shooters" keep constant vigil over telephone and telegraph service.

On another floor he stands before a switchboard labeled CLR, presided over by a line of operators. Here he sees the operating practice which accounts for the fact that any long distance call he makes will be completed, on the average, within two minutes. Less than ten years ago the speed of service was 11.3 minutes. The gradual reduction to two minutes has been due in part to the fact that the long distance operator who answers the subscriber's signal not only records the details of his call, but picks up the proper circuit and puts it through without turning this function over to a line operator as formerly was the practice. Thus, CLR takes its initials from the phrase "combined line and recording."

Shortly after leaving the CLR section the visitor finds himself before the Foreign Service switchboard, where labels at various intervals suggest really long distance: "London," "Buenos Aires," "Havana," "Ship-to-Shore." Needless to say, here are the operators who handle all overseas radio telephone calls and those to ships at sea. More than thirty foreign countries, together with a dozen ocean liners figuratively are at the tongue-and-finger-tips of these specially trained girls. Among them these operators speak several languages. Each has before her a chart from which all transoceanic rates may instantly be quoted to the calling party upon request. A bulletin board serves the same purpose with reference to ships. This board, revised daily, shows at a glance which vessels may be reached and at what hours, and whether the lower or higher rate applies.

In calling Buenos Aires the operators actually ring the distant office by radio, but in calling London (through which

Continental points, Asia, Africa and Australia are reached) the operators merely say "Hello, London" on the circuit until the distant operators, who are on duty at all times, answer.

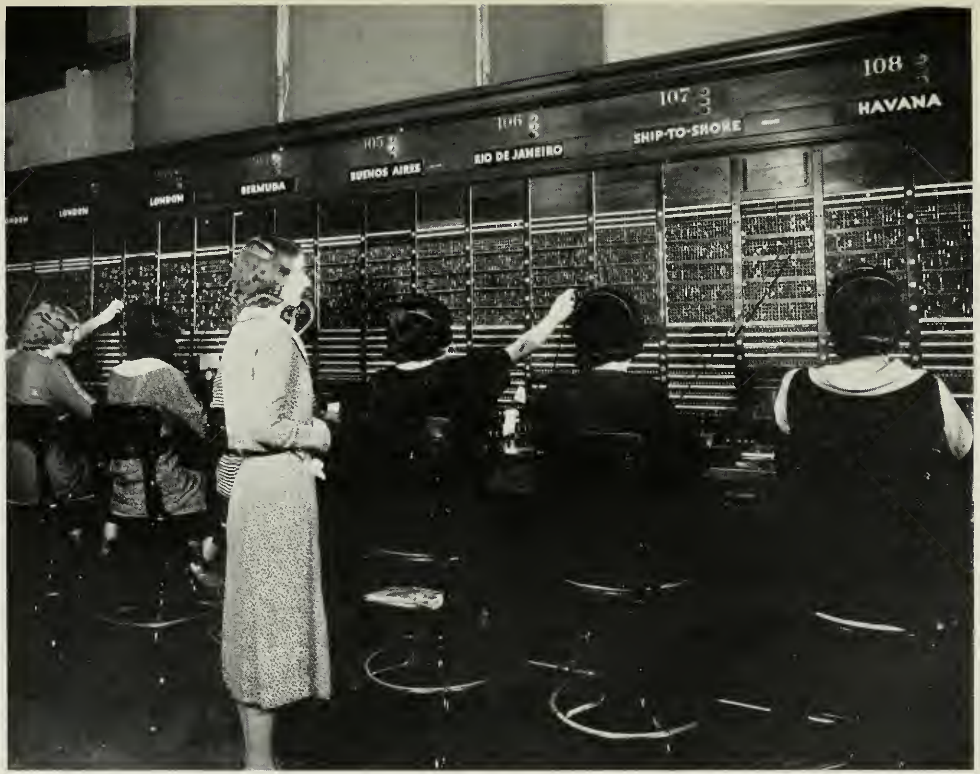
The maintenance and general technical side of this service are on view in the Overseas Control Room. The land terminations of the various radio circuits pass through this room, where technical operators make constant adjustments to compensate for variations in atmospheric conditions, as well as for varying land connections and voices of different speakers.

The radio facilities consist of one long-wave and three short-wave channels to England, a short-wave circuit to Bermuda, another which alternates to Brazil and Argentina, and a short-wave circuit to ships at sea. A sixth short wave circuit, to Peru, was opened for commercial service on October 14. The long-wave transmitting station is at Rocky Point, Long Island, N. Y., with the corresponding receiving station at Houlton, Me. All of the short-wave radio facilities are at stations in New Jersey. At Lawrenceville are the transmitters for England, South America, and Bermuda, while at Netcong are the corresponding receivers. For ships at sea there is a transmitting station at Ocean Gate and a receiving station at Forked River.

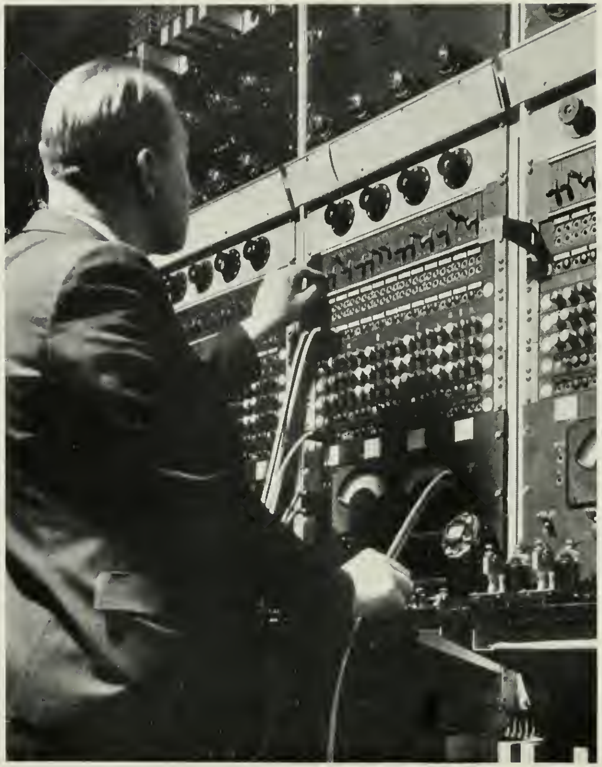
A radio telephone circuit actually consists of two one-way channels, the voices of the two subscribers reaching their destinations by separate routes and on different wave lengths. These two sides of a complete circuit are merged in the Control Room, on the twenty-fourth floor of the Long Distance Building.

An important piece of apparatus in this room is the privacy device. This "scrambles" the speech before it leaves the central room, to make the conversation unintelligible to any unauthorized persons who may chance to pick up the radio signals, and "unscrambles" a similarly garbled voice from across the ocean.

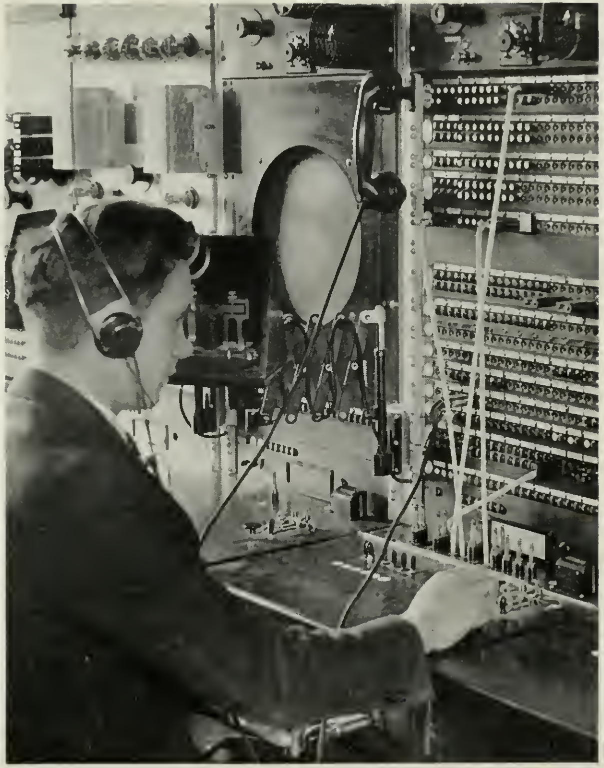
Another radio control room in the Long Distance Building



The Transoceanic Switchboard Where Telephone Connections are Made with Overseas Countries and Ships at Sea.



A Technical Man Keeps Private Wire Telegraph Systems in First-class Order.



A Monitor Sees that Radio Programs are Satisfactorily Transmitted by Wire to Chains of Broadcasting Stations.

represents the nerve center for the gigantic network of long distance telephone wires delivering distant programs to the various stations of the major broadcasting companies. At present the Bell System furnishes to broadcasting companies about 45,000 miles of special telephone circuits. In addition, about 75,000 miles of telegraph and teletypewriter wires are used to co-ordinate the activities of nearly 200 broadcasting stations scattered throughout the country. With programs which may change every fifteen minutes, from dawn until midnight, the demands upon this force and their equipment are of an exacting nature. Changes must be effected with split-second accuracy, emergencies must be provided for—whatever happens, programs must go through.

