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THE BELL SYSTEM RESEARCH LABORATORIES

BY

EDWARD B. CRAFT

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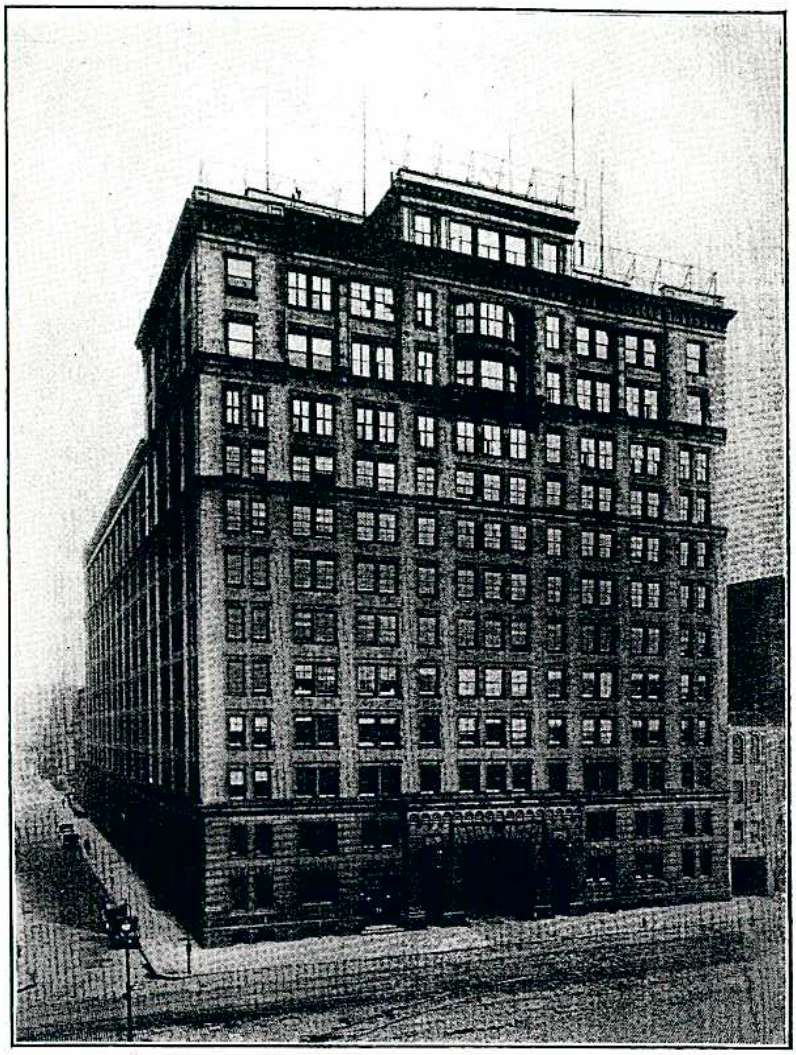
Vol. 2 No. 3 JANUARY, 1924

Printed in the
United States of America

The Bell System Research Laboratories

By EDWARD B. CRAFT

Chief Engineer,
Western Electric Company, Inc., and
International Western Electric Company



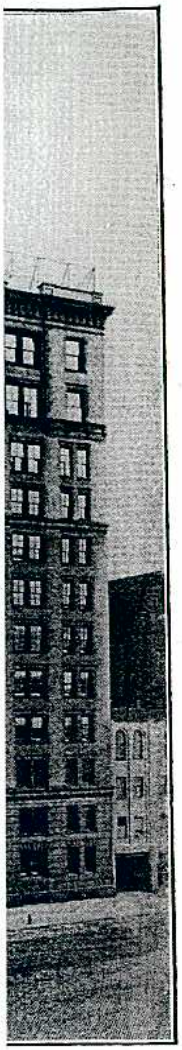
RESEARCH LABORATORIES

of the

AMERICAN TELEPHONE AND TELEGRAPH COMPANY

and the

WESTERN ELECTRIC COMPANY, INC.



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The Bell System Research Laboratories

By EDWARD B. CRAFT

Chief Engineer,

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THE genius of one man gave us the speaking telephone. The labors of an army of scientists, engineers and workers of all sorts extending over a period of fifty years have given us the present-day system of telephonic communication.

There were many fortuitous circumstances incident to the birth of the telephone.

First, it was associated with the electrical art, the scientific aspects of which were then and have ever since been the subject of the most enlightened kind of research and development.

