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COSMIC RAYS

By RUSSELL M. OTIS

THIS is an age of rays. We are familiar with X-rays; with alpha, beta and gamma rays; with cathode rays; and with ultra-violet and infra-red rays. This is a rather large family of comparatively respectable rays. Indeed, they are all quite at home in the laboratory. Now, alas, we have the spectacle of a more unruly brother ray who has spent himself dissolutely roving through interstellar space and has only recently come home to Mother Science to be named—The Cosmic Ray.

Cosmic rays are the most penetrating rays known. The X-rays employed in our hospitals are valuable through their ability to penetrate matter. One-half of an inch of lead will stop the most penetrating of them, but the cosmic rays have been observed after having passed through matter equivalent in thickness to six feet of lead.

One cannot perform this experiment in a laboratory. To make the acquaintance of cosmic rays it is necessary to go to high altitudes either in airplanes or balloons or by climbing mountain peaks, for the intensity of the rays increases as one goes higher into the atmosphere. Indeed, it was this very fact that led physicists as early as 1912 to suspect the existence of some form of cosmic rays. Up to that time, however, they had not been distinguished from what was called the "penetrating radiation," a radiation very similar to the gamma rays which for some years had been found to occur in the atmosphere, away from all known sources of radiation. Gamma rays themselves are produced when the nuclei of certain radioactive atoms suffer disintegration. They are an electromagnetic radiation like ordinary light, but of a wave-length only about one hundred-thousandth as great.

Following the discovery of the penetrating radiation a great deal of work was done toward locating the source of the rays, and that problem is not yet completely solved. Their intensity was measured in buildings,

in forests, in tunnels, over water and under water. From this work the conclusion was reached that most of the rays observed anywhere on the earth's surface at sea level, were simply gamma rays from radioactive matter in the surroundings; and that is today held to be true.

Fortunately the matter did not rest there. Some experimenters made observations on towers and in balloons and found that the intensity of the radiation did not decrease as they thought it should as they left the earth's surface and went on high altitudes. True, as they ascended the radiation first became weaker; but when they reached an altitude of less than half a mile the radiation started to grow stronger until at an altitude of 5.6 miles it was reported by Kolhörster in 1914 to be nine times as intense as at sea level. This increase in intensity of the radiation with altitude was very perplexing for it meant that as one traveled to higher altitudes he was coming closer to the source of the rays; and it was not to be expected that the upper layers of the atmosphere contained more radioactive substance than the air close to the earth. So where could the rays come from if not from outside of the earth's atmosphere?—perhaps from the sun or from a layer of cosmic dust. And if the rays came from outside the earth's atmosphere how penetrating they must be to come all the way through our protecting coat of air which is equivalent to a thickness of over two and one-half feet of lead!

With this suspicion of an unknown cosmic ray the problem rested while the world went to war, and interest in the subject has only recently been aroused through the announcement by Dr. R. A. Millikan of the results of researches on the penetrating radiation made by him and three of his students at California Institute of Technology.

First, the increase in the penetrating radiation with altitude, which had been noted by the European physicists in balloons, was qualitatively checked employing airplanes instead of balloons. Then an ingenious little recording electroscope was sent to an altitude of nearly ten miles and brought back the information that the radiation at these very high altitudes was much less intense than one should expect from an extrapolation of Kolhörster's data. This indicated that the radiation must be extremely penetrating; or that it came from radioactive matter suspended in the atmosphere, in which case it would have the same absorption coefficient as ordinary gamma rays. It, therefore, became important to know the penetrativeness of the rays which were being observed.

Accordingly, experiments were made on Pike's Peak which proved of great interest. It was necessary to do the work at a high altitude because only at high altitudes is the intensity of the penetrating radiation great enough to permit significant experiments. It was found that two inches of lead would cut out by far the greater portion of the penetrating radiation and that most of the rays, even at high altitudes, were not distinguishable from ordinary gamma rays. This, of course, meant that they could not have come a great distance through the atmosphere; i.e., they were of relatively local origin; and if any rays of cosmic origin were present they were decidedly in the minority.

But, as is always the case, the mi-

nority was extremely important, for other experiments performed at a lake on the trail to Mt. Whitney detected the elusive cosmic ray as the chief constituent of that minority. The cosmic rays were still strong enough to register an effect after having passed through fifty feet of water! Since they had presumably come all the way through the earth's atmosphere, which to that altitude is equivalent to twenty-three feet of water, they really had traversed matter equivalent in thickness to seventy-three feet of water or over six feet of lead!

Great penetrating power is a property of radiation of high frequency—that is, of short wave-length. Making calculations on this basis it is found that the cosmic rays have extremely short wave-lengths—the shortest observed being one-fiftieth that of the most penetrating gamma rays or about one-ten millionth that of ordinary visible light. It seems likely that these very high-frequency rays, upon striking matter, are transformed into radiation of lower frequency, and that this accounts for the large amount of less penetrating radiation observed on Pike's Peak.

But where in nature's great laboratory is the birthplace of these strange wanderers? The sun? No, because there is no difference in the intensity of the rays between day and night; furthermore, there is no one direction from which they come more plentifully than from any other. Pretty certainly they come from outside our atmosphere and that is about all we can say.

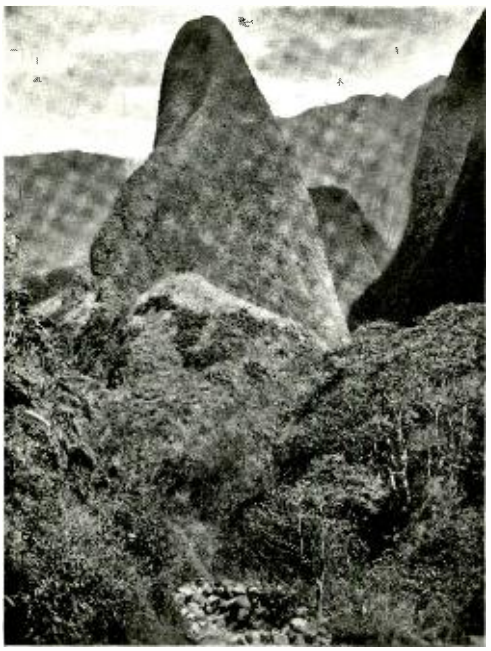
As to how these unique rays originate it is at present only possible to guess. The unproven hypotheses which have been advanced are of interest because of their tremendous importance if they should be proved true. The change in the nuclei of hydrogen atoms if they were transformed into helium atoms would involve a liberation of energy which, if it were in the form of radiation, would have a frequency close to that of the observed cosmic rays. That is one possibility, but Millikan thinks the most probable source of the rays is the capture of electrons by positive nuclei. We must wait for further research to disclose the import of these signals from the atomic world of the interstellar spaces, for any attempt to produce them in the laboratory seems at present quite hopeless because of the tremendous energies involved.

What are these cosmic rays going to be used for? Of what practical value are they? They assuredly cannot be drafted into industry nor act as a new source of power; nor will they revolutionize society. Although very penetrating, they are very feeble. At sea level their intensity is hardly more than a tenth that which comes from the radioactive materials in the ordinary things around us. Probably their chief value will be in stimulating further research; and that value is difficult to estimate, as anyone in a research organization well realizes.

Planning a Radio-Telephone System

By Francis M. Ryan

As vacationers come and go, they talk of trips to Maine, the Adirondacks, the Rockies, and even to the uttermost parts of New Jersey. All their mileage-records, by boat, train and car, leave me cold, for last year about this time was I not setting out myself on a ten thousand mile expedition? True, it was not a vacation, yet it had all a vacation's



The Needle, in Iao Valley near Wailuku, Maui

pleasures—"new sights, new sounds, new air," as Kipling says. For the Mutual Telephone Company of Hawaii had decided that an inter-island radiophone network was worth studying, and the choice fell upon me to make the field investigation.