In another part of the building considerable space is devoted to the latest Bell System communication development—Teletypewriter Exchange Service. At switchboards similar to those already seen, operators swiftly interconnect teletypewriters for sending and receiving messages throughout the country just as telephones are connected to transmit the spoken word.

The arrangements for this service closely parallel those for telephone service. A teletypewriter, of either the tape or page type, is installed in the subscriber's office and connected with the exchange. When he wishes to hold a teletypewriter conversation with another subscriber he signals "Central" and types out the name and address or number of that subscriber. The operator builds up a circuit to the desired teletypewriter and rings the bell on the latter machine. The called subscriber acknowledges—by typing—and the two are connected.

Facilities of the Long Lines for the transmission of pictures by wire have been available for public use since 1925. Stations are located at New York, Chicago, San Francisco, Los Angeles, St. Louis, Atlanta, Cleveland and Boston. A picture may be sent from any one of these stations to any or all of the others. The Long Distance Building houses the New York telephotograph station, and it is here that the visitor may learn what makes it possible for the "electric eye" to bring camera records across the miles to his favorite newspaper.

* * *

The Long Distance Building, dominating the region it occupies on Manhattan Island, exemplifies a certain spirit and a certain aspiration which impress themselves upon the visitor not only while he is within the structure but long after he has left it. Not long ago another British guest, a member of a commission of four sent to examine Bell System methods of handling long distance traffic, made the building an important part of his investigations. In a paper read before the Telephone and Telegraph Society of London, shortly after his return home, he said in part:

"You have all heard no doubt of the 'Spirit of Service' as applied to American companies. You may have thought it an advertising catch phrase. It certainly is not in the Bell Telephone Service. It is a real, live, active spirit, pervading the business from top to bottom . . .

"Whether a man wants his neighbor in town, or some one in a far-away state, whether the calls come one or ten a minute, the work of the operator is ever the same—making direct, instant communication everywhere possible.

"This is Bell service. Not only is it necessary to provide the facilities for the weaving of speech, but these facilities must be vitalized with the skill and intelligence which in the Bell System have made Universal Service the privilege of the millions. That is the Spirit of Long Distance Telephony in the United States of America."

K. T. Rood

Ladder Safety Code

Editor's Note:

In the Bell System, ladders are a contributing cause in approximately five per cent of all lost time accidents, and have accordingly been given intensive and continuous study in the program for elimination of accidents that for many years has enlisted the attention of various groups throughout the System. The results of accident prevention work in general are perhaps no better illustrated than by what has been done in the case of ladders.

Many of the problems are common to numerous other organizations, and through co-operative efforts with them the Ladder Safety Code has been developed. The following description of the code which was prepared as a report of the Code Committee to its sponsor body, the National Safety Council, and presented to it on October 4, 1932, outlines the more important details and some of the interesting considerations that enter into this type of accident prevention work. It also explains the Bell System's interests in this particular safety program and sets forth some of the benefits that have been realized therefrom.

ACCIDENTS from the use and misuse of ladders was selected as one of the first subjects to justify the inauguration of a safety program of national scope under the procedures of the American Engineering Standards Committee (now the American Standards Association). The selection was based primarily upon the available accident statistics which indicated high frequency and severity rates for this class of accidents in practically all types of industrial and domestic establishments.

Where diversified interests are involved, it is recognized that the first and one of the most important steps in establishing a constructive safety program, is to prepare a code, or as it may be called, a set of standards which define and outline the best practices that can be devised for the common guidance of all interested parties.

The national program for the elimination of ladder accidents, was initiated when this organization—the American Society of Safety Engineers—accepted sponsorship for the ladder code in 1920 and organized a sectional committee to draft it. In order to insure that all interests of the project were fully represented, the personnel of the committee included representatives of the ladder manufacturers, the lumber industry, employers and employees as ladder users, state regulatory bodies, the insurance interests, engineering and safety societies, and the Federal Government. This resulted in a sectional committee of about 25 members.

Before discussing the work of the code committee, I believe that it will be helpful if we take a few moments at this point to consider some of the more important phases of the ladder situation. A ladder may be defined as an appliance designed for use in ascending or descending at an angle exceeding fifty degrees with the horizontal, usually consisting of side pieces called rails, joined at short intervals by cross pieces called steps.

This definition covers two general classes of equipment—the fixed ladders which are securely fastened in a permanent position on structures such as buildings or water towers, and the portable types of ladders which may be used at various locations. This latter class includes the commercial types of ladders such as extension ladders, step ladders, single ladders, rolling ladders, sectional ladders, and trestle ladders. These portable types are mainly wood products while the fixed ladders are built of wood, metal or combinations of these materials, and are usually built and installed during the construction of the structure of which they form a part.

The ladder industry is fundamentally a wood working industry, interested in the production and distribution of the portable types of ladders. However, in addition to the factory made product, it is also necessary to consider the "hand made" and "built on the job" ladders which are quite common in the building industry.

In considering ladders from the standpoint of their utility, we find that their field is almost unlimited. There is scarcely an establishment whether it be domestic, commercial or industrial that does not make use of ladders in one way or another. They are indispensable in many classes of work and new uses are constantly being developed as it is learned that makeshifts and substitutes for ladders do not pay. Each use, however, introduces individual problems with reference to handling, transporting or maintaining ladders which may or may not be common to other uses.

The code was drafted in sectional form in order that the subject matter might be presented in an orderly arrangement and be convenient for reference. The sections with a brief outline of their subject matter are as follows:

Section 1 is of a general nature covering the scope and purpose of the code.

Section 2 defines the different types of ladders and has an added objective of standardizing nomenclature.

Section 3 covers the materials that are acceptable for use in ladders and in the case of wood parts it covers timber requirements and permissible defects as a basis for grading ladder stock. This section also includes a classification of native woods on the basis of mechanical properties considered from the standpoint of suitability for use in ladders.

Section 4 outlines proof tests for certain types of ladders with methods of testing.

Section 5 specifies the dimensional requirements for the parts common to different types of ladders. It also covers requirements governing the assembly of these parts.

Section 6 covers the construction features for each type of ladder such as overall dimensions, spread and slope, locking devices, non-skid bases and all other equipment and features that are special to each individual type.

Section 7 covers the installation of fixed ladders.

Section 8 covers accessories such as cages and landings for fixed ladders.

Section 9 outlines the safe practices that should be followed in the use of the different types of ladders.

Taken as a whole the code represents a set of specifications which outline the standards of performance that are generally acceptable from a safety standpoint in the construction and installation of all types of ladders. Furthermore, it includes recommendations and safe practices for the general use of ladders. The code was approved as a Tentative American Standard and issued during the latter part of 1923, as Bulletin No. 351 of the United States Bureau of Labor Statistics.

You may have noticed that up to this point I have not mentioned "controversy" and "compromise," two of the terms which are associated with the subject. Personally, I feel that these two words do not reflect a true picture of the processes of development of the ladder code. In my own opinion, the discussions that arose in this work were based primarily on differences of viewpoints which are inevitable in development and research work of this type with a group earnestly endeavoring to solve a perplexing problem. Furthermore, I believe that an integration of these various viewpoints resulted from the discussions rather than a compromise, i.e., that through free and frank discussion, the salient features of each view were presented and through these presentations the conflicting viewpoints were modified so that mutual understanding and agreement resulted. We shall discuss later some of the original differences of opinion in connection with the present revision of the code.

While the main objective of the code is to promote safety, its acceptance by all interests offers a number of commercial and economic advantages as by-products. The most important advantages are:

1. It serves as a background of common understanding between the users, ladder manufacturers and other interests.

2. It standardizes and simplifies the problems of the lumber industry and broadens the field for their product.

3. In the ladder industry it brings standardization and simplification with mass production at lower costs.

4. It serves as a background for standardization to the big user and permits consolidated purchases for use throughout the country.

5. It makes available to the small user a satisfactory product at reasonable cost.

6. It serves as a basis for the establishment of uniform regulations by regulatory agencies.

7. It raises the quality level of the product.

8. Last but not least, it serves as the foundation for further accident prevention work.

A question might well be raised whether these advantages are theoretical or whether they have been actually realized. This can be answered by outlining the experience of my organization—the Bell Telephone System—in their accident prevention work on ladders.

Ladders are necessary and serve an important rôle in connection with the construction, installation and maintenance of the telephone plant. Practically every occupational employee has occasion to use one or more types in his work and practically every automobile truck engaged in plant work is equipped for carrying one or more ladders. The types most commonly used are extension ladders, sectional ladders, step ladders, straight ladders and rolling ladders. When the national code was issued the only types covered by Bell System standards were the rolling ladders employed in the maintenance of central offices and a straight ladder for manhole use. The remaining types, which are largely employed by the outside construction and installation forces, were furnished under local arrangements established individually by each operating company of the system.