Second, its development and commercial exploitation came into the hands of men with imagination and foresight—men with a keen appreciation of the value and necessity of the scientific development of the technique of the art.

Lastly, its place of birth was a new country of vast dimensions as to population and area, where a rapid and convenient means of communication was of greatest necessity and value.

The history of the development of the telephone in America has been a succession of scientific achievements followed by immediate and large scale application, so that today the Bell Telephone System represents one of the largest aggregations of capital and personnel to be found in the industrial world. Its engineering and scientific achievements combined with those of others in many parts of the world, have resulted in a system of telephone communication by means of which whole continents can be served by a universal, effective and economical means of inter-communication.

It is the purpose of this brief contribution to tell our readers something of the Bell System Research Laboratories which from the beginning have occupied an important place in the group of organizations comprising the Bell Telephone System.

For a considerable period, laboratories were operated by the American Telephone and Telegraph Company in Boston and by the Western Electric Company in New York City and in Chicago. In 1907-8, in the interest of greater efficiency, it was decided that they should be combined in New York City at the Western Electric Company's Bethune and West Street building. The fact that there were no divergent interests made this possible; certain kinds of apparatus being developed at the expense of one company and other kinds at the expense of the other, by agreement, and all patents resulting from this work being either owned or controlled by the American Telephone and Telegraph Company.

The operation of the laboratories is entrusted to the Engineering Department of the Western Electric Company, Incorporated, and they are located in New York City in a thirteen story building comprising a floor area of more than 400,000 square feet.

The personnel is made up of more than three thousand workers, whose sole function is the carrying on of research and development looking toward more effective and more economical means of electrical communication. Physicists, chemists, metallurgists, engineers, mechanics and many other classes of workers are combining their efforts in a systematic and coordinated attack on the manifold and never-ending succession of problems, the solution of which has resulted in the telephone system of today and will without doubt very largely determine the telephone systems of the future.

Operating problems of the Bell Telephone System as gathered from the field or originated in the Department are studied by the Department of Development and Research of the American Telephone and Telegraph Company and formulated as problems to be solved either by or for that Department, or by the Engineering Department of the Western Electric Company, Incorporated.

Because of the very considerable number of workers, and the variety and number of problems, a certain amount of formal organization is essential. The various units of the organization are built up on a functional basis, each unit whether it be made up of physicists, chemists, systems engineers or any other of the classes employed, is organized to

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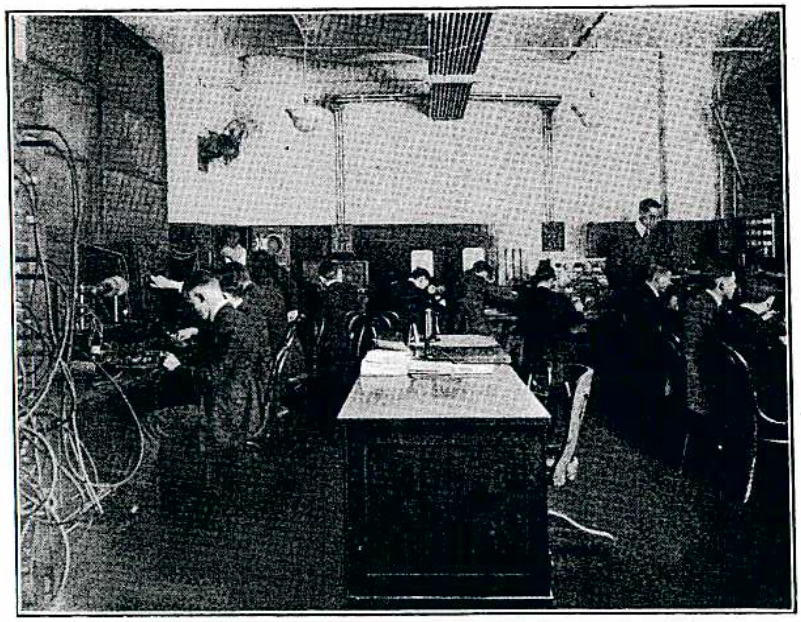
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Historical Museum



Educational Department Instruction Laboratory

carry on the work in its particular field and is equipped with the laboratory facilities peculiar to its own class of work.

The problem to be solved may require the consideration of one or more of these groups and whatever the number, each contributes that which he is best qualified to do. As a result, each problem receives the benefit of the attention of experts in any field the direction of its development may take.