There are eight principal islands in the Hawaiian group, of which four seemed to justify inclusion in a radio net. The Mutual Company operates telephone systems on three of these islands; on the fourth is a system operated by local interests. My assignment was to study radio transmission—static and signal strengths and their variations—and recommend apparatus and locations for radio stations.

After a pleasant trip across the continent, Harold Buttner and Nathan Levinson, then representing Western Electric's radio interests at San Francisco, wished us "bon voyage" as we* began our sea trip. Day by day the weather became warmer and when we were three days out from the Golden Gate our steamer rugs were cast aside. At night we sailed under an intense moon which played hide-and-seek with beautiful white clouds and painted a path of silver across the ocean. We were caught by the beauty of these tropical nights, and their charm held us throughout our stay in the Islands.

The morning of the sixth day found our steamer anchored off Honolulu awaiting the formalities of medical inspection. The greatest surprise was the verdure of the hills and mountains of the Island of Oahu. Some-

* *Mr. Ryan's mother shared with him the pleasure of this trip.*

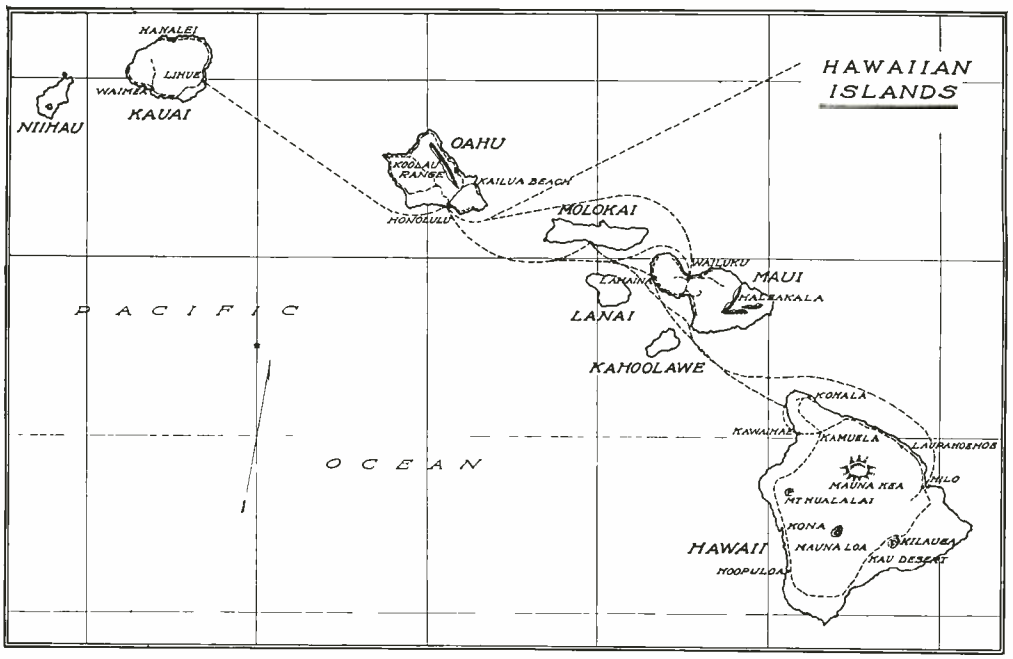
The business section of Honolulu as viewed from Punchbowl, one of the several extinct volcanoes on the island of Oahu

how, I had expected dry brown hills like those of California in summertime, and here they were beautifully green.

Our first day in Honolulu was a full one, giving us at once a sample of the hospitality for which Hawaii is famous. Visiting the beach home of Mr. F. G. Hummel, General Manager of the Telephone Company, at Waikiki, surrounded by a luxurious tropical garden and then the home of Mr. J. A. Balch, Vice-President and Treasurer* of the Company, situated on the mountainside in beautiful Manoa Valley, and overlooking Waikiki, Diamond Head and Kaimuki, we had our first opportunity to study the relative advantages of living "makai" or "mauka" (toward the sea or toward the mountains). It was a problem that we never solved for the attractions of both the sea and the mountains in Hawaii are innumerable. Probably the only solution is that which so many residents have adopted; that of having both a beach and a mountain home and alternating their place of residence.

This first day brought us our first view of the Nuuanu Pali, which, for combined beauty and grandeur, is not equalled elsewhere in the Islands, if indeed elsewhere in the world. A scant seven mile drive up the moderate grades of the splendid highway through the Nuuanu Valley brought us suddenly to a lookout point at a

** Mr. Balch has since been elected president of the Mutual Telephone Company.*



An outline map of the Hawaiian Islands. Mr. Ryan's route is indicated by the dotted lines

notch in the Koolau Mountain Range. Here there is a sheer drop of 1200 feet to the lowland which sweeps on to the sea on the windward side of the island. The beauty of the coloring is beyond the power of description; above, a blue sky dotted with lovely clouds; below, a carpet of green on a floor of red soil reaching out to a blue and green ocean with a border of white surf; and to either side, rugged mountains carpeted with green. Looking over the miles of land between the mountains and the sea, the eye picks out patches of the light green of young rice, the regular patterns of the pineapple fields of gray-green, the banana and papya trees, and in the distance sugar cane fields. It was a point we frequently visited and which grew in charm. Changing positions of the sun produced totally different effects; sometimes it all looked more like a stage setting than a natural scene. It was over this pali or cliff that Kamehameha, King of Maui, drove the warriors of Oahu to their death when he conquered the island in 1795.

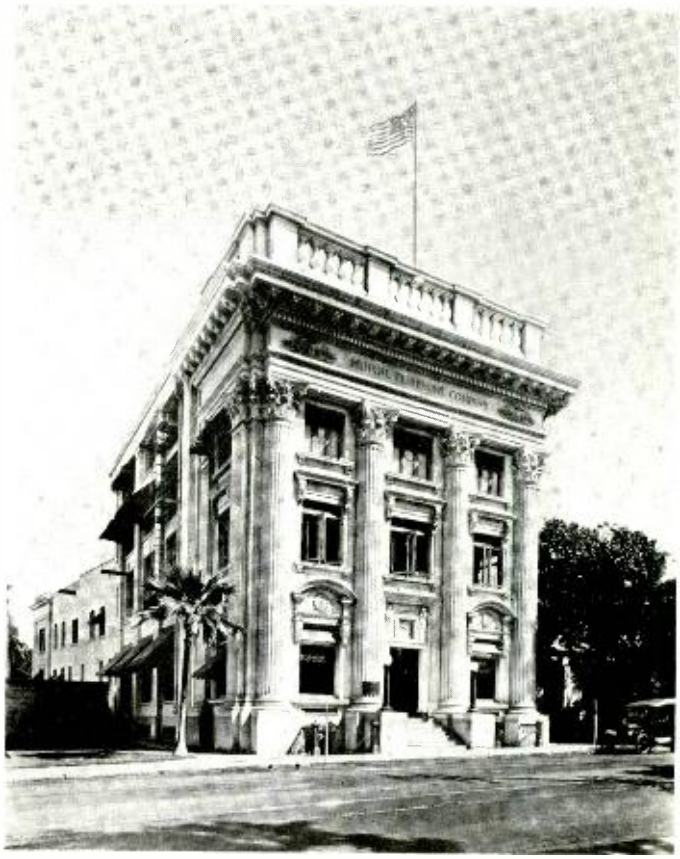
Honolulu is an up-to-date city of 100,000 people with many modern buildings, well-paved streets, an excellent street-car system, gas, electric lights and every convenience to which we are accustomed at home. The telephone system is of the "step-by-step" automatic type and serves 12,000 subscribers, all with single party lines. The system is unique in that more than one-fourth of the subscribers are served through small unattended automatic exchanges located in the outlying districts of the city. There are sixteen of these little "of-

fices" each housing one or two hundred rotary line switches and having a separate compartment for the storage batteries which are continuously charged by tungar rectifiers. There are also three large attended offices, the downtown one of which contains the toll board, providing connections to all parts of the Island of Oahu, and from which it is planned, through the medium of radio, to provide service to the other principal islands of the territory.