With the issuance of the code in 1923, steps were immediately taken to prepare detailed purchase specifications for the types not previously standardized. Specifications for extension ladders were issued early in 1924 and those for step and sectional ladders about a year later. While these specifications were based upon the code requirements, they were drafted to cover a definite design and the construction and material features were outlined more fully in order to eliminate all variables and permit the establishment of a thorough inspection routine. All ladders purchased under our specifications are inspected 100 per cent by a trained inspector to insure that all materials and workmanship are equal to or better than the specified limits or requirements.

In addition to the consolidation of purchases which insures competent inspection under standard specifications, there are many other activities which contribute directly to accident prevention in the Bell System. The most important of these that relate directly to the safe use of ladders are:

1. The standardization of plant design.
2. The preparation of standard practices for the construction and maintenance of each type of telephone plant.
3. Safety organizations which investigate, study and recommend conditions or methods to effect improvements in safety.
4. The publication of posters to illustrate safe practices.
5. An educational program for training occupational employees in the most efficient and safest methods of performing their duties.
6. Preparation of safety codes for each class of work.
7. Study of accident data as guide for future developments.
8. The development of improved methods of transporting ladders on trucks.

9. A development program for investigating and trying out new products, designs or processes in advance of their adoption.

10. The preparation of tool instructions to cover use, care and field maintenance, as illustrated by a handbook of 32 pages which outlines in considerable detail specific recommendations for extension ladders.

The safety results obtained from this program may be summarized as follows: For convenience let us assume that 100 represents the frequency index of lost time accidents for ladders per 1000 male plant employees for the year 1923. For 1924 when standards were in effect for extension ladders this index dropped to 70, a reduction in frequency of ladder accidents of 30 per cent. In 1927, after all types were standard, the index was 61 or a reduction of 39 per cent. In 1929, the peak of plant activity, the index was reduced to 40 or a reduction in accident frequency of 60 per cent. Estimates for 1932 based upon the accident records for the first 7 months indicate an index of 26 or a reduction in the frequency rate of ladder accidents for the 10-year period of 74 per cent.

We have followed the ladder situation closely since the code was issued and find that many improvements have taken place. The lumber interests have improved their product through standardization of grading, the ladder industry has effected improvements in production methods and a better product is generally available. Furthermore, the users are paying more attention to their ladder problems and the general trend, particularly in industry, is toward higher safety standards. While all of the benefits mentioned can not be credited to the safety code, it must be recognized that it has proved an important factor in stimulating the endeavors and actions to minimize accidents in which the handling or use of ladders are concerned.

Several years ago the code committee undertook a revision of the code with the thought of bringing it up-to-date and of having the rating changed from tentative standard to standard.

It may be of interest to mention a few of the major topics that came up for discussion in connection with the revision.

One of the first subjects to bring out differences of opinion had to do with the section which outlined a proof test as a means of checking quality of the rails of extension and straight ladders. While this method of inspection is commonly applied to many kinds of materials, it has never been widely used to determine the suitability of timber or similar materials which have such a wide variation in their mechanical properties. Experience indicates that proper grading of the ladder stock followed by adequate visual inspection of the completed product offers a more reliable and a safer basis of insuring quality control. This procedure will at least insure that the method of inspection does not introduce an additional defect in the product, as might occur by overloading a ladder in the test.

The section on material requirements was originally based on minimum dimensions of parts and limiting the timber defects for each part. Inasmuch as it is commercial practice to build certain grades and types of ladders considerably heavier than safe practices require as a minimum, the establishment of such inflexible grading requirements was considered by many as too severe. It was claimed that it resulted in unnecessary waste of material and uneconomical production. The proposed draft includes a complete revision of this section allowing more latitude in the timber grading without impairing the overall safety standards.

The original draft included a number of specific construction or design requirements which were of questionable value from a safety standpoint. For instance, it required a uniform step spacing of 12 inches for all types of ladders. There appears to be no question that uniformity of spacing is desired at all times. In general, the 12-inch requirement is probably satisfactory. However, there are cases where this equipment is designed to reach definite heights where operations are performed and it is entirely possible that a 10-inch spacing in specific cases might prove more acceptable from an overall safety standpoint. This condition was recognized and a more liberal rule was drafted.

Another feature which has occasioned considerable discussion has to do with rung construction. There are opinions that rung joints should consist of a full mortise and tenon; in fact this requirement is included in a state code on ladders. On the other hand, the pocket type of rung construction in which the rung tenon does not extend entirely through the side rail has been used extensively with satisfactory results. In fact, for certain classes of use it appears to offer advantages over the other construction. The principal objection to its use as a standard practice has to do with the difficulty of inspecting the finished product to insure an adequate bearing for the rung. Since the original draft of the code did not cover specific requirements for this feature, the revision recognizes both constructions and outlines requirements for both.

Another feature which causes differences of opinion whenever ladders are discussed is the matter of so-called safety feet to prevent slipping of a ladder on its footing. There are many types available and new ones are constantly being developed. They are generally recognized as a safety feature; however, due to the limitations each type has in the different classes of use and with the many different kinds of footings, no specific recommendations appear appropriate for inclusion in the code. It seems better to leave the decision of selecting safety feet to the different classes of ladder users who are intimately familiar with the types of surfaces encountered for ladder footings in their work and the other special conditions of use.

In general, quite a large number of the proposed changes involve substituting suitable performance standards for requirements which specify methods. The revision involves an additional section on mine shaft ladders proposed by the mining interests and so many minor changes that it was found necessary to rearrange the entire text. Aside from a few last minute suggestions, the revision is complete and it is hoped to submit it for final consideration before the year closes.

It is felt that the acceptance of the revised draft as an American Standard Safety Code will bring the different interests into closer agreement and will intensify their combined efforts toward the elimination of ladder accidents.

H. D. Bender

Large Capacity Manual and Dial Private Branch Exchanges

SUPPLYING the telephone needs of large business organizations will be recognized as an undertaking of some magnitude when it it recalled that some of the larger business concerns and industrial establishments such as banks, hotels, public utilities, manufacturing plants and similar establishments house thousands of people in a single building. For organization of this kind an efficient communication system is essential, not only for service between the departments within the organization, but also for inward and outward service with the business associates or clientele of the concern.

Recognizing the need for suitable telephone service for this class of business and in accordance with its expressed policy of providing telephone service that shall at all times be adequate, dependable and satisfactory to the user, the Bell System has recently developed two large capacity private branch exchange systems having service and operating features which are particularly adapted to meet the requirements of this service.

In one of these systems all calls are answered and completed by attendants at a manual switchboard. In the other system, employing a combination of manual and dial equipment, calls between the stations and also outward calls to the central office are ordinarily completed directly by means of dials on the telephone instruments. Inward calls from the central office are distributed by attendants to the particular stations desired. In addition, the stations can dial the attendants and arrange to have outside calls, such as toll calls, completed through the manual switchboard if desired.

The manual private branch exchange is coded 606-A and the combined manual and dial equipment 702-A. The 606-A has a capacity for 5,000 station lines and 700 central office lines and the 702-A a capacity for 9,600 station lines and 900 central office lines. Except for the arrangement of the jacks and lamps in the face of the switchboard, the manual part of the combined manual and dial equipment is the same as the manual private branch exchange and the 606-A switchboard, with the proper face equipment, is employed in both systems. To give some idea of the number of telephone calls that can be handled through these large capacity private branch exchanges, it may be mentioned that they are comparable in size to the central office in cities of from 25,000 to 50,000 inhabitants.

A general view of a 39 position 606-A switchboard which in this case is employed in conjunction with 702-A dial equipment, located in an adjoining room, is shown in Figure 1. A view of a 606-A switchboard used as a separate manual private branch exchange is shown in Figure 2. A general idea of the amount of wiring and cabling required for terminating the station lines and central office lines for a 702-A installation may be obtained from the view of the distributing frame shown in Figure 3. Due to the new features which are incorporated in the 606-A switchboard, an unusually large amount of relay apparatus is required in the cord circuits and on account of insufficient space in the switchboard section it was necessary to depart from the usual private branch exchange practice of mounting the cord circuit apparatus in the section, and the plan of mounting it on separate relay racks was followed. A typical assembly of the relay rack equipment is shown in Figure 4. A general arrangement of the 702-A dial equipment is shown in Figure 5, and a closer view of a selector frame and the apparatus required for miscellaneous circuits is shown in Figure 6. A 702-A private branch exchange power plant is shown in Figure 7.

The more important new features of the 606-A switchboard are similar to those obtained on the larger central office switch-

Figure 1. Manual Switchboard Used in Conjunction with Dial Equipment.

Figure 2. Manual Switchboard Used Separately.

Figure 3. Distributing Frame.