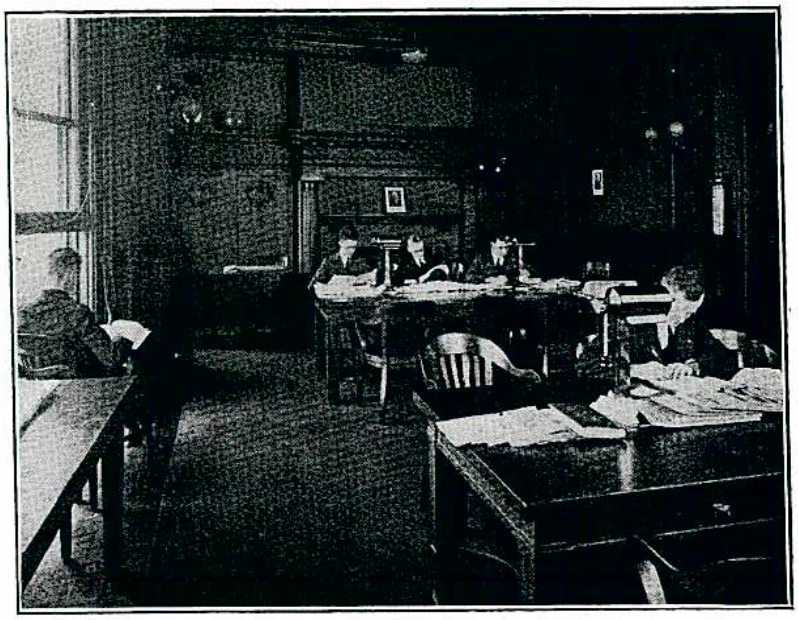
While in no way limiting the scope or initiative of the individual worker, this plan provides for the application of a very large amount of cooperative talent to any specific problem.

In addition to the laboratory facilities involving as they do an investment of several millions of dollars, there are provided all the necessary auxiliary services for a completely self-contained operating unit.

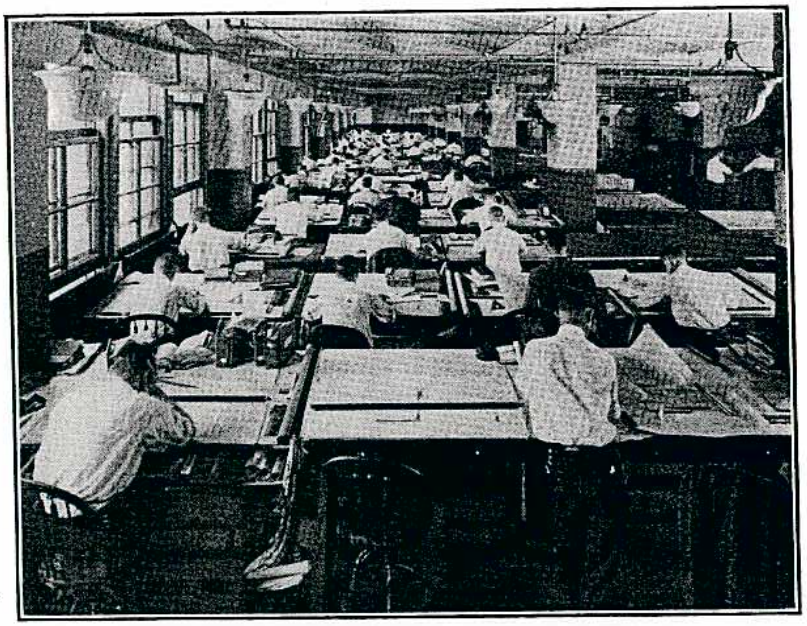
Machine shops for the construction of operating models for laboratory and field trial, drafting rooms for the preparation of experimental and manufacturing drawings, a library with a corps of translators and abstractors for the accumulation and distribution of technical data, educational and training classes for the younger personnel, all contribute to the effective carrying on of the primary function of research and development.

To review the accomplishments of this organization would be to relate the story of the development of the communication art, but a brief statement of some of the outstanding achievements of the past ten years will serve to illustrate the character of their work and its effect upon the industry.

Any telephone system can be considered a system of transportation in which the commodity transported is intelligence in the form of articulate speech. A large portion of the research effort has always been directed to the problem of converting speech into an electrical condition, its transmission to a distant point and its reconversion into mechanical energy in the form of speech. To assist in the determination of the best instrumentalities to be employed, consistent effort has been made to get away from the old empirical methods and build up a system based on a scientific consideration of the fundamentals of speech and audition.