As one strolls about Honolulu he is immediately struck with the strange mixture of East with West, for a large part of the population is of Oriental extraction. Figures show that of the Territory's population of some 300,000, more than a third are Japanese, with Europeans and Filipinos next, and the native Hawaiians a scant seven percent.

A glance at the Honolulu Telephone Directory shows the Yamamotos and Yamadas to outnumber the Smiths and Joneses; the Changs, Chings and Chongs are close seconds. A striking example of the matter-of-fact way in which these people of such varied racial ancestry look on each other is had in the Honolulu office of the Mutual Wireless Telegraph service. The superintendent is a white man or "haole," the chief operator a Chinaman, the counterclerk a Portuguese and the bookkeeper a Hawaiian. These men work together with the same spirit of cooperation and as little friction as we have in our own organization.

English is universally spoken and it is very seldom that anyone is encountered in the Islands who cannot understand it. However, much Japanese, Chinese and Hawaiian are spoken by the older generation. The Hawaiian language utilizes but twelve letters, the five vowels a, e, i, o, u and the consonnants h, k, l, m, n, p, and w. A few Hawaiian words have come into general use in the



Main office building of the Mutual Telephone Company, Honolulu. This is a splendid example of the many modern buildings in Honolulu

"Windward Oahu," from Nuuanu Pali. This is the most beautiful scene in the Islands

Territory by all people, and the headlines of the daily papers are sprinkled with such words as "mauka," "pau," "maikai," etc.

Three first-class daily newspapers, two in English and one part in Japanese and part in English are published in Honolulu, and several of the smaller towns on the other islands have their own papers. During the lunch hour early editions of the evening paper appear on the street, carrying the closing prices for the day of the more important issues traded in on the New York and San Francisco exchanges. These quotations reach Oahu from the mainland, 2,100 nautical miles distant, over the system of the Radio Corporation of America. The transmitting and receiving stations of this system were established in 1914 under the direction of N. H. Slaughter, who is now in charge of our Laboratories' radio development work. Telegraph communication with the mainland is also had by cable and by Naval Radio. An efficient inter-island telegraph service is provided by the wireless system of the Mutual Telephone Company.

Among my equipment was a 250-watt radio transmitter which with the assistance of the Telephone Company was set up on their building at Honolulu. Afterward it was moved to other locations, one on the shore a few miles away, and another at Lahaina on the island of Maui. Carrier field strength tests were made with a measuring set similar to that described by A. G. Jensen in a recent* issue of the RECORD. Articulation

* *June*, 1926; *page* 177.

Cocoanut trees on the rugged coast of the Island of Hawaii

tests were made by repeating lists of disconnected words and counting the number of errors made in interpreting them at the receiving station. This station was moved to fifteen different locations; in its migrations I saw a great deal of the islands by rail, automobile and steamers of all sizes and descriptions, from little cattle-boats to ocean liners. At those places which appeared to be promising as sites for stations, several continuous tests of twenty-four hours were made. In general the static level was lower than at home and in the frequency-range finally adopted—1500 to 1750 kilocycles—the signal strength was satisfactorily constant.

The project contemplates a two-way radio channel from Honolulu to Kawaihae, with a wire extension to Hilo, this channel to have a radio repeater station at Lahaina. Under control of the switchboard operator at Wailuku, a line from this point could be cut into the circuit at the repeater station, just as any long distance circuit is cut for local service. Other proposed channels are from Honolulu to Lihue; and a second Honolulu-Lahaina-Wailuku channel if traffic warrants it. Each radio link would be about 80 miles long, for which 500-watt radio transmitters have been proposed. By this system of radio linkage, telephone subscribers on any of the four principal islands could be connected.

The middle of January brought the field work to completion, and

A field of sugar cane

from the deck of the steamer we had our last view of beautiful Honolulu and Waikiki, for several months our home. It was with considerable regret that we left the many friends made during our half-year sojourn in those Islands for which we had come to care so much.

In Tune or Out of Tune

By Joseph C. Steinberg

When an orchestra tunes up, their instruments are not brought into exact synchronism because the ear is unable to perceive the small differences in pitch which are measurable with physical apparatus. Similarly a singer may deviate somewhat from the pitch of the accompanying music without the audience being aware of it. Not only may sound waves differ in frequency, but they may differ in intensity as well, and still appear identical to the ear. The frequency is associated with the rapidity of vibration of the sound source, and the intensity with the power that is radiated by the vibrating source. The corresponding aspects of the sensation of tone which is produced when such a wave acts on the ear are respectively pitch and loudness.

In telephony it is necesary to transmit, and to reproduce as speech or music, sounds which are combinations of tones with various frequencies and intensities. In general the reproduced waves are not exact copies of the initial waves because some of the component tones have suffered modification in frequency and intensity. It is important, therefore, in designing or selecting apparatus, and in setting proper operating limits, to know the amounts by which either the frequency or the intensity of a tone can be changed before the change becomes perceptible to the human ear.

Only within a definite range of frequencies can sound waves cause a sensation of tone; and similarly the intensity which will cause a sensation of tone is limited in range. Each sound wave of a given frequency requires a definite intensity in order to be just audible. If the intensity is greater than another definite amount a "stinging" or "tickling" sensation is produced. These limits are known respectively as the "threshold of audibility" and the "threshold of feeling." The range of frequencies within which sounds will cause a sensation of tone extends from twenty cycles per second to 20,000 cycles per second, or in musical notation through approximately ten octaves. Sounds of frequency outside this range will not cause a definite sensation of tone at any intensity.

If the intensity of a sound be slowly increased from some definite value, and if one compares the increased sound with that of the original intensity by listening to them alternately, the sounds will appear equally loud until the intensity has been increased by a definite amount. The actual amount differs in various cases, for it depends upon the intensity and frequency of the initial sound. Similarly if the frequency be slowly increased, a minimum and definite change will be required before an observer can distinguish between the tone of increased frequency and the initial tone.

When either the intensity or frequency has been increased by a just perceptible amount the tone that is thus produced, differing from the ini-

tial tone in either loudness or pitch as the case may be, can be regarded as a new tone. From this point of view, in going from the threshold of audibility to the threshold of feeling there are approximately two hundred and seventy tones, all of which may have a common frequency of vibration of one thousand cycles and yet can be perceived as being different in loudness. For a note of about two octaves above middle "C," in other words, there are possible about two hundred and seventy perceptible steps by which the intensity may be varied. Similarly at a loudness about half way between the threshold of audibility and the threshold of feeling there are about 1300 tones which are perceivable as being different in pitch.

The intensities of sound at pitches ordinarily encountered in speech and music, and hence of most importance to the telephone engineer, extend from about one-quarter to three-quarters of the way between audibility and feeling, that is over a range of about two hundred just-perceptible steps. Within this range a ten per-cent change in intensity will just produce a new tone; and so will a three-tenths per cent. change in frequency.