Figure 4. Cord Circuit Relay Rack Equipment.

boards. As these features make the service more efficient for the telephone users and more convenient for the attendants, it was felt that they would be advantageous to private branch exchange customers requiring systems of these capacities. These new features, which are discussed below, are applicable either when the switchboard is employed separately or when it is associated with the dial equipment, except as indicated.

Line lamps are required with the station lines only when the 606-A is employed as a separate manual switchboard. In this case these lamps are associated directly with the station line jacks which serve both as answering and completing jacks and provision is made for multiple appearances of each line lamp throughout the switchboard. With this arrangement each line can have four lamps, distributed before the attendants as desired. This gives a very convenient method for dividing the work evenly among the attendants and is helpful in keeping the operating forces at a minimum, especially during the night or at other times when there is not enough traffic through the switchboard to warrant keeping all of the positions occupied.

In this switchboard, when a telephone user wishes to attract the attention of an attendant after a connection has been established from one station line to another or from a central office line to a station line, depressing the telephone switchhook once will start a flashing light and an audible signal at the attendant's position to emphasize that her attention is desired. The flashing light and audible signal are stopped as soon as the attendant throws the key to the answering position. This feature is known as "audible flashing recall" and is advantageous to the telephone user, particularly in cases where it is desired to have inward calls transferred from one station to another.

In dial private branch exchanges, on intercommunicating calls, the telephone bells are rung automatically with a two second ringing period and a four second silent period, this feature being known as "machine ringing." A similar feature has been provided in the 606-A switchboard whereby the telephone bells are rung automatically when the attendant inserts a plug into the jack of the called line, this method avoiding the operation of a ringing key. This feature results in more regularity in ringing the bells at manual installations and gives a uniform ringing arrangement for both the manual and dial parts of the 702-A private branch exchange.

"Audible ringing" is also provided on intercommunicating calls in conjunction with dial private branch exchange equipment, this feature permitting the calling party to hear a ringing tone while the bell of the called station is being rung. A similar arrangement has been incorporated in the 606-A switchboard which gives this feature on calls from one station line to another, thus providing an additional service improvement.

"Idle trunk indicating" is a feature of the 606-A switchboard which is particularly advantageous from an operating standpoint. In this arrangement a lamp is associated with each multiple appearance of all the jacks in a group of central office lines, commonly called central office trunks. A lighted lamp at any attendant's position indicates the lowest numbered trunk in the group that is not in use. When the trunk is seized by an attendant all multiple appearances of the idle lamps are extinguished and the next higher numbered trunk in the group that is not in use will be indicated by the lighting of the associated lamps. As this arrangement facilitates operation of the switchboard, it serves to improve the general telephone service of the system.

The dial equipment, which constitutes the major part of the 702-A private branch exchange, is of the usual step-by-step type employing line finders, selectors and connectors. Telephones within the private branch exchange are reached directly through these switches by dialing the numbers of the stations, which consist of four digits. The attendants are reached through the line finders and selectors by dialing "0." Outside connections are obtained directly through the line finders and

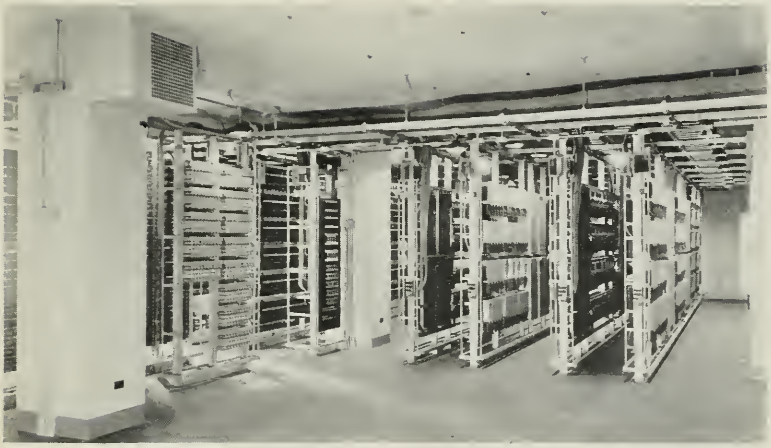


Figure 5. Dial Equipment Frames.

Figure 6. Selector Frame and Relay Equipment for Miscellaneous Circuits.

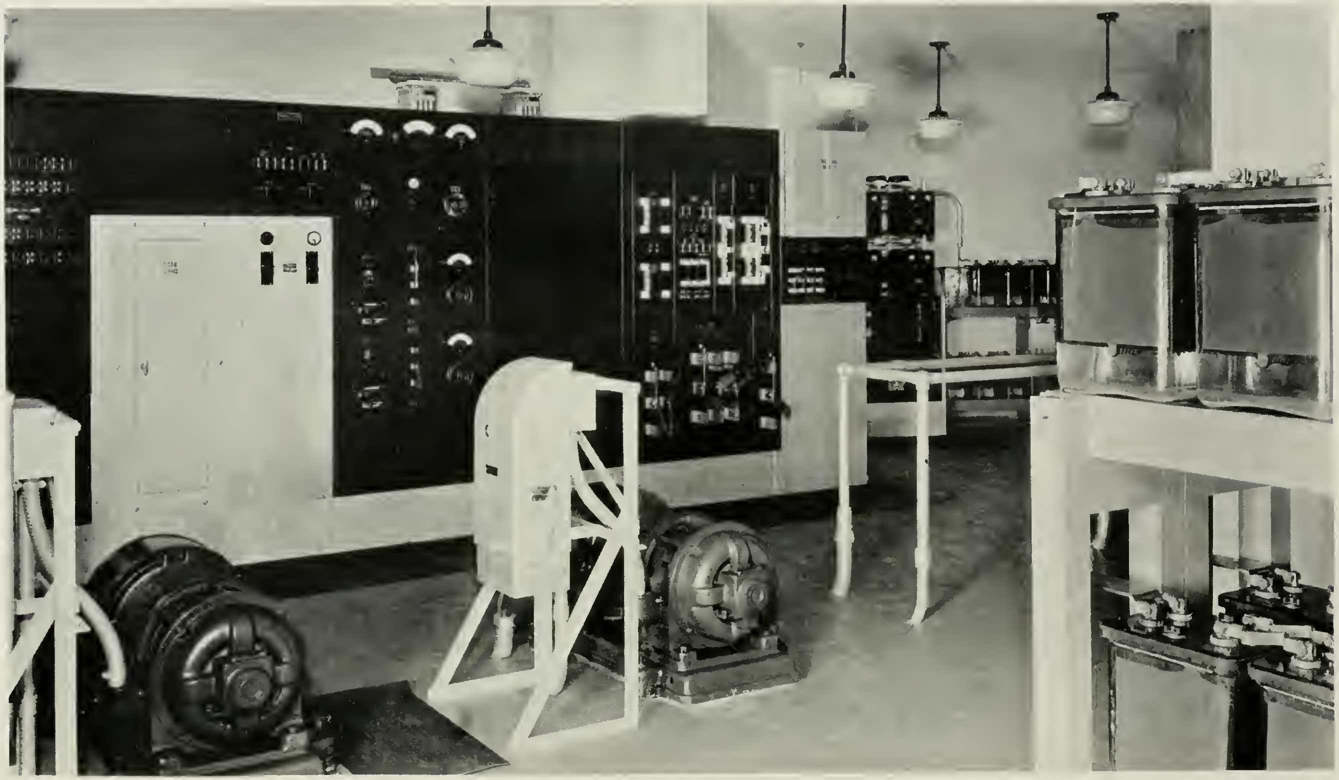


Figure 7. Power Plant for Combined Manual and Dial System.

selectors by dialing "9" followed in dial areas by the number listed in the telephone directory or in manual areas by giving the call to the central office operator.

The step-by-step switches of the various kinds and the relay equipment for the miscellaneous circuits are mounted on single-sided frames and these frames, as well as the distributing frame, are uniform in height and somewhat higher than those previously employed in dial private branch exchanges. This design of the framework permits efficient use of the customer's floor space, provides a convenient arrangement for wiring and cabling between frames and facilitates maintenance work.

The power plant may be called the heart of the private branch exchange since it furnishes battery supply, ringing current, tones, signals and maintenance alarms and is, of course, a most important part of these systems. It consists principally of a storage battery, charging equipment, ringing and tone machines and a power board. The charging equipment is operated from a commercial source of power and supplies energy for the private branch exchange equipment and for charging the battery. All units of the power plant are designed to insure continuous and reliable operation of the private branch exchange. They include such features as a liberal sized battery, to provide reserve in case of a failure in the commercial power, and automatic voltage regulation, to maintain the battery voltage within the fixed limits required for proper operation of the switches and relay equipment.

H. R. White

Recent Changes in Agriculture as Revealed by the Census

DURING the period from 1920 to 1930, agriculture in the United States experienced perhaps some of the most revolutionary changes in its history; in fact, it is still in the process of readjustment to a new set of conditions, especially with respect to labor-saving devices and better management. Many of these changes have been vividly reflected in the returns of the 1930 Federal Census of Agriculture. In general, the intercensal decade may be characterized briefly as a period of accelerated mechanization of agriculture, resulting in increased efficiency and volume of production in spite of a diminishing agricultural population.