Library Reading Room



One of the Drafting Rooms

The elements of speech most essential to proper intelligibility, the factors of extraneous noises whether they be mechanical or electrical, have been subject to quantitative study. These studies have resulted in a much more intelligent understanding of the elements that must be taken into account in the design of lines and instruments.

The electrical transmission features of the problem are peculiar to themselves, and an entirely new art as to the measurement and control of these extremely delicate and complex phenomena has been built up, so that the trial and error methods of earlier days have been supplanted by the methods of the physicist and mathematician.

Probably no single advance has contributed so largely to change our whole picture of the art as the advent of the thermionic valve or vacuum tube as it is designated in America. Located in a practically unexplored field of physical phenomena, the laws governing its operation and structures best adapted to meet some useful purpose, have received constant and intensive study by the laboratory organization. This work has resulted in the transformation of a crude and unwieldy device into an instrument of precision of tremendous commercial value.

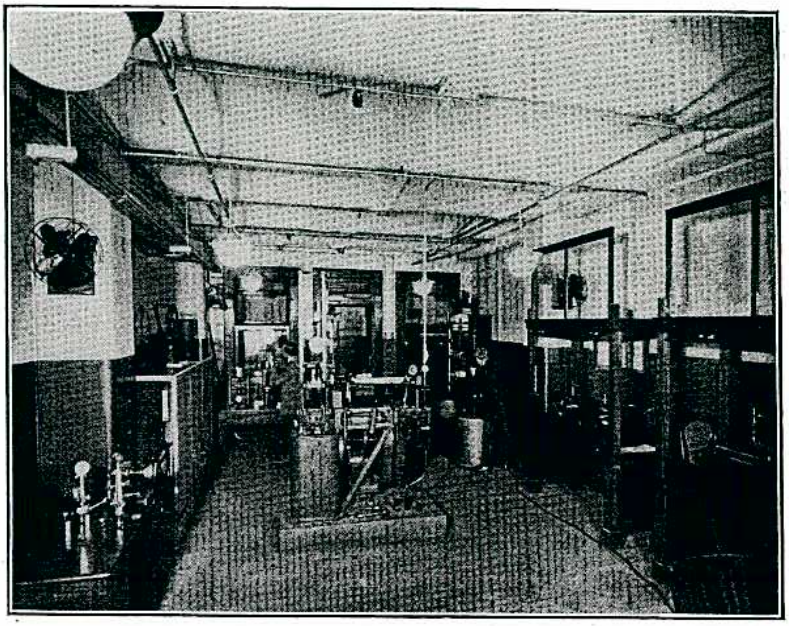
The fields which have been opened up by the commercial production of vacuum tubes of great uniformity and long life are much greater than might be ordinarily considered.

One of the most valuable applications has been in the extension of the range of long distance telephony. The vacuum tube telephone repeater has made possible telephonic transmission over practically unlimited distances. Conversations over distances of four to five thousand miles involving the use of twenty or more repeaters are no longer uncommon.

The repeater has also brought great advances in the use of telephone cables for long distance transmission, with the attendant gain in the reliability of service. Cable systems a thousand miles in length are in the process of installation.

The subject of radio transmission, particularly radio telephony, has been one of the important problems of research and commercial development.

The first important tests of radio telephony were made in the year 1915, when speech was distinctly heard from New York by way of the Arlington radio station near Washington,



Materials Testing Laboratory



Experimental Machine Shop

in Paris, Panama and Honolulu. Since that time developments have been rapid along a variety of lines. As a result of the successful development of the high power vacuum tube of an output of from 10 to 20 kilowatts, more complete and satisfactory demonstrations of trans-Atlantic telephone transmission have been made during the past year, when scheduled telephonic communication was established with England.

Radio broadcasting, which carries music and speech to hundreds of thousands of homes, has been brought to a high state of perfection and a large proportion of the most successful broadcasting stations are equipped with apparatus developed in the Bell System Laboratories.

Another development in the transmission field in which the vacuum tube has played an important part, is that relating to the more effective utilization of the wire plant through the use of carrier currents.