In the experimental determination of this minimum perceptible change in pitch the observers were required to recognize change in frequency only, and not the direction of the change, *i.e.*, whether higher or lower in pitch. It appears that those with musically untrained ears perceive as small a change as do musicians, but that the latter are better able to determine the direction of the change. The minimum perceptible changes represent in frequency one two-hundredth of an octave and in intensity one-half a transmission unit. These amounts may also be regarded as changes in frequency and intensity respectively which will just escape detection. They are limits set by the ear itself and represent the requirements which must be met by apparatus for transmitting and reproducing sound in order that the reproduction be indistinguishable by direct comparison from the original sound.

New Amplifier For Public Address Systems

By Harry A. Dahl

As the use of public-address systems has become more general, a need has been increasingly felt for convenient and economical power supply. Originally systems of all types were supplied with direct current from storage or dry cells or from generators. With the development of the art, ways are being found to eliminate one after another of these direct-current sources. Filaments in certain stages of amplifier systems may now be heated by 60-cycle alternating current from a transformer connected to the central station lines. For the plate circuits direct current may be obtained by rectifying 60-cycle alternating current of suitable voltage. For the grid circuits necessary biasing potentials are derived from the voltage drops across resistances through which flow the direct currents of the filament or plate circuits. All of these ideas are applied in the 6025-B amplifier, described in a recent issue of the Record; in fact, the success of this device suggested that it be made the final stage of a new amplifier for public address use.

The 32-A Amplifier

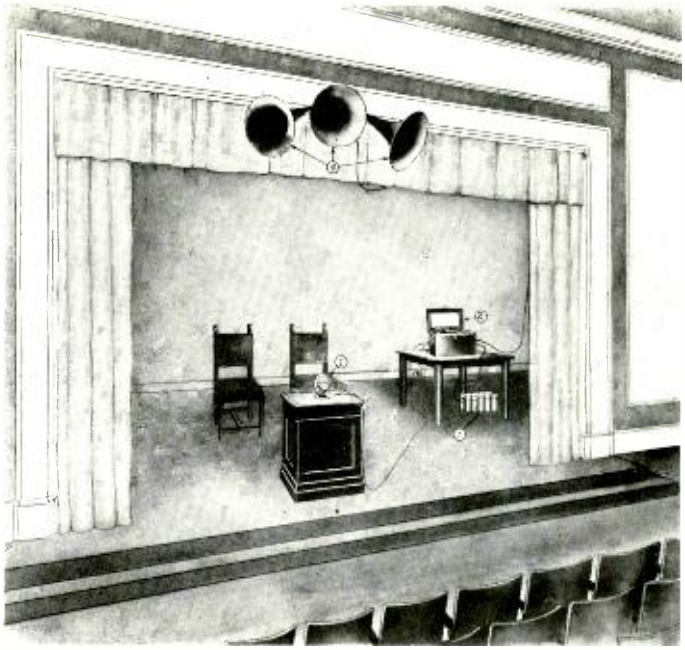
In planning this new amplifier suggestions were invited from our engineers who install and demonstrate public-address systems. As 60-cycle alternating current is almost universally available, it was decided to use it as far as possible as the source of power. To speed up installation, standard attachment plugs were used for external connections; since many installations are temporary, the amplifier was designed to be portable. Facilities for measuring significant currents and voltages were provided.

As finally designed and code numbered, the 32-A amplifier contains four stages of amplification; the first three employ the new 230-D tubes.* Coupling between tubes in the first three stages is effected by resistances and in the last stage by a transformer. For the final stage, the apparatus and wiring assembly of the 6025-B amplifier is used; this assembly contains a vacuum-tube rectifier and filter. Part of the resulting current feeds the last stage; the remainder is again filtered

* *This tube requires 60 milliamperes filament current at 3 volts; it may be used with plate voltages up to 135.*

and passed through resistances to give the proper plate current in the tubes of the preceding stages.

Many public address systems are called upon to amplify radio programs. A radio receiver usually terminates with a vacuum tube whose impedance is much greater than that of a microphone. Accordingly, two input transformers are incorporated in the 32-A amplifier, one of high impedance for connection to a radio receiver, the other for connection to a microphone. Two microphones are frequently used, for example on a speakers' table or on lectern and pulpit; a switch is provided in the amplifier to connect either microphone to the input transformer. Amplification is controlled by a potentiometer having twenty-two steps of three transmission units each. By connecting the two secondary windings of the output transformer in series or in parallel, two values of output impedance are available. The higher value is used for a load of one to four sound-projectors and the lower for a greater number.



The 4-A Public-Address System: 1—speakers' microphone; 2—amplifier; 3—battery for microphone (11-15 volts); 4—projectors

Current for the filaments of the first three tubes, and for the microphones, is drawn from a 12-volt battery, either storage or dry, for little more than one-tenth ampere is required. All other currents and potentials are furnished from the alternating-current mains; the load is about forty watts. (Where only direct current is available from the mains, a small motor-generator supplies alternating current). For the 13-C amplifier, used in the No. 3 public address system, a 12-volt storage battery, delivering several amperes and a 250-volt dry battery were required. All of these are now replaced by the new 32-A amplifier which, combining advances made in several experimental fields, becomes the backbone of No. 4-A, the new public-address system.

The First Underground Telephone

As the telephone came into general commercial use, its advantages became apparent for communication between mining operations and the surface. Several arrangements of existing instruments were tried, but due to excessive humidity and acid vapors underground they proved short-lived. Finally, in the laboratory of the American Bell Telephone Company of Boston a subscriber's set was designed whose heavy wooden box, treated with acid-proof paint, had a cover screwed down on a rubber gasket. The crank post of the generator and the striker rod of the ringer were brought out through oil glands in the side of the box. Operation of the transmitter and receiver located within the box was effected through long rubber tubes. The line wires were copper heavily insulated with rubber, over which was a treated and braided linen covering. To provide against interruption of service in case of accident the wires were carried into the mine by separate routes. They were hung in long loops from the timbers of the slopes; in case of a cave-in they would go down with the falling earth with small probability of breaking. Normally the circuit used was metallic but in the event of a broken line-wire a switching device at the telephone set provided a means of using the wire which remained intact in a ground-return circuit.

Disguised as miners: W. L. Richards of the Boston Laboratory; John Crowfford of the Telephone Company; and Mahlon Frederick, an installer

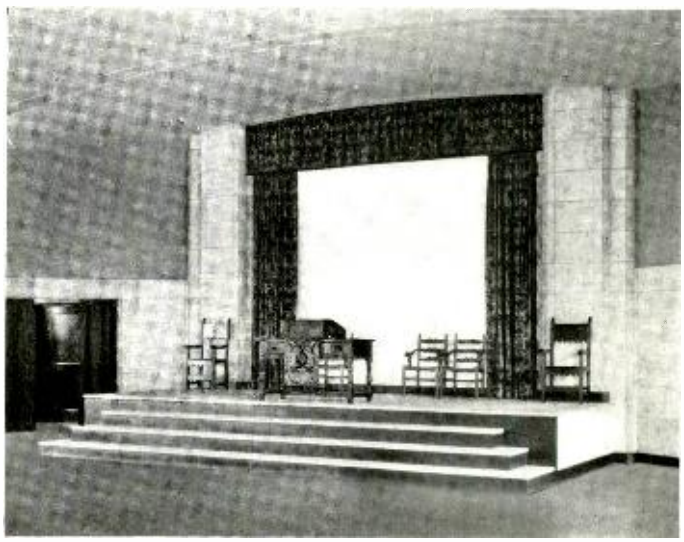
In 1888 W. L. Richards, our Consulting Historian, was a member of the Boston Laboratory Staff. He was sent to supervise the installation of some of these sets in the mine of the Lehigh Coal and Navigation Company at Lost Creek, Pa. One instrument was placed at the foot of the slope and another in the engine room at the surface.