Naturally the telephone industry is interested in changes in the number and composition of the farm population, and is equally interested in the many developments in agriculture which tend to raise the level of farm profits under normal conditions and which consequently lead to an improvement in the average farmer's standard of living.

According to the recent census enumeration, there were 30,445,000 persons living on farms in the United States on April 1, 1930, comprising one-fourth of the total population. Since the agrarian population constitutes such an important part of the rural market and normally receives an annual cash income from farm production amounting to $10,000,000,000 or more, it is necessary to give serious and continuous consideration to the particular telephone problems which are created by the nature of agricultural pursuits.

Changes in Farm Population

The farm population has been a declining proportion of the total population in the United States for many decades, dropping from 30 per cent to 25 per cent during the past ten-year period, which reflects a reported numerical loss of nearly 1,200,000. There is, however, good reason to believe that the reduction in farm population during the past decade was actually greater than that indicated by the census returns, due to a more thorough enumeration in 1930 than in 1920. The U. S. Department of Agriculture has estimated the annual net loss of farm population between 1920 and 1930 by deducting the natural increase from the net cityward migration; and the result of these yearly calculations indicates an aggregate loss for the ten-year period of over 4,000,000, a figure which probably more nearly represents a true measure of the actual decline in farm population during the past decade than the reduction reported by the census.[1]

Not only are the agricultural workers declining in number, but there are indications that the distinction between urban and rural classes is becoming less clearly defined. According to the 1930 Occupational Census, one out of every eight gainful workers engaged in farming lived in non-farm rural or urban territory. Indeed, the purely rural population may gradually disappear as the agricultural workers tend more and more to live off the farms in towns or unincorporated communities. For with the rapid transportation afforded by the automobile and improved roads, it is now possible for the farm owner and farm laborer to maintain his home in some central community and commute to his daily work. Thus, there has arisen a noticeable tendency away from the long established conception of farming as a mode of living to the modern idea of farming as a daytime business. On the other hand, the tendency for many agricultural laborers to live apart from the farm on which they work is offset to a considerable extent by the fact

[1] Some of the evidence of the superior efficiency of the 1930 census may be found in the article on "Significant Features of the Early Census Returns," which was published in the October, 1930, issue of the Bell Telephone Quarterly on pages 275 and 276.

that 1,500,000 of the 10,600,000 workers living on farms are engaged in activities other than agriculture.

Changes in the Number, Size, and Operation of Farms

The number of farms in the United States declined by 160,000 or 2.5 per cent between 1920 and 1930, while during the same period the acreage of all land in farms increased by nearly 31,000,000 or 3.3 per cent. Some farms have been abandoned outright, while others have been absorbed in consolidation proceedings; and a considerable number have disappeared in the engulfing wave of urban expansion and suburban development. Increases in farm acreage have resulted from the exploitation of marginal territory, from reclamation projects, and from the transfer of western lands from range use to crop cultivation.

There was a wide variation in the distribution of the gains and losses in farms and in farm acreage between broad sections of the country. A loss of over 300,000 farms and 32,500,000 acres in farm land occurred in the states east of the Mississippi River, with the principal declines taking place in the industrial states of the East and Central West, although several southern states—Kentucky, Virginia, South Carolina, and Georgia—also lost heavily. By contrast, the remainder of the country experienced gains of nearly 150,000 farms and 63,500,000 acres. In general, losses in farm acreage occurred wherever the number of farms declined, but there were a few outstanding exceptions. East of the Mississippi River, four states—Alabama, Florida, Mississippi, and North Carolina—gained a total of about 57,000 farms but declined in farm land by nearly 6,000,000 acres, while three states west of the Mississippi River—Missouri, Montana, and Idaho—lost about 18,000 farms but increased their land in farms by 10,000,000 acres.

Further evidence of the decline of agriculture in the East is shown by the fact that every state and some 90 per cent of all counties east of a line passing through San Antonio, Oklahoma City, Kansas City, Des Moines and St. Paul lost farm acreage between 1920 and 1930. The few counties in which acreage increased were largely in recently cut-over forest areas and in sections reclaimed by drainage operations—the most important being the Mississippi-Yazoo and the Mississippi-St. Francis Deltas in Mississippi and Arkansas. West of the Mississippi all the states and a great majority of the counties gained farm acreage, in the main by a large percentage.

The great majority of the farms of the country, 84 per cent in 1920 and 81 per cent in 1930, were farms of between 20 and 500 acres. In all five size groups into which farms between these limits are divided by the census, the number of farms decreased in the country as a whole. On the other hand, the number of farms under 20 acres in size increased 15 per cent between 1920 and 1930, while the farms over 500 acres in size increased by 11 per cent. While the small farms of less than 20 acres have increased in number in two-thirds of the states, this gain has very little agricultural significance. These farms tend to be concentrated in the vicinity of towns and cities and a majority of them constitute the suburban homes of urban workers raising crops for their own family consumption. On the other hand, the increase in the number of large farms and the decrease in intermediate sized farms are significant. This movement toward more large farms has resulted from the more economical operation of the larger unit with mechanical power and more scientific methods. The net result of these changes has been fewer farms and more economical production.

As might be expected, the distribution of farms by size shows a preponderance of small farms in the East and of large farms in the West. Two-thirds of all land in farms under 100 acres in size and over one-half of the farm acreage in units from 100 to 175 acres are in the area east of the Mississippi River, while 64 per cent of all land in farms between 175 and 500 acres and

Region	Changes 1920 to 1930 by Regions							
	In the Number of Farms Operated by				In Farm Acreage Operated by			
	All Classes	Owners	Tenants	Managers	All Classes	Owners	Tenants	Managers
					("000" Omitted)			
New England	− 31,700	− 26,100	− 3,700	− 1,900	− 2,710	− 2,110	− 370	− 230
Middle Atlantic	− 67,600	− 28,000	− 35,800	− 3,800	− 5,530	− 1,250	− 3,630	− 650
East North Central	−118,300	− 72,900	− 40,500	− 4,900	− 6,830	− 4,160	− 1,900	− 770
West North Central	+ 15,800	− 50,100	+ 69,200	− 3,300	+ 8,520	− 7,930	+17,550	−1,100
South Atlantic	−100,400	− 67,100	− 32,500	− 800	−11,410	−10,150	− 610	− 650
East South Central	+ 10,600	− 60,500	+ 71,700	− 600	− 6,070	− 8,730	+ 2,900	− 240
West South Central	+107,100	− 53,900	+160,500	+ 500	+10,450	−11,620	+16,060	+6,010
Mountain	− 2,800	− 23,600	+ 21,300	− 500	+40,110	+23,340	+11,690	+5,080
Pacific	+ 27,600	+ 25,500	− 700	+ 2,800	+ 4,370	+ 4,210	− 240	+ 400
United States	−159,700	−356,700	+209,500	−12,500	+30,900	−18,400	+41,450	+7,850

93 per cent of the acreage in farms over 500 acres in size are west of this waterway.

PERCENTAGE DISTRIBUTION OF FARM LAND ACREAGE BY SIZE OF FARM

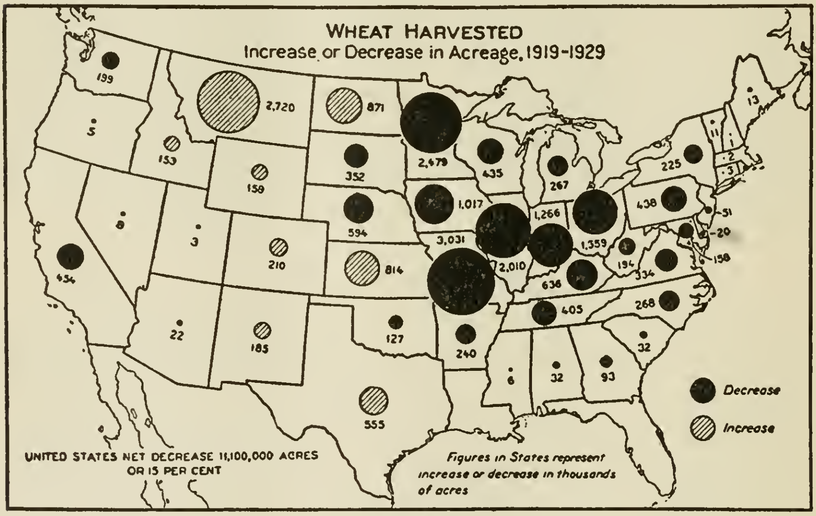
Size of Farm in Acres	Unites States		East*		West *	
	1930	1920	1930	1920	1930	1920
Under 20	1.0	0.9	2.0	1.8	0.5	0.4
20–99	14.7	16.1	29.7	29.9	7.5	8.1
100–174	18.3	20.4	29.4	29.6	12.9	15.0
175–499	27.0	29.0	30.2	29.0	25.5	28.9
500+	39.0	33.6	8.7	9.7	53.6	47.6
	100.0	100.0	100.0	100.0	100.0	100.0

* Mississippi River is taken as the dividing line between East and West.

