Bell Laboratories Record

Volume Six | July, 1928 | Number Five

Research Methods

By FRANK B. JEWETT

Excerpts from a Talk before the Annual Meeting of the Highway Research Board, National Research Council

I IMAGINE that a large part of the population who give any thought to it think of research in the physical sciences as something new among man's activities. As a matter of fact, it is not at all a new thing. Research work in its broadest sense has been going on for centuries. Every engineering problem that was ever undertaken, which required the planning of some new thing, involved some form of research work.

There has come about within the last two hundred years a realization that to get authoritative and lasting results one has to perform experiments based on a well-considered plan, worked out from the experience of the past, and so controlled that data can be capable of definite interpretation. One of the hardest things we research people and engineers have to contend with is the temptation to draw conclusions from complex experiments or experience in terms of only a part of the factors of the problem. Even in our modern institutions and industrial research laboratories, equipped with the best means and men available, we find this tendency continually cropping up. Results are stated with a complete knowledge of only part of the factors, and sooner or later we realize that our conclusions were unjustified because of neglected factors which have played an appreciable part in the results.

Engineers and scientific people alike do this sort of thing, not consciously but unconsciously. To get a result that means anything, in most cases one must so control his investigation that but one factor is variable at a time. If you have two, it is very difficult to interpret your result as between the two factors. If you have three or more, it is practically impossible. Yet this is attempted every day, usually with the result that progress, when it comes at all, comes from doing a thing over and over again, until by statistical methods we arrive at some sort of an approximation to the truth.

There is another thing which we are very prone to do and that is to try out initial experiments on too large a scale. Suppose you have an idea and perform an experiment on a large scale and the result does not come out as you thought it was going to; you do not know why it didn't, you do not know whether your assumption was wrong or whether failure was due to unrecognized and uncontrolled factors. Having decided what one wants to do and having made an assumption as to the correct method of doing it, he must try it out on what is essentially a laboratory scale. It has to be tried out under conditions that, so far as is humanly possible, are precisely controlled to provide only a single variable factor in a given experiment. If at the conclusion of that experiment we obtain results which are in line with our expectations, we may fairly assume that the thing we started out to do can be done, at least experimentally. We may want to repeat the experiment once or twice under other conditions to make sure of our conclusions. We are then ready to start the next part of the experiment, namely to see if we can transfer this laboratory process into a large scale operation.

I have seen experiments started on the supposition — and I am afraid I have been guilty myself at times — that certain operations can be launched at once on essentially a commercial or large scale engineering basis because they have worked on a small scale. If you can do a thing in a test tube in a laboratory under controlled conditions, you *may* be able to do it on a large scale, but not necessarily.

In order to bridge the gap between small scale and large scale experiments, our method in the telephone industry has for years followed these lines. Let us assume that the problem in hand has for its end the design of a complicated piece of apparatus. The first experiments are primarily to check up the necessary fundamental physical or chemical characteristics or reactions. We have succeeded, let us assume, in checking our fundamentals. The next step in the process is to make a piece of apparatus which as nearly as possible conforms to the ideal requirements. It is the best we can do regardless of cost. We use the best machinery and the best men and the best materials we can to make this thing an ideal piece of apparatus. Any results we obtain with it are a test, not of the fundamental principles since these have already been checked, but are a test of our ability, with the tools at present at our disposal, to make a physical thing giving certain desired results. When this carefully made sample is tested under actual operating conditions, it is a ten to one chance that certain difficulties appear which our earlier and more fundamental tests did not disclose. It means that we must make modifications if we are going to use our fundamental principles commercially.

Finally, let us suppose we have an operating piece of apparatus made under this ideal condition but which is not at all commercial. For example, this particular piece of apparatus may have cost a thousand times what we know we can afford to pay for a large number of these pieces of apparatus used commercially. We have shown, however, that the thing can be done.

The next step in the process is to build what we call tool-made models. These models conform as nearly as possible to the ideal thing but are made under commercial processes applicable to large scale production and with ultimate cost considered. Tests on tool-made models are not tests of the fundamental thing nor of our ability to make one thing to conform to the ideal, but are tests of our ability to make in a physical, economical fashion a large number of things capable of producing a desired result.

It is only after we have gone through all three of these steps and have tried the tool-made models under service conditions and found them satisfactory that we feel safe in going into production on a huge scale and using the apparatus as a part of our standard equipment.

This general process must be gone through with in one way or another in practically every line of industry where science is applied for practical purposes.