A report on file dated 1892 shows that these instruments held up well under the conditions to which they were subjected and gave uninterrupted service, until, with the advance of the art, they were superseded by other types.

News Notes

WHILE our new auditorium in section H is not, as yet, fully equipped and has not been dedicated for formal use, it was used informally on July 6th when some eight hundred men of the Laboratories were addressed by Mr. Craft. Defining the auditorium as an "inspirational laboratory," Mr. Craft expressed the hope that it might frequently be used by various groups to promote better acquaintance and the interchange of ideas. Equipment is being installed for motion pictures—silent and talking—and for lantern slide projection; and beginning next autumn it is expected to have every month an assembly similar to this.

That these Laboratories are a business institution was Mr. Craft's next point. Although their product is the unusual one of ideas resulting from research, development, and engineering considerations, nevertheless they are a business institution, and must operate on business lines. In advance of each year a budget of expenditures is prepared representing totals which, in the judgment of its directors, are legitimate expenditures for that year for the assigned purposes. Business principles require adherence to such budgets. Although this appears difficult since the demands of research and development work and their possible extensions, can not always be closely predetermined, it is necessary as a business organization not only to end each year within the budget provided but with a rate of expenditure which does not demand exhorbitant extensions for the succeeding budget. Since salaries constitute over three-quarters of the operating expense a proper selection of projects to be worked upon and effective coordination of existing personnel are two immediate methods of accomplishing desired results. Such selection and coordination can only be accomplished by the active cooperation of the entire supervisory staff and indeed of every member of the organization.



Speakers' platform in our new auditorium

A GENERAL CONFERENCE regarding quality rating methods and general apparatus inspection matters was held in Hawthorne during the week beginning June 14th. R. L. Jones, D. A. Quarles and H. F. Dodge represented the Laboratories.

G. Q. Lumsden recently visited Indianapolis in connection with an investigation of wood preservatives. E. M. Honan has been in Massachusetts, Indiana and Missouri for the purpose of discussing with various manufacturers matters affecting design and quality of clay conduit and certain types of outside plant hardware.

During June, W. A. Boyd, R. M. Moody, H. F. Kortheuer and W. C. Miller were in Hawthorne in connection with regular Inspection Survey Conference work.

J. K. Erwin, Local Engineer for the Inspection Department at Atlanta, has recently visited Miami, West Palm Beach and other Florida points in connection with regular work in his territory.

P. B. Almquist, Local Engineer at San Francisco, visited Seattle and other points in the northern part of his territory during July.

* * *

SERGIUS P. GRACE was recently elected president of the New York Electrical Society for the coming season. The Society, which has nearly 900 members, has as its aim the popular interpretation of advances in science and achievements in industry and the arts.

The newly elected vice-presidents are E. E. Free, consulting engineer; E. E. Dorting, Interboro Rapid Transit Company; and J. P. Alexander, General Electric Company. H. E. Farrer, secretary, and David Darlington, treasurer, were re-elected.

* * *

HUMPHREYS O. SIEGMUND has received from the University of Illinois a professional degree in Electrical Engineering. This degree is awarded to graduates who have completed several years' professional activity and presented a thesis covering some phase of their work. The title of Mr. Siegmund's thesis is "The Use of Electrolytic Condensers in a Special Low-Pass Electric Wave-Filter."

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"SOME MEASUREMENTS of Short Wave Transmission" was the subject of a paper presented at the June 30th meeting of the Institute of Radio Engineers by J. C. Schelleng and R. A. Heising of the Laboratories and G. C. Southworth of the American Telephone and Telegraph Company.

The Viewpoint of Inspection Engineering

By R. L. Jones
Inspection Engineer

In the advance of science new fields of activity open, to which new names must be applied. Physics and chemistry jointly enter an unexplored region which is then called physical-chemistry; biology and physics, as well as biology and chemistry, find relationships in biophysics and biochemistry. With the junction of areas previously distinct, new points of view arise of which the composite names are more or less apt indications.

In the advance, also, of applied science, new fields of activity open; and their points of view are symbolized by suitably compound terms. Engineering, the art and science of making useful to man the materials and energies of his surroundings, envelopes the more routine art of inspection; and inspection, which is carried out for engineering purpose, becomes "engineering inspection."

The development engineer or designer assures himself through "engineering inspection" that the embodiment of his design, manufactured on a scale of quantity production, has not lost between its conception and its commercial utilization any salient features. Such inspection is usually a spot check on the "manufacturing inspection" through which the manufacturer himself insures that his production processes are functioning accurately and efficiently. In the most favorable cases it is possible for the designing engineer to produce in his own laboratory conditions effectively duplicating those of actual service and thereby to submit his design to conclusive tests; then all that remains necessary is that its salient features shall not suffer during manufacture, distribution, or installation.

Similar advance assurance as to the adequateness of design can be obtained under those conditions where field trials are practicable. But, in general, both in laboratory test and in field-trial installation it is impracticable to duplicate all the conditions which may be met in some form or other of service. A further inspection, under service conditions, with an ear to customer's complaints, is therefore necessary for the engineering purposes of the designer in order that he may be advised of objectionable features in his design, or of others which may advantageously be added. Investigation and analysis of customer complaints thus become a part of engineering inspection.

Beyond these occasions for engineering inspection a new emphasis arises which is best expressed by transposing the terms to "Inspection Engineering." *In order that engineering inspection shall be of greatest value there must be an art and science of inspection engineering.* The pure sciences of mathematics, physics, chemistry and the like must be applied to the problems of inspection in the same spirit and with similar research point-of-view as guide their application to development and de-

sign. The physical and economic variables of inspection must be given engineering consideration, and fundamental principles and standards established. This is beyond the current development of test machinery for determining the specific qualities of equipment; and, indeed, such determination is an integral part of the work of design and manufacture.

In the evolution of our industry these various functions have become more clearly defined; and within our Laboratories inspection engineering, carrying also a responsibility for quality oversight and criticism, is assigned to a separate department.

The duties of the department are closely interrelated with those of the development departments and certain technical groups in the Western Electric Company. With proper interpretations they are described as follows:

1 To develop the theory of inspection: putting existing mathematical knowledge into available form for use in laboratory and factory, and developing new principles where existing knowledge is inadequate.

2 To develop methods of stating the quality of various types of apparatus and switchboards, and methods of applying these concepts in every-day work; to develop economic standards of quality which telephone materials should meet.

3 To maintain oversight of the quality of apparatus, supplies and systems currently being furnished for communication service; to make regular reports on the current quality of these materials.

4 To study the quality and performance of telephone plant in service as an aid to further and improved developments; to give special study to instances where unsatisfactory quality is reported and to guide the steps taken to prevent recurrences of such cases.

The fulfilment of these duties requires men of many talents: physicists, mathematicians; experts in glass, metals, wood, leather, paper, textiles; engineers experienced in design, manufacture, and operation. Each endeavors to know all that is of engineering interest throughout the history of the design, production, and use of the apparatus or systems in which he specializes. Such duties require the closest cooperation with other departments and involve frequent conferences with engineers concerned with manufacture, installation, or operation. Those members of the department who deal with telephone supplies furnished by producers other than the Western Electric Company must have similar familiarities with these supplies and with the manufacturers and their methods. Other engineers of the department, scattered through the telephone centers of the country, must act as outposts of the developmental side of the industry gathering from their associates in Sales and Installation Departments of Western Electric, and directly from the Operating Companies, information and helpful criticisms relating to apparatus and systems.