Closely associated with these changes in the number and size of farms is the altered distribution of operation between owners, tenants, and managers. In the United States as a whole the number of farms operated by owners declined by 357,000 or 9 per cent between 1920 and 1930, while farms tenant-operated gained by 210,000 or 8.6 per cent. This is a continuation of the trend toward more tenancy that has been in evidence since the first report on farm tenure by the census in 1880. The regional changes in farm operation during the past decade are shown in the accompanying tabulation.

MAJOR CASH CROPS

The two most important cash crops in the United States are cotton and wheat, and in both of these farm commodities there has occurred a notable westward movement of the center of production. In the case of cotton, the proportion raised in the states west of the Mississippi River increased from 47 per cent of the total production between 1910 and 1920 to 57 per cent during the past decade. Most of this expansion occurred in the semi-arid plains of western Oklahoma and Texas, where vast areas of cheap range lands, formerly thought suitable only for stock raising, have proved capable of producing low-cost cotton. During the period 1920–1930 wheat growing pushed steadily forward into the brown-earth belt in the western parts of the Dakotas, Nebraska, Kansas, Oklahoma, and Texas and in the Mountain States from Montana to New Mexico. In fact, practically the entire expansion of wheat acreage in the United States since 1920 has been on the drier subhumid or semi-arid grasslands in the West, where large areas of fairly level surfaces and the less diversified system of agriculture have made it possible to mechanize wheat farming to a greater extent than in most other regions. Indeed, machine methods and large scale operations have been the principal factors in making possible the profitable exploitation of broad areas in these regions of low rainfall, as the tractor and combine are ideally suited to extensive farming operations, and the greater efficiency of production more than offsets any tendency toward lower acreage yields in marginal territory.

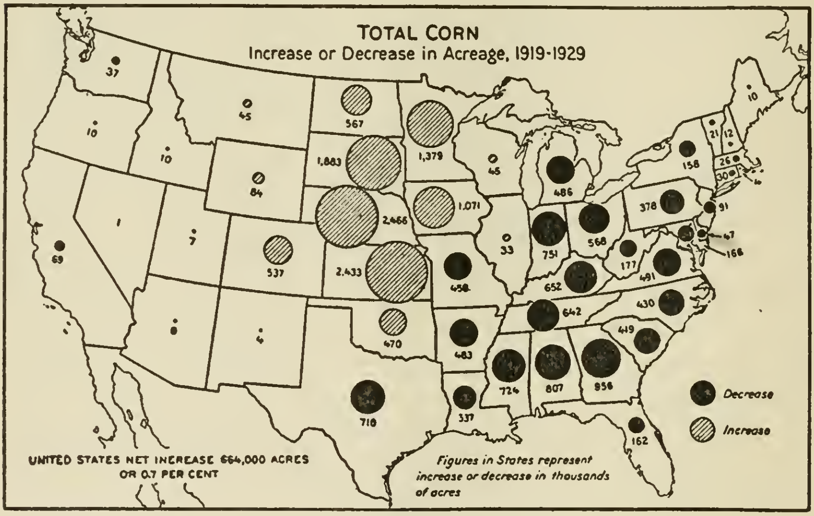


(From 1932 Yearbook of Agriculture)

In contrast to the westward expansion of cotton and wheat growing during the past decade, severe contraction in acreage and in production took place in some of the eastern states. In the old plantation piedmont area including South Carolina and Georgia, in the heart of the territory which has suffered most from the devastation of the boll weevil, cotton acreage was 27 per cent lower in 1929 than in 1919 and cotton production was 43 per cent less between 1920 and 1930 than during the previous decade. In fact, much of the land in the Southeast is now submarginal for cotton, resulting in considerable farm abandonment. At the same time, the concentration of wheat production in the Great Plains region occurred at the expense of the eastern part of the grain belt. The aggregate losses in wheat acreage in six states—Ohio, Indiana, Illinois, Missouri, Iowa, and Minnesota—equalled the total reduction in wheat acreage in the United States between 1919 and 1929, while a gain of 5,000,000 acres in Montana, North Dakota, Kansas, and Texas was offset by losses in other states.

During the past decade the land devoted to raising cotton was expanded by 9,500,000 acres or 28 per cent, while the average annual production increased by only 230,000 bales over the previous ten-year period. This unbalanced relationship between added acreage and production emphasizes how the returns from greatly increased acreage in low yield areas have only slightly more than offset the losses in the eastern part of the cotton belt due to boll weevil infestation. In contrast to the increase in cotton acreage between 1920 and 1930, a reduction of 11,000,000 acres or 15 per cent occurred in land devoted to wheat production. However, this decline in wheat acreage merely represents a logical contraction in the unprecedentedly wide area which was placed in cultivation in order to supply the abnormal foreign demand which marked the period immediately after the World War.

The migration of wheat production into the Great Plains area has permitted a material westward shift in other grain crops, principally corn but including oats and barley. This change has in turn resulted in a marked reduction in the acreage devoted to grain production throughout the South as well as in the eastern part of the cereal belt. In connection with the increased grain production in the West North Central region, it is especially noteworthy that in Iowa and the southern portion of Minnesota and in the eastern part of South Dakota, Nebraska, Kansas, and Oklahoma the gains in corn acreage very largely replaced losses in wheat acreage during the past decade. In this region the temperature and moisture conditions are better suited to growing corn and the relative yields of corn and wheat are more favorable to corn production. Furthermore, the acreage in oats expanded appreciably in Minnesota, Iowa, South Dakota, and Nebraska, while barley acreage made important gains in Minnesota and the Dakotas. Thus, during the past decade there has been a considerable concentration of grain production in the area including Minnesota, Iowa, and the tier of states extending southward from North Dakota to Texas.



(From 1932 Yearbook of Agriculture)

Between 1919 and 1929 there was a reduction in crop land devoted to raising corn and oats of about 4,600,000 acres each, equivalent to 5.3 per cent in the case of corn and 12 per cent in the case of oats. The reduction in the production of these feed crops, as well as of hay, reflects the drastic decline in the number of work animals on farms since 1919.

Livestock

In general, the country's livestock population has shrunk considerably during the past decade, especially in the numbers of horses and cattle. The number of horses on farms dropped from nearly 20,000,000 in 1920 to about 13,500,000 in 1930, a reduction of nearly one-third; and the shortage of colts means a continued decline in the horse population. This reduction has been made possible and advantageous by the introduction of power machinery in many routine farm operations—plowing, planting, cultivating, and harvesting. Not only has the substitution of tractors and trucks for horses and mules resulted in greatly increased efficiency of production, but it is estimated that the demand for at least 15 to 20 million acres of hay and grain land has evaporated as a result of this transition from horse power to internal combustion motors. One-half of the reduction in work animals occurred in the North Central states where the mechanization of agriculture has been most widely adopted.

No accurate measure of the change in the cattle, sheep, and hog population between 1920 and 1930 census dates is possible because the counts were not taken at the same time of the year and, consequently, the figures are not on a comparable basis. However, the Department of Agriculture has estimated the number of livestock on farms at the beginning of every year since 1920. These estimates indicate that during the past decade the number of meat cattle declined by about 12,000,000, or 25 per cent, and the number of hogs by 5,000,000, or 8 per cent; while the milk cattle increased by 1,500,000, or 7 per cent, and the sheep and lambs increased by 11,000,000, or 27 per cent. But since there are rather definite and recurring cycles of production in the livestock industry, a direct comparison of cattle, sheep, or hog population at the beginning and at the end of a ten-year period does not conclusively indicate fundamental changes in the industry. However, some geographical shifts in production are apparent.

The hog industry has followed corn growing because of the importance of that grain as fodder. There were nearly 7,000,000 more hogs on the farms of the West North Central region in 1930 than in 1920, while losses of 3,000,000 and 7,000,000 occurred in the eastern half of the corn belt and in the South, respectively. The principal gains in sheep population took place in the Mountain States region and in the range states of the Great Plains region extending from Montana to Texas.

There was an increased concentration of meat and milk cattle in the North Central region, resulting largely from the release of cropland formerly required to raise feed for work animals. In this area, the farm animals are more productive per unit of feed consumed than in the southern states and most other parts of the country. Furthermore, as the acre yields of the feed crops and the productivity of the pastures are also higher in the northern states than in the South, the use of tractors in the North has resulted in the production of more milk and meat on a smaller acreage of land.

Although the output of dairy products increased considerably during the past decade, there was very little change in the geographical distribution of the industry. There appeared a slight tendency toward further concentration of dairying in the North Central region which accounted for most of the increase in dairy cattle between 1920 and 1930—with half the total gain occurring in Wisconsin, Minnesota, and Iowa. This region now has more than half the dairy cattle of the country and over 50 per cent of these are in 4 states—Illinois, Wisconsin, Minnesota, and Iowa.