A variety of systems have been developed which permit the operation of a considerable number of telephone and telegraph circuits over a single pair of wires. In the case of telephony as many as five simultaneous conversations are possible over a single circuit. The same system applied to telegraphy affords twenty operating channels over a single pair of wires. The economies which can thus be obtained over lines of considerable length are large, and the service rendered has proved highly successful in a large number of installations which are in constant commercial operation.

Multiplex printing telegraphy has found an important place in the communication system, and by its use as many as eight telegraph messages may be sent in each direction over a single pair of wires over which a telephone conversation is being carried on at the same time.

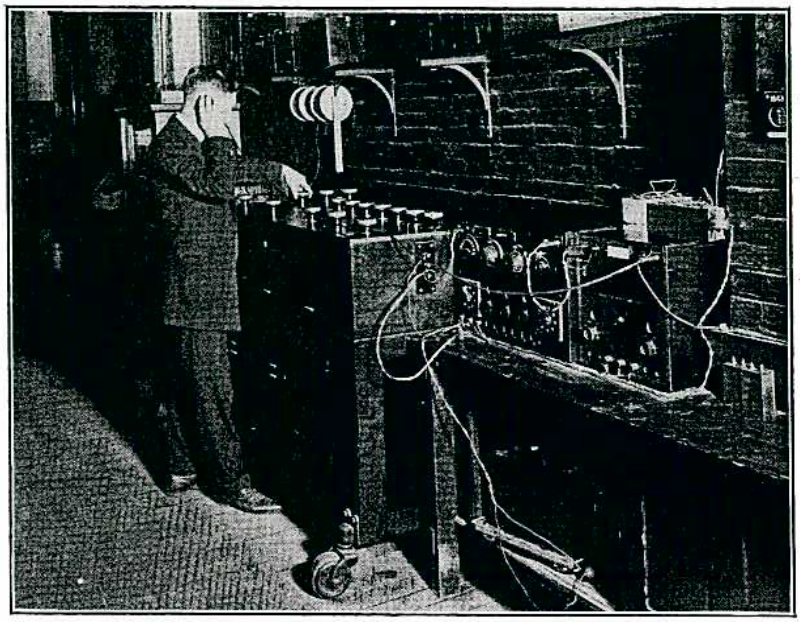
A great deal of effort has been and is continuing to be devoted to the perfecting of satisfactory mechanical central office switching systems to care for the extremely complex traffic conditions of the great cities. This work has resulted in the development and introduction of mechanical switching systems by means of which the manifold requirements of large metropolitan areas, such as New York and Chicago, have been successfully met. Hundreds of thousands of lines are now equipped and a continuing program of new installations of a similar character is under way.

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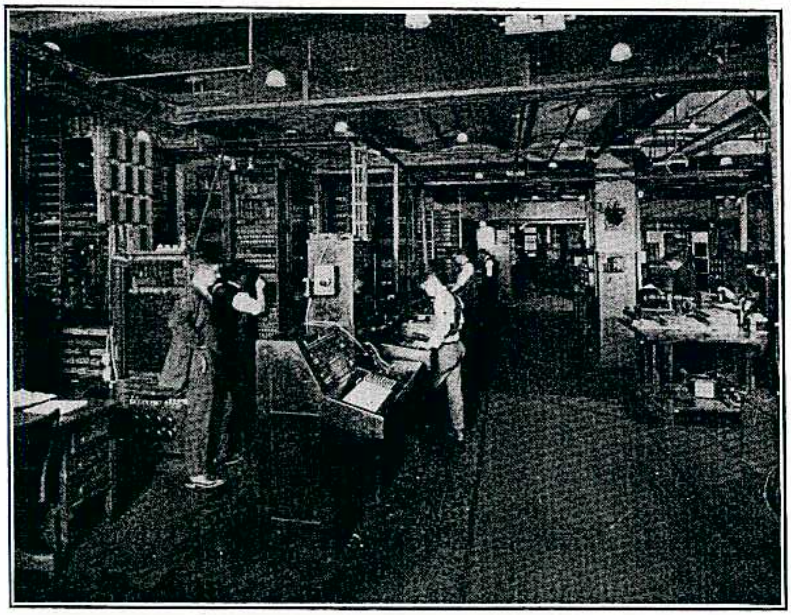
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One of the Carrier Current Testing Laboratories



One of the Machine Switching Laboratories

Study of another kind of switching and signalling problem has resulted in the production of selecting apparatus for railway train dispatching purposes which permits a dispatcher at a central point to put himself into immediate communication with any one of a large number of local stations along the section of the line for which he is responsible.