In all this work of the Inspection Engineering Department, consulting and cooperating with many departments and companies, the activities of its members must be those of team play—they have no separate laboratories, no individual problems apart from the broad problem of contributing, through cooperation, towards the best telephone instrumentalities which present day science and economics admit.

The Inspection Engineering Department

By Francis J. Hallenbeck,
Bureau of Publication

In the days of craftsmanship which preceded our modern industrial situation a single artificer wrought, planned and inspected his own product. Although the method of production has almost entirely changed from individual to group and from manual to machine, the original sequence is followed today: namely, the inception of an idea, its material embodiment, and the inspection of the completed accomplishment. With the increased complexity of the product the successive steps must of necessity be made by different individuals and even by separate functionalized organizations. Usually, however, there is first the recognition of a need, and always there is research, development, and design; then comes the making and the underlying origination of processes for manufacture; and finally there is inspection.

Inspection is a critical examination which in turn involves three stages: first, the determination of what to look for and how to see it; second, the act of looking; and last, the conclusions to which the observations lead—and that is not always "behold it was very good." The first and last of these stages are engineering: the intermediate, in contradistinction, is an operation. And so, in our functionalized organization there is associated with the Research and Development Departments the coordinate Department of Inspection Engineering which this article is to describe. Its contributions are to the development of theories of inspection and of methods of dealing with inspection problems. Its conclusions—the interpretations of its results—include constructive suggestions for new or revised designs which are then considered by the engineers of the other departments. The actual operations of inspection are performed by the Western Electric Company as part of its responsibility for manufacture and supply of communication equipment.

In brief, then, the Department sets up economic standards of quality and satisfies the Laboratories as to how well the material going into the telephone plant lives up to those standards. In the performance of this work it determines the information necessary for a comparison of quality, it studies the theory underlying the inspection problem, and it develops inspection principles. Inspection reports from the Manufacturing, Installation and Sales Departments of Western Electric are studied and the details indicative of performance or failure are carefully analyzed. The substance of these inspection analyses is incorporated into reports which give the management of the Bell System an idea of the quality of the plant being furnished.

This work is carried on by a personnel of approximately eighty-five people directed by R. L. Jones, Inspection Engineer. The Department is divided into five groups operating

along functional lines as departments of apparatus inspection, systems inspection, supply materials, theory and special studies, and inspection methods and results.

D. A. Quarles

The Apparatus Inspection Department specializes in the inspection engineering concerned with apparatus manufactured to Laboratories' specifications by Western Electric and by outside companies. This group is in contact with the Apparatus Development Department, the manufacturing departments of Western Electric and outside companies, and the Department of Development and Research.

Several channels of action are employed in the prosecution of this inspection problem. A prime means is the "inspection survey," one of which covers each type of apparatus. These surveys are conducted with the Check Inspection and Inspection Control divisions at Hawthorne; they include studies and discussions of the specifications and of the inspection methods being employed. The group regularly receives, from Hawthorne, reports which indicate the quality condition of the product and these are used in the formulation of its Inspection Engineering Reports.

A most effective way of appraising quality is through the behavior of the product in service. One method of attacking this subject is through a study of cases where the quality of the product is questioned. The Apparatus Inspection Department, therefore, technically investigates all complaints as to apparatus which are received from the field, determines the nature of the fault, and obtains ideas as to the solution of the trouble. Steps are then taken by the Development Departments to prevent recurrence.

This work is carried on under the direction of D. A. Quarles and of five engineers reporting to him. Mr. Quarles is a graduate of Yale, where he held an instructorship; he also served overseas during the war, before entering the Laboratories in 1919. His first interest was transmission, a work at which he remained until his transfer to the Inspection Department in 1924.

In the five divisions reporting to Mr. Quarles, switching apparatus is handled by W. A. Boyd. Wound apparatus such as relays and coils is watched by R. M. Moody. A group concerned with special apparatus and vacuum tubes is in charge of W. C. Miller. The group reporting to E. G. D. Paterson carries on current engineering concerned with inspection of power and protection apparatus. O. S. Markuson studies the problems arising in cable inspection. Inspection engineering on telephone instruments

is under direct charge of Mr. Quarles.

Systems Inspection, another major group reporting to Mr. Jones, is responsible for matters involving apparatus as assembled into circuits and complete systems. Its direct relations are with our Systems Development Department, and with the Manufacturing and Installation Departments of Western Electric, the American Telephone and Telegraph Company, and the operating companies in the field.

This work is headed by G. D. Edwards who, after graduation from Harvard in 1913, entered Western Electric's student course at Hawthorne. In 1914, he came to the Laboratories' transmission branch, becoming head of its transmission engineering division in 1917. During the war he was concerned with methods for submarine detection. In 1920 he went to Europe as Transmission Engineer of the Stockholm-Gothenburg cable project, becoming its chief engineer in the latter stages of the job. At its completion in 1924 he entered the Inspection Department.

In its inspection engineering work this group operates in a manner similar to the apparatus group. "Systems surveys" and conferences are held, and technical investigations of complaints are conducted. Machine-switching systems are handled by H. G. Eddy. Manual and toll equipment are the chief responsibilities of H. F. Kortheuer.

Also reporting to Mr. Edwards, are groups which act for the Inspection Department as a whole. The first of these concerned with field activities is in direct charge of Mr. Edwards. This group is in constant touch with conditions in the field and for this purpose in various parts of the country it maintains engineers whose duty it is to keep the Department informed as to the performance of equipment developed by the Laboratories, and as to special conditions encountered in connection with the operation, maintenance or quality of this equipment. They act as general agents of the Department, and assist the telephone companies in preparation of complaints and in obtaining technical information or aid from the Laboratories. Groups in charge of H. G. Eddy are stationed at points throughout the eastern, southern, and western sections of the country with headquarters in New York, Philadelphia, Cleveland, San Francisco and Atlanta. The Central territory is in charge of H. K. Knowlton, who is also the Hawthorne representative of the Department. Members of Mr.

G. D. Edwards

Knowlton's group are stationed at Chicago and St. Louis. Questions relating to field service, and preparing Inspection Engineering Reports

are in charge of E. B. Hinrichsen.

Complaints, which yield valuable information as to the quality of product, are handled by another group reporting to Mr. Edwards. The Complaint Bureau acts as a clearing house for all classes of complaints, and is the contact point between the Laboratories and users of Western Electric apparatus. It is responsible for acknowledging and analyzing each complaint and for its assignment to the proper engineer for investigation. It follows the complaints through the various departmental organizations, and writes a final reply. Adjustment of the claim is recommended and if

S. C. Miller

the complaint warrants a change in design, the bureau is notified as to the change order. The Bureau is in charge of T. C. Rice.

Western Electric purchases from other manufacturers a large amount of material produced to specifications of the American Telephone and Telegraph Company. The Supply Materials Department handles this work about as described for apparatus. Inspection-survey conferences are held with the supplier in which he obtains technical advice from the Depart-

W. A. Shewhart

ment's experts and complaints as to his product are discussed upon the basis of the Department's technical investigations. The various factors affecting quality are studied in conjunction with the Department of Development and Research, and inspection reports are written. This work is directed by S. C. Miller, who initiated his Bell System career in 1911 in the student course at Hawthorne. A year later Mr. Miller came to the Apparatus Development group, where he remained until 1917. He was then transferred to the Inspection Department, and when the Department was reorganized in 1925,

took over his present work. Mr. Miller is a graduate of Union College.

In his organization, C. H. Amadon is interested in timber; E. M. Honan takes care of telephone supplies; special studies are made by R. H. Hart, B. A. Merrick and L. R. Stadtmiller.