Between 1919 and 1929 the volume of milk produced increased 42 per cent, while the amount of whole milk marketed gained by 76 per cent. A declining amount of butter was churned on farms during this period, but the quantity of cream sold as butter fat was greater by 122 per cent in 1929 than in 1919. More than 60 per cent of the milk sold is produced in 7 states—New York, Pennsylvania, Ohio, Indiana, Illinois, Michigan, and Wisconsin—while 80 per cent of all cream sold comes from the North Central region. This rapid expansion of the dairy industry in the middle western states has been made possible through the use of machinery that includes mechanical means of feeding, milking, and cream separating.

Practically the same situation obtains in the poultry industry as in dairying. The number of chickens sold in 1929 was more than double the corresponding figure in 1919, while the number of eggs marketed was 93 per cent greater in 1929 than in 1919. Here again, the preponderance of production was in the North Central region which accounted for over half the total production. The heavy increase in the volume of dairy and poultry products is significant as indicating the greater importance of these foods in the changing American diet.

Farm Machinery and Facilities

The transition from horse power to mechanical power in agriculture, although starting about 25 years ago, has shown its most striking progress since 1920. In terms of horsepower the average farmer is four or five times as efficient as he was scarcely a decade ago. One man in the wheat belt with a combine can harvest as much as five or six men could ten years ago, while the cotton farmer in Texas, with tillage implements and harvesting machinery, can attend to as much cotton acreage as six or eight planters in the old South. Along with this development has gone an increase in the average size of farm.

Montana presents a typical example of the change taking place in agriculture in the grain growing region as a result of the rapid mechanization of farming operations. The number of farms declined by over 10,000, or 17.5 per cent, between 1920 and 1930, while the acreage of all land in farms increased by 9,600,000. The average number of acres per farm increased from 608 to 940 during this period, the number of farms over 1,000 acres in size increasing from 5,622 to 10,501. Farm population declined by over 21,000 or 9.5 per cent, and work animals on farms decreased by 220,000 or one-third. Meanwhile, the acreage devoted to the raising of wheat increased from 1,700,000 acres in 1919 to 4,420,000 in 1929 and the production jumped from 7,800,000 to 40,560,000 bushels. All other grain crops increased in volume, particularly oats and barley. Thus, greatly increased crop production per unit of human and animal labor was accomplished through the application of machine methods and large scale operations.

Every state had more automobiles, motor trucks and tractors on farms in 1930 than in 1920; in many regions the gains were very considerable. During this ten-year period the number of farms reporting automobiles increased from 1,980,000 to 3,650,000, while the farms with motor trucks increased by 714,000 or 540 per cent and the corresponding gain for tractors was 622,000 or 270 per cent. Many farm lands classed as inferior in the horse age because of their remoteness from the railway shipping point, from the improved highway, or from the farmstead have had their accessibility, and hence their economic productivity, very much increased by the introduction of the tractor, the truck, and the automobile. The accompanying tabulation shows the regional distribution of the decade gains expressed as a percentage of all farms reporting specified farm machinery and facilities. In addition, there has been a very material increase in supplementary machinery used for farm work, for which the basic power is supplied by the electric motor and the stationary gas engine; but comparable data are not available by which to measure the exact degree of gain since 1920.

Another development closely associated with the increased mechanization of agriculture has been the marked decrease in farm expenditures for feed and labor. The principal declines in expenditures for feed occurred in the North Central, the West South Central, and the Mountain regions, where the percentages of decline—averaging 30 per cent—corresponded very

Percentage of Farms Reporting Specified Farm Machinery and Facilities, by Regions, 1920 and 1930

Region	Automobiles		Motor Trucks		Tractors		Dwelling Lighted by Electricity		Water Piped into Dwelling	
	1930	1920	1930	1920	1930	1920	1930	1920	1930	1920
New England	60.5	25.7	26.6	4.7	10.5	1.4	43.0	15.3	64.0	47.9
Middle Atlantic	71.0	35.2	30.7	4.8	21.5	3.1	31.9	14.1	38.0	23.3
East North Central	79.7	47.3	19.5	2.3	24.7	5.1	21.0	10.5	21.9	12.4
West North Central	82.6	57.6	15.7	2.9	26.5	8.4	13.2	8.9	16.2	9.8
South Atlantic	42.1	16.2	8.3	1.3	4.2	0.9	6.1	3.9	6.3	3.3
East South Central	30.2	7.8	4.1	0.5	2.1	0.5	3.0	2.1	2.6	1.5
West South Central	45.6	17.4	8.4	0.9	5.7	1.8	3.7	1.9	8.0	4.9
Mountain	67.7	37.6	21.8	2.9	18.0	6.5	20.4	10.3	20.0	10.8
Pacific	75.1	47.2	23.9	4.6	20.9	7.5	52.9	19.3	59.8	41.8
Unites States	58.0	30.7	13.5	2.0	13.6	3.6	13.4	7.0	15.8	10.0

closely with reductions in the number of work animals on farms. Reductions in expenditures for farm labor amounted to $135,000,000 or 30 per cent in the North Central area and to $37,000,000, or 25 per cent in the West South Central states —regions where labor-saving appliances and machine methods have been most widely adopted during the past decade.

Value of Farm Property and Amount of Mortgage Debt

The reported value of all farm property—principally land and buildings but also including implements and machinery and livestock—declined by nearly $21,000,000,000 or 27 per cent between 1920 and 1930, reflecting the drastic decline in the general price level which took place between those years. Over three-fourths of this reduction occurred in the North Central group of states, while the South also suffered relatively heavy decreases. Only two states of agricultural importance registered any considerable gains in the value of farm property, and these—Florida and California—experienced land booms during the decade.

The proportion of the total number of fully-owned farms which were mortgaged increased from 35.5 per cent in 1920 to 39.3 per cent in 1930. At the same time, the financial burden on the encumbered farm grew heavier, since the average amount of mortgage debt per fully-owned farm increased by $210 or 6 per cent during this period of radically reduced farm values, while the value of land and buildings on these farms declined by $3,500,000,000, resulting in an increase in the ratio of mortgage debt to farm value from 29.1 per cent to 39.6 per cent. However, so far as the farmer's purchasing power is concerned, offsetting factors to the increased portion of the farm income required for mortgage payments were the increased proportion of land available for cash crops and the reduced expenditures for labor and feed.

The ratio of mortgage debt to farm value in 1930 varied greatly among the several states, ranging from 27 per cent in Florida to 50 per cent in Wisconsin. When geographical areas are considered, the North Central group of states showed the greatest increase and the highest level in the ratio of debt to value, advancing from 28 per cent in 1920 to 44 per cent in 1930, while the Pacific region experienced the smallest change and had the lowest ratio in 1930 of all areas, with the ratio increasing from 30 per cent to 32 per cent during the decade.

Co-operative Marketing

In the marketing of agricultural supplies in the United States during the past decade there has been evidence of a much stronger tendency toward co-operation for the purposes of selling farm products than for the purchase of supplies. Whereas the value of farm supplies purchased through co-operative channels amounted to only $125,000,000 in 1929, the value of farm products similarly sold was nearly $900,000,000. However, the former item represented an increase of 48 per cent over the corresponding 1919 volume of business, while the growth in co-operative selling during the ten-year period amounted to only 24 per cent.

With few exceptions—notably in Michigan, Kansas, Nebraska, and the Dakotas where large decreases occurred—there was a general increase in the value of farm products sold during the past decade through co-operative associations; many states showed considerable gains in this item, especially Wisconsin, Minnesota, Iowa, and Missouri in the dairy region, Florida in the South, Oklahoma and Texas in the Southwest, and California and Washington on the Pacific Coast. Similarly, an increase in the value of farm supplies purchased by co-operative methods between 1920 and 1930 was reported in the great majority of states—the principal exceptions being Kansas, Nebraska, and the Dakotas—while sizable gains were recorded in several states, among which were New York, Ohio, Michigan, Missouri, California, and Washington.

Significance of the Improved Farm Market from the Standpoint of the Telephone Industry

Several developments in agriculture during the past decade, including such factors as the tendency toward larger farms, heavier investment, greater use of machinery, and more widespread education, have combined to improve the farm market from the standpoint of the long pull, although progress may have been temporarily retarded by the depressed conditions of the moment. In fact, there is direct evidence that, associated with the greater efficiency in agriculture realized through the increased use of machinery, there has been a material betterment in living conditions on farms resulting from the more widespread adoption of modern conveniences. For example, the number of farms reporting water piped into dwellings increased from 644,000 in 1920 to 994,000 in 1930, while the farms with dwellings lighted by electricity increased by 390,000 or 86 per cent over the number served either by electricity or gas in 1920. While the figures for these items vary widely between regions, substantial progress over 1920 has been realized in all sections of the country.