A similar system has been applied to the control and operation of the apparatus of power distribution networks. This system permits either the control of a number of switches or other apparatus located at a single point, such as a large power substation, or the apparatus to be controlled may be located at many points throughout the system, such as individual feeder circuits or small substations. By means of this system, the condition of the power control equipment at many distant points is automatically reported to a central point and through its use the so-called automatic power substation is made a thoroughly practical and reliable innovation.

Out of the results of the work of the laboratories directed toward the major problems of telephone and telegraph communication, arise many interesting by-products which often have valuable applications in other fields. As an example, in the study of telephone quality previously referred to, it was found necessary to devise an instrument for measuring with great precision the sensitivity of the ear to tones of various pitches and intensity. This instrument, which is known as the audiometer, has attracted a great deal of attention from ear specialists to whom it has been shown and bids fair to provide a valuable instrument for the study of defective hearing. In this same connection a knowledge of the characteristics of precision types of transmitters and receivers together with vacuum tube amplifiers has made possible the production of apparatus for the aid of those whose hearing is defective, and makes possible the correction of hearing deficiencies far beyond anything that has previously been considered possible.

The oscillograph evolved from the familiar Braun tube has found a place in the study of high frequency currents of the character employed in telephonic transmission. In this type of oscillograph the inertia of its moving element, a



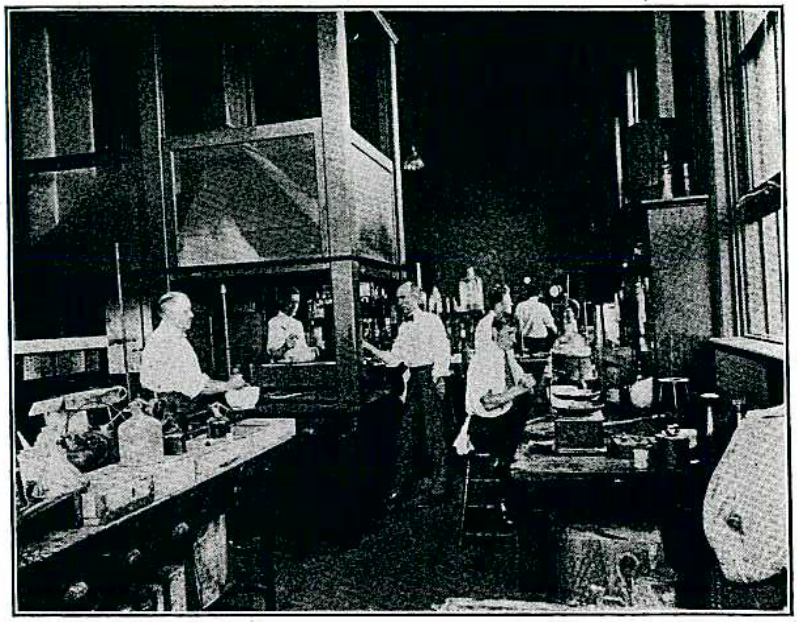


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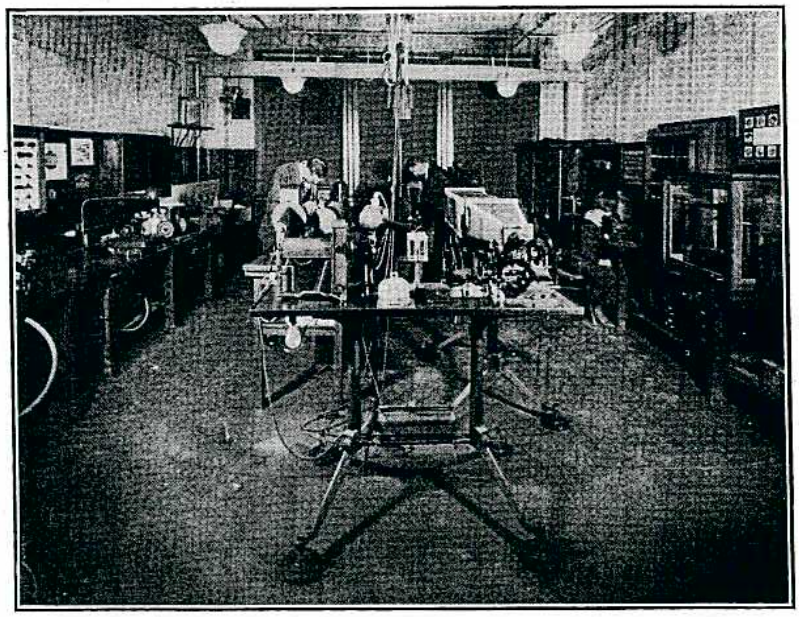


Photo-Micrographic Laboratory

stream of electrons instead of the ordinary coil and mirror, is so small that it may be made to accurately follow frequencies of a million cycles or more.