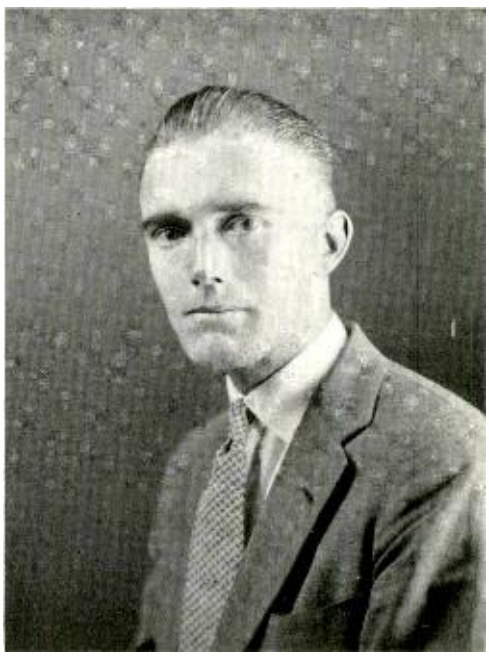
For the proper handling of inspection engineering work basic theory must be made available. This is accomplished by W. A. Shewhart who not only adapts old theories to inspection but also discovers mathematical principles applicable to mass inspection. In this abstract mathematical consideration of the problem, he seeks the answer to such questions as, What is quality? What factors determine it? How careful must inspection be to insure quality information of satisfactory precision? The results of his labors are not entirely abstract, however, for in his theoretical work on sampling, Mr. Shewhart has evolved such practical devices as the control chart.

Mr. Shewhart was graduated from Illinois and later pursued graduate study at California. He entered the Research Department in 1918 and was transferred to the Inspection Department in 1924.

The fifth major group, the Inspection Methods and Results Department, is in charge of H. F. Dodge. The work of this group is closely linked with that of the theoretical group. This department assembles the theoretical principles into a form adaptable to actual practice. It develops specific methods of expressing quality, such as quality rating plans. Questions of character and content of quality reports also are studied.

Mr. Dodge is a graduate of Massachusetts Institute of Technology, where he was an instructor for a year. After this, in 1917, he entered the Research Department where he was concerned with transmitter development. The microphone now in use in the Signal Corps, and the electrical stethoscope are some of the developments with which he is identified. Mr. Dodge entered the Inspection Department in 1924.

This, then, is the manner in which the groups of the Inspection Engineering Department bring the research and development point of view to inspection, and through it to the development, manufacturing and maintenance operations of the telephone industry. It is their task to ensure that ideas, born in the Laboratories, serve to fuller measure in electrical communication.



H. F. Dodge

The Engineering Department as it was in May, 1913, photographed on the roof of Section C. In the center will be noted Charles E. Scribner seated between J. L. McQuarrie and F. B. Jewett, then Assistant Chief Engineers

Death Claims Charles E. Scribner

On June 25 ended the long life of Charles E. Scribner, first Chief Engineer of Western Electric, and for many years head of our organization. Mr. Scribner had been in retirement for several years, living for most of the time at his country place in Jericho, Vermont.

Mr. Scribner was born in New York City in 1858, and was educated in the public schools of Toledo. Soon after graduating from High School, he had invented a telegraph repeater, a finished model of which he had constructed in the shops of the Western Electric Manufacturing Company in Chicago. Here he attracted the attention of Enos M. Barton, who employed him in 1877 to maintain stock-quotation telegraphs. As opportunity offered, Mr. Scribner followed his bent for invention, and gradually rose to have charge of all development work. He was Western Electric's first Chief Engineer, a title which he held for twenty-three years.

Among Mr. Scribner's early jobs were the development of the switchhook and the polarized ringer. The jack-knife switch and the board in which it was used were his inventions. Switchboards, in fact, were one of his particular interests, since they formed an outstanding problem of the industry in those days. He was a prolific inventor; our Patent Department's records show 441 patents issued to him, a number ranking him third among electrical inventors. Of him, Mr. Thayer once said: "He understood as though by intuition the critical points of a patent situation, and his advice in regard to electrical and mechanical features of patents

Charles E. Scribner

was relied upon by officers and attorneys, and never failed to prove correct."

In 1907 with the concentration of various laboratories, Mr. Scribner came to West Street. In 1916 he retired from active service. And now he has passed beyond the range of that communication art to which he dedicated his life, leaving all of its workers who knew him to regret his going but to hold pleasant memories of their associations with him.

IN the West during June D. M. Terry, W. F. Kannenberg and G. H. Huber tested an installation of the new pilot-channel system for the Type "C" carrier telephone between Denver and Sacramento.

F. E. Anderson has been transferred from the Laboratories to the Graybar Electric Company to serve as its engineering representative in the Pacific Coast District, with headquarters at San Francisco.

D. M. Cole spent May and June in Minneapolis, Minnesota, in connection with the power-line carrier-telephone system installed for the Northern States Power Company.

L. W. Davee installed power-line carrier-telephone equipment for the Central Virginia Power Company at Roanoke, Glen Lyn, and Lynchburg, Virginia, and for the Kentucky and West Virginia Power Company at Logan, West Virginia.

R. E. Kuebler has been in Philadelphia recently on several occasions to assist in the installation of demonstration equipment for talking motion pictures which the American Telephone and Telegraph Company is to exhibit during the Sesqui-Centennial Exposition. A miniature moving picture theatre, seating about 250 people, has been built within one of the main exposition buildings.

In connection with the testing of new picture transmission apparatus, E. P. Bancroft and L. A. O'Brien have made several trips to Philadelphia and are now spending some time there in assisting the Philadelphia Shop in testing these sets, which are produced on a semi-commercial basis.

* * *

FROM THE Systems Department E. H. Smith, E. W. Hancock, and E. J. Kane visited McKeesport, Pennsylvania, in connection with the installation of the cordless "B" switchboard designed to handle calls from manual offices to a step-by-step machine-switching office. This switchboard is being installed as a part of the new step-by-step machine-switching office in that town.

A. Chaiclin spent a few days in Philadelphia the latter part of May installing a picture-transmitting set in the Long Lines Office, for use in sending pictures of important events at the Sesqui-Centennial Exposition.

The first commercial installation of the new No. 11 switchboard in the East, at Wakefield, Mass., was visited by C. Borgmann, together with several Telephone Company engineers. Other No. 11 switchboards have just been placed in service at Iron Mountain, Michigan, and Monroe, Louisiana.

At Reading, Pennsylvania, F. F. Siebert and J. R. Stone have been making tests on the new commercial generators for charging central-office batteries. The power plant for this large step-by-step office and for the No. 3 toll switchboard utilizes the electrolytic condenser in a filter which permits charging batteries from commercial generators.

The first interconnecting cord circuit repeaters were placed in service

at Providence, Rhode Island, and after demonstrating satisfactory operation will be removed, as traffic conditions do not require their continued operation at this place. R. H. Kreider has been at Providence arranging for the restoration of the toll office to the former cord circuit operation.

L. A. Leatherman visited Atlanta, Cleveland and Detroit in connection with our work on questionnaires as to telephone offices which are used by the Telephone Companies in placing orders for equipment.

* * *

Bell Telephone Laboratories, Incorporated, is a patron member of the American Mathematical Society to which it pays annual dues of $500. This membership assists the publication of the researches of that society and is a recognition on the part of the Laboratories of the contributions of mathematics to the physical sciences and their engineering applications.