Telephone usage for social purposes in rural areas is fundamentally important, while the farmer's marketing problems require efficient service for communication as well as for transportation. With the increase of standardized grades for agricultural products and with the speeding up of the distribution processes, the greater importance of the telephone for toll as well as for local usage in connection with efficient marketing of farm products will become more and more apparent. Constant co-operation between the telephone industry and the farmer in working progressively toward further extension of telephone service on farms is essential to meet adequately the peculiar requirements of the farm market.

R. L. Tomblen

The Bell System's Part in the Work of the International Polar Year

THE year following August 1, 1932, has been designated as the Second International Polar Year. During this period interested scientists throughout the world will make a concerted effort to obtain a large amount of information on such phenomena as the aurora borealis, earth currents, and the motion of the earth's magnetic poles. In order to study these effects at close range, expeditions have been sent into the polar regions by many of the leading nations. A group from the United States is at Fairbanks, Alaska. One from Canada is at Chesterfield Inlet which is near the magnetic north pole. A number of European nations have parties in Northern Europe. The Soviets have inaugurated an especially ambitious program covering several fixed stations as well as special cruises.

The First International Polar Year took place just fifty years ago. It was participated in by even larger groups than will be active this year. It was in this connection that the ill-fated Greely expedition was sent into the Arctic by the United States Government. It may be remembered that due to the failure of two different relief expeditions, Lieutenant Greely (now General Greely of Washington, D. C.) and his party of twenty-five men were left in the arctic for three years with provisions barely sufficient for two years. During this time they advanced to the northernmost tip of Greenland and explored a large part of Grinnel Land, very painstakingly collecting a large amount of valuable scientific information enroute. As relief failed to appear, the party retreated to Smith Sound where they spent their last winter. The following June the seven of the party who had survived the starvation and exposure were rescued by Commander Schley of Spanish American War fame. With true scientific devotion, the men had carefully preserved their records and data.

This year's study will differ somewhat from that of fifty years ago in that it will be devoted more to the electrical state of the earth than to geography. Consequently, there will be very important but possibly less spectacular work to be done in the lower latitudes. For instance, special observations will be made at Hauncayo, Peru, which is located on the magnetic equator. Other work will be done at Watheroo, Australia, which, roughly speaking, is located on the opposite side of the earth from America. A phenomenon which will receive special study will be that of earth currents. It is in this connection that the Bell System will make observations.

As many telephone and telegraph people know, there are occasionally times when abnormally high currents flow in the crust of the earth. This is almost certain to be the case on nights when the aurora borealis is seen. These currents sometimes interfere with service on grounded Morse telegraph circuits. It is perhaps less generally known that the short-wave transoceanic radio-telephone circuits are also adversely affected at times of aurora. Here the effect frequently leads to several hours of lost time and occasionally longer periods. It is interesting to know that at such times the long-wave radio-telephone circuit may actually be improved. It is for these practical reasons as well as the broad interest in the advancement of science that the Bell System is taking part in the work of the International Polar Year.

Earth potentials are being measured at four points in the United States. One is at Houlton, Maine. Another is at New York City. A third is at Wyanet, Illinois, while the fourth is at Tucson, Arizona. Measurement is accomplished by connecting recording voltmeters into telegraph circuits grounded at both ends. These instruments make a continuous night and day record on long strips of paper of the voltage difference prevailing between the two ends. Several hundred volts have on occasion been recorded on a line a hundred miles in length. Simultaneous records made at each of the four points on two lines running respectively North and South and East and West give an idea of the magnitude and direction of the flow of current in that region. In order that the effects produced by nature may not be masked by those of man-made origin, the connections to earth are located as far as possible from industrial centers where trolleys or other sources of vagrant currents may originate.

Much progress has been made in the methods of measuring terrestrial effects since the last polar year. In particular, the scientist has a useful ally in radio. Both radio echoes and the angles at which distant radio signals reach a station strongly indicate the existence of an electrically charged layer or atmosphere, a hundred miles or so above the earth. This is exactly what scientists hypothecated to explain the aurorae and certain characteristics of the earth's magnetism even before the time of Marconi. It is expected that with the new methods available other facts of nature will be discovered which may be associated with the knowledge already at hand and assembled as important pieces in our jig-saw puzzle picture of the universe about us.

G. C. SOUTHWORTH

Notes on Recent Occurrences

OVERSEAS TELEPHONE SERVICE EXTENDED

Siam

TRANSOCEANIC telephone service was extended to Siam on July 15, but for the present is limited to calls to and from a special call office in Bangkok. The rate for the initial three minutes is $45 between Bangkok and the first zone in North America, and the report charge is $5 in all cases. The hours of service are generally from 3 A.M. to 5 A.M. and from 8 A.M. to 9 A.M., Eastern Standard Time. Calls to and from Siam go by way of Germany.

Balearic Islands

On July 15 service was extended to the Balearic Isles. The rate to and from the first zone in North America is $36.75 and the report charge is $5.25. The hours of service are generally from 4:30 A.M. to 8:30 A.M. and 11:30 A.M. to 5 P.M., Eastern Standard Time. Transmission to the Balearic Isles is through the short wave station in Madrid.

Egypt

On August 8 service was made available between Cairo and Alexandria, Egypt and all Bell and Bell-connecting telephones in North America. A three-minute conversation between New York and either of the Egyptian cities costs $36, with $12 for each additional minute.

Egypt is reached over the regular transatlantic radio telephone channels operated by the American Telephone and Telegraph Company and the British Post Office, and a radio circuit between London and Cairo. The circuit distance from New York to Cairo is about 6,000 miles. Cairo, with a population of 1,100,000, has some 17,500 telephones; Alexandria, with 600,000 people, has about 11,600.

Peru

On October 14 telephone service was inaugurated between North America and a number of cities in Peru. The service was opened by an exchange of greetings between officials of the United States and Peruvian governments in Washington and Lima.

The voice channel thus established links Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico with those of Lima, Callao and other Peruvian cities. These represent about 70 per cent of all telephones in that country. The charge for a three-minute call between New York and any of these cities is $30.

The channel between North America and Peru is formed by a radio circuit between American Telephone and Telegraph Company radio stations in New Jersey and those of All America Cables, Inc., at Lima. It is operated on short waves, employing a wave length of approximately 15 meters, corresponding to a frequency of about 19,000 kilocycles.

SERVICE PLANNED TO SEVERAL COUNTRIES AROUND THE CARIBBEAN SEA

RADIO telephone service from the United States will be extended to half a dozen Central and South American republics bordering on the Caribbean Sea by the end of this year, according to plans of the American Telephone and Telegraph Company. Furnishing the service will necessitate the establishing of a new radio station at Hialeah, Florida, near Miami. Equipment for the station has been ordered.

Among the new countries to be reached by the service is Panama, including the Canal Zone. The latter will be the second outlying possession to be connected with the United

States by radio telephone, as service with Hawaii was opened last December.

Other Central American republics included in the scope of the service will be Honduras, Nicaragua and Costa Rica. The South American countries to be connected are Colombia and Venezuela. The Bahama Islands will also be reached through the new station. With the proposed services in operation, the United States will have direct telephone connection with nearly all the countries and islands bordering on what was formerly known as the Spanish Main, as wire service already reaches Cuba and Mexico, and radio telephone service was extended to Bermuda late last year. The additions will bring the total foreign countries within telephone reach of the United States to forty-five.

Through arrangements with the Tropical Radio Telegraph Company, land and buildings owned by that company near Hialeah will be used to house the equipment which the American Telephone and Telegraph Company is installing for the new station. Due to the requirements of direction, location and distances, five sending and receiving antenna units will be set up, each operating with different distant countries.

In Panama City; Managua, Nicaragua; and Tegucigalpa, Honduras, the stations are owned by the Tropical Radio Telegraph Company. In San Jose, Costa Rica, the station is owned by the Compania Radiographica Internacional de Costa Rica; in Colombia by Marconi's Wireless Telegraph, Ltd.; in Venezuela by the Venezuelan Government and in the Bahamas by the Bahaman Government. Wire connections with the radio stations will be made through the telephone networks of the Compania Panamena de Fuerza y Luz, an affiliate of the Electric Bond and Share Co., in Panama; of the Compania Anonima Nacional Telefonos de Venezuela and of the Compania Telefonica Central, Colombia, both of which latter companies are affiliates of the Associated-General Telephone Group.

The Western Electric Company is supplying the equipment to be used in Florida and the transmitting and receiving units to be installed in Central America and the Bahamas. This equipment consists of seven specially designed short wave radio telephone transmitters and the same number of superheterodyne receivers. Distances to be covered by the voice waves range from less than 200 miles to Nassau, in the Bahamas, to more than 1,200 miles to Bogota and Caracas.

SHIP–SHORE SERVICE TO S.S. *REX*

ON OCTOBER 6 ship-shore service was extended to the S.S. *Rex,* 50,000 ton liner of the Italian Line, enroute to New York on her maiden voyage. This is the first vessel flying the Italian flag to have this service, which reaches a dozen other large liners.

PRINTED IN U. S. A.