In most cases a development is undertaken to meet a recognized need. Often, however, a line of investigation is pursued with a view to extending our general scientific knowledge; and such a study sometimes bears fruit where least expected. Experiments with transmitters of the greatest possible faithfulness of reproduction, regardless of sensitiveness or efficiency, became of great importance with the sudden development of radio broadcasting and public address systems. A scientific investigation of the so-called "piezo-electric effect"—the characteristic of certain crystals of generating an electromotive force, sometimes of several hundred volts, through the proper application of a mechanical movement—is developing interesting possibilities. Studies started some years ago, on the magnetic properties of certain nickel-iron alloys, are now bringing about revolutionary changes in submarine cable construction and operation, and promise equally important advances in other directions.

Many of the developments that have thus been briefly referred to have been the subject of previous contributions to this Journal and it is to be hoped that many similar contributions are to follow.

Consideration of these more outstanding developments does not, of course, give any picture of the vast amount of detail work which is done every day in the preparation of information and specifications to permit the manufacture of the various products of the Western Electric Company. All those familiar with the problems of large scale production of intricate apparatus can appreciate the magnitude of this task.

Neither can it picture the steady improvement and refinement in quality and reliability of standard equipment which has contributed a large share to the progress of the telephone art in America.

In many ways the organization is unique, in that its efforts are directed toward the production of devices and systems not primarily for sale but for use. Its objective is the production of systems and equipments and materials