* * *

John J. Gilbert is the Bell Telephone Laboratories engineer in charge of the installation and testing of the sending and receiving apparatus now being installed at the Western Union Cable station at Bay Roberts, Newfoundland, where the new permalloy ocean telegraph cable was landed last month. The European end of this high-speed cable leaves the ocean bed at Penzance, immemorial haunt of the pirates of Land's End, England. Mr. Gilbert is photographed at Heart's Content, Newfoundland inspecting the broken shore end of the first successful ocean cable which was landed at this remote fishing village by the tender of the "Great Eastern" on July 27, 1866. The gentleman in the straw hat is C. H. Tranfield, who has been in charge of the Western Union station at

J. J. Gilbert and C. H. Tranfield inspect the first successful ocean cable

Heart's Content for the past 36 years. His father was a member of the crew of the "Great Eastern" when this historic work was done.

The picture was taken by C. W. Barrell, Motion Picture Director of the Western Electric Company, who recently voyaged to Newfoundland on the Western Union Cable Ship "Cyrus Field" to make a motion picture record of the landing of the new permalloy cable.

* * *

In the July issue of the *Bell System Technical Journal* are papers on speech sounds, by C. F. Sacia and C. J. Beck; on interference in submarine cables by J. J. Gilbert; on vacuum-tube circuits by F. B. Llewellyn; on ionization, by K. K. Darrow; and on recording and reproducing speech and music, by J. P. Maxfield and H. C. Harrison.

THE Fall Golf Tournament will be held on two Saturdays in September at the Salisbury Country Club, Garden City, Long Island; each round will consist of eighteen holes of handicap medal play. On Saturday, September 11, the qualifying round will be played. Twenty-eight golfers will be qualified for the finals, which will be played on Saturday, September 18. These twenty-eight men will be divided into two classes, the division being based on the scores shot in the qualifying round. The twelve low gross scores will decide eligibility for Class A and the next best sixteen net scores will make up the list for Class B.

The golf trophy won by J. M. Hayward

Distribution of prizes for the qualifying round will not be affected by this classification, but will be the same as in previous tournaments. Two prizes will be given for the two best gross scores and two prizes for the two best net scores. In the finals four prizes will be awarded Class A and Class B.

In order to decide the Club championship the winner in A will play the winner in B for the Club trophy during the week of September 20th.

Entries for the tournament will be limited to eighty players. Entry blanks must be filed with D. D. Haggerty, Room 164, not later than September first. An entry fee of two dollars will be charged, and should accompany each entry.

A golf tournament between the Commercial Relations Department of the Laboratories and the Price Managers Department of the Western

Our hikers on the road to Ringwood, N. J.

The Laboratories team

Kuhlman at bat

Some of the Laboratories rooters at the N. Y. Tel.-Long Island game

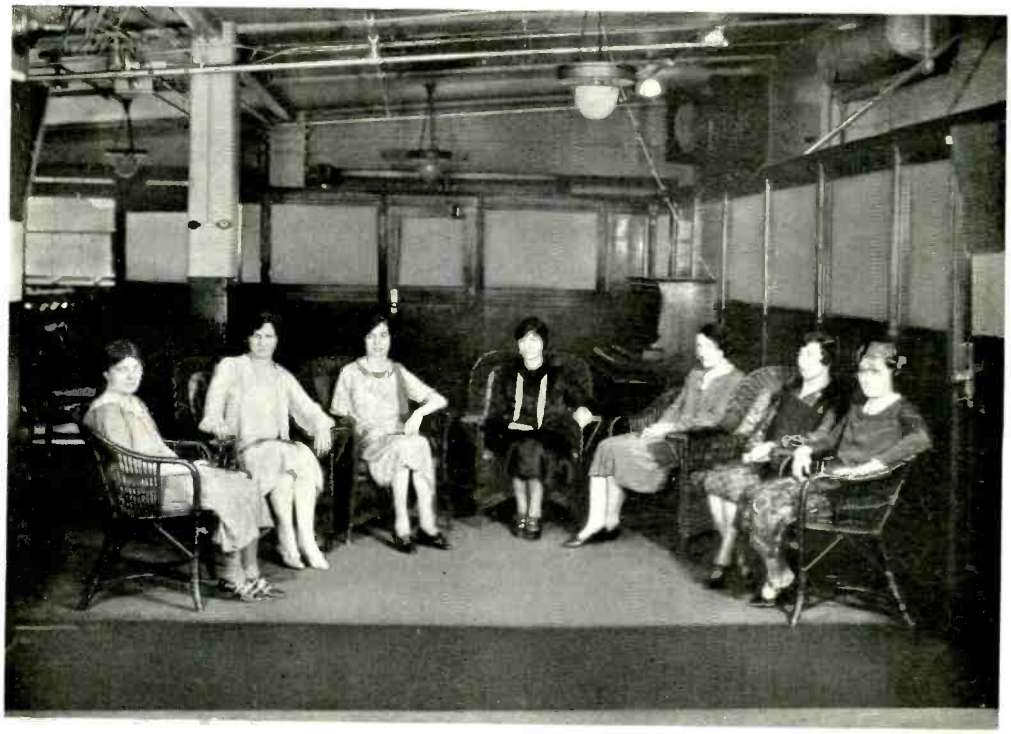
Drenkard rounding first

A putout at first by Brodley

G. E. Kellogg, J. Hillier, G. T. Lewis, A. L. Thuras

B. W. Kendall makes a sand-pit in one

The Carroll Club swimming class



Committee on Women's Activities. Left to right: Misses P. Barton, M. G. Gilmartin, M. G. Mason, Helen Cruger, M. Horne, E. B. Bolan, E. E. Hence

Electric Company, 195 Broadway, was played at the Salisbury Country Club, Garden City, on Saturday, July 10. Sixteen players teed off for eighteen holes of match play; after the battle was over, the men from West Street had carried off six of the eight matches.

The scores are as follows:

B. B. Webb 2 up over H. E. Young of Broadway.

A. A. Reading 3 up over A. Dole of Broadway.

C. R. McConnell 5 up over F. J. Wallworth of Broadway.

W. L. Smith 5 up over H. H. Hotchkiss of Broadway.

W. F. Johnson 1 up over H. J. Hamnel of Broadway.

J. W. McCaw 9 up over C. E. Budd of Broadway.

A. T. Boland 1 down to K. J. Bishop of Broadway.

J. C. Kennelty 4 down to S. G. Timmerman of Broadway.

It is hoped that this tournament will encourage more of these inter-company tournaments, particularly in the cases where the two departments have constant business relations.

The men of the Tube Shop held their third annual outing and clambake on Saturday, June nineteenth, at Glenwood Landing, Long Island.

The yearly baseball game between the married men and the single men was the big event of the day. T. Smith, who hurled the full game for the Bachelors, had too much stuff for the Veterans and won without a great deal of trouble. The box score:

	1	2	3	4	5	6	7	8	9	
Single Men.....	0	1	1	0	0	5	1	0	0	—8
Married Men...	0	0	2	1	0	1	1	0	0	—5

Batteries:

Single Men—T. Smith and G. Rutt.

Married Men—P. Lancella and Kieper, Leuthner and Leykam.

Umpire: P. Schwerin.

After the ball game there were a few athletic events, the first a fat men's race. This was won by W. Anderson, with H. Bosch, P. Schwerin and W. Cormick finishing closely bunched in the order named. A half-mile relay race between teams captained by E. Russell and G. Sheehan was won by the latter's outfit. The winning runners were G. Sheehan, C. Maurer, A. Kontis and H. Kieper.

A dip in the Sound followed, and then supper. The evening's entertainment was featured by the singing of "Schnitzelbank," with Mr. Schwerin conducting and E. F. O'Connell at the piano.

Campfire supper at a deserted quarry near Milburn, N. J.