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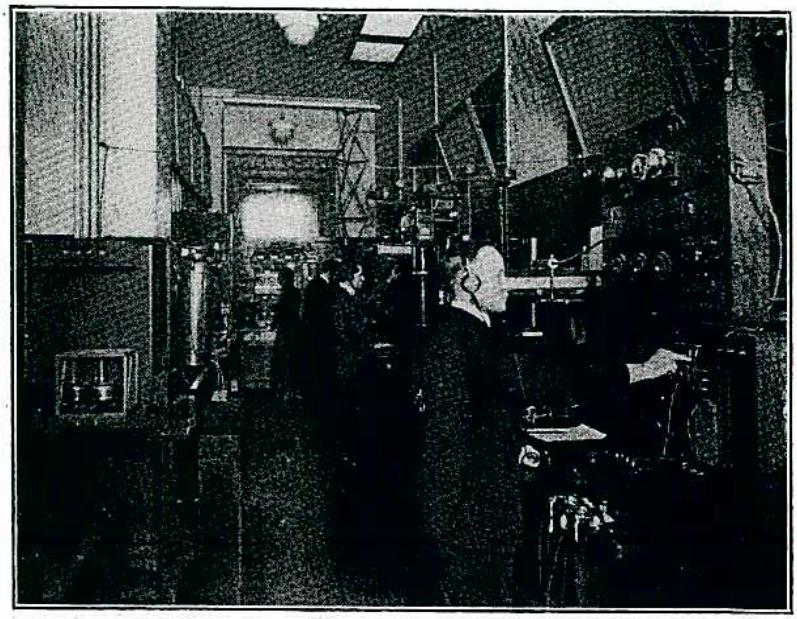
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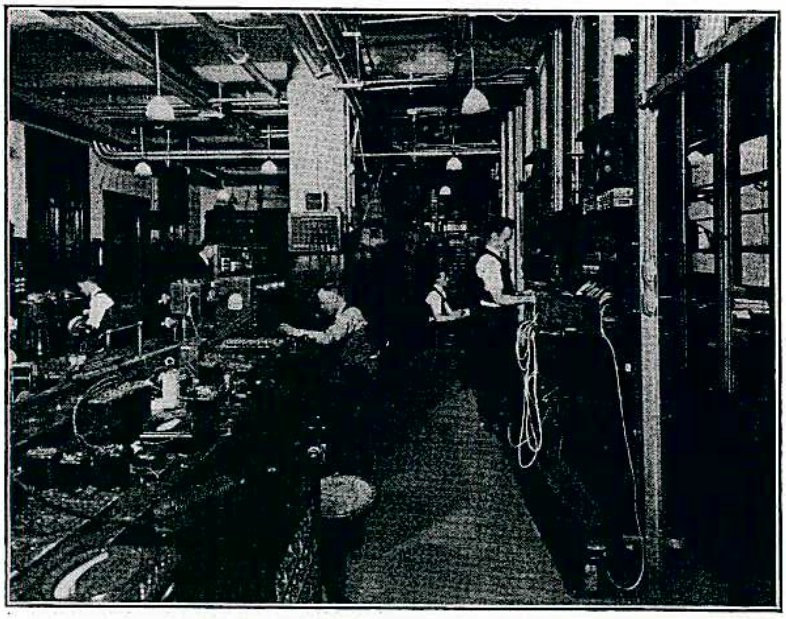
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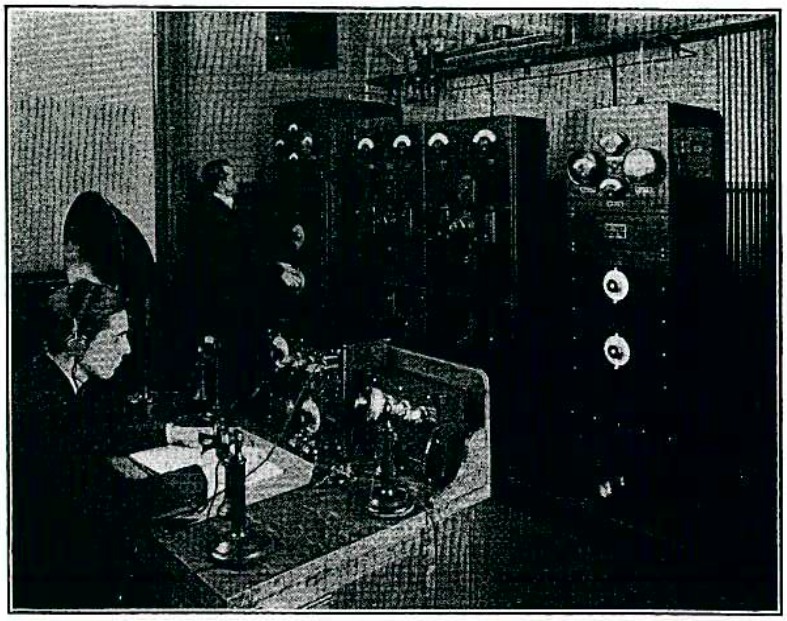
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One of the Transmission Research Laboratories



One of the Systems Development Laboratories



Experimental Radio Broadcasting Station



One of the Vacuum Tube Research Laboratories



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which will render the most economical and effective service throughout their useful life. This may often mean that a more expensive rather than a cheaper device, so far as first cost is concerned, will be employed, or a higher grade material used than might be considered if such factors as maintenance and repairs and freedom from operating irregularities were not considered in arriving at a conclusion which is to meet the test of the above formula. Thus it is possible to apply the same scientific and engineering methods to the practical application and use of the products, as were employed in their original conception and development. This means in the last analysis that so far as human frailties will permit, those finally chosen are the ones that are fundamentally best qualified to meet the requirements of the service to be rendered, and the choice is made without regard to many of the artificial considerations that must be taken into account if mere salability is the criterion by which the product is to be judged.

The Bell System Research Laboratories have been honored by visits from many of our readers, but for those who have not yet made the pilgrimage, the accompanying photographs will serve to give some idea of the physical appearance of the institution which is dedicated to the development of the art of Electrical Communication.

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Western Electric Company

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Western Electric Company (Australia), Ltd., Sydney

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Vereinigte Telephon und Telegraphen Fabriks A. G., Vienna

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Bell Telephone Manufacturing Company, Antwerp

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International Western Electric Company, Inc., Rio de Janeiro (Rua dos Ourives 91-1)

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Le Matériel Téléphonique, Paris

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Hungary—
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Western Electric Italiana, Milan

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Nippon Electric Company, Ltd., Tokyo

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Western Electric Norsk Aktiesel-skap, Christiania

Spain—
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Straits Settlements—
Western Electric Company, Ltd., Singapore

Switzerland—
Bell Telephone Manufacturing Company, Berne

OR THE

International Western Electric Company

INCORPORATED

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