Now, another thing. We have learned, particularly in the past thirty or forty years, that it is not always safe to neglect very small admixtures of foreign substances. This is particularly true with regard to things chemical. There was a time not so long ago when a thousandth of a per cent or a hundredth of a per cent of a foreign body in a chemical mixture was looked upon merely as an incidental inclusion which could have no appreciable effect on the characteristics of the substance. We have learned in recent years that this is an absolutely erroneous idea.

As somewhat approaching conditions of the problem which confronts you gentlemen, I might cite a situation which developed in an undertaking of the Engineering Division of the National Research Council some years ago. In connection with the problem of marine borers, teredos and the like, a study was made of substitutes for wooden structures, particularly concrete. In the course of the work, industry all over the United States and Canada and abroad became involved, and it developed from the extensive data gathered that concrete, good concrete or what people thought was good concrete, when immersed in sea water was a very variable thing. The records show that some concrete structures have stood up for an almost indefinite time, with very little deterioration. Yet right alongside of them other concrete structures, presumably made in exactly the same way, had gone to pieces in a very short time.

Investigation pointed to the conclusion that this variation was not so much due to variations in the mechanical processes of mixing the concrete as it was due to chance variation of composition in the cement, sand and stone employed. Although different cements might be nearly alike chemically, they probably reacted slightly differently when submerged in sea water, and similarly with the other ingredients. The trouble, where trouble occurred, really went back to the raw materials used in making the concrete and their chemical composition. It seemed clear that no satisfactory answer to the problem of concrete structures in sea water could be hoped for until light was thrown on the constituents of the materials.

I am citing these instances to emphasize that experience teaches us to use extreme caution. Good engineering practice must be based on conclusions drawn from controlled experiments where one variable at a time is involved, and frequently the variables are ingredients present only in greatly attenuated amount.

Finally, coming back to the problem which confronts you gentlemen, we have a situation so vast in its entirety and so diverse in its ramifications that only by some form of general cooperative attack can we hope, I believe, to make the progress which the world demands. It seems to me that sooner or later under the auspices of a group like yourselves, we must work out a scheme of cooperative research involving all of the elements required in the whole problem of road planning and road building, for in this way can we best study and evaluate the innumerable factors which enter such a complex problem.

If you are going to make conspicuous progress throughout this whole art of road building—which has become one of our largest concerns and one of the greatest needs of the country—you must, I believe, devise some very comprehensive mechanism for focusing the widely scattered knowledge and skill of the highway engineer, the chemist, the physicist, the geologist, and other scientific men in the universities and industrial laboratories. And granting that your problem is one which calls for a cooperative attack, I know of no better agency under which to bring about such cooperation than this very body of which you are a part. The National Research Council is known to be a national body without an ulterior motive of self-interest—a body designed for service along scientific lines for the population as a whole. As such its reports and conclusions carry great weight.

"The Devil Machine"

Among the many letters received at Whippany in praise of its test transmissions, is one from Mr. D. R. Gowen, Manager of the Hudson's Bay Company station at Fort Good Hope, Northwest Territories, Canada. Mr. Gowen's interest in radio reception is intensified by the fact that only four mails a year reach the settlement, and the eight white men who comprise its population depend almost entirely on programs from broadcasting stations thousands of miles away for news bulletins and information. The Indians in the radio audience find the emanations from the loudspeaker a never-ending source of awe. To them, the radio is "The Devil Machine."

A Short-Haul Carrier System

By H. S. BLACK
Systems Development Department

THE type "C" carrier telephone system is essentially a long-haul multi-channel system which will add three high-grade circuits to the facilities afforded by a single pair of wires. It is capable of operating over distances in excess of 1,000 miles, if desired, and is not infrequently economical for use on circuits as short as 100 miles. While this system thus satisfies the relatively long-haul circuit demands, there is also a considerable field for a cheaper system designed particularly for circuits between 50 and 200 miles in length. A single-channel system, the type "D", has been designed for this purpose. It can be operated over No. 12 gauge (.104) open wire lines about 135 miles long with liberal allowances for such losses as may be encountered in the toll entrance cables at each end.

Outstanding among the requirements for the proposed system as formulated by the engineers of the American Telephone and Telegraph Company were low first cost, simplified installation, minimum maintenance, good volume and fidelity of reproduction of transmitted speech, and relative freedom from all types of interference. In addition it was necessary that the new system could

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Editor's Note: The definitive technical presentation of the Type D Carrier System will be made in a paper to be presented jointly by the present author, and M. L. Almquist and L. M. Ilgenfritz of the American Telephone and Telegraph Company before the A. I. E. E. at Spokane in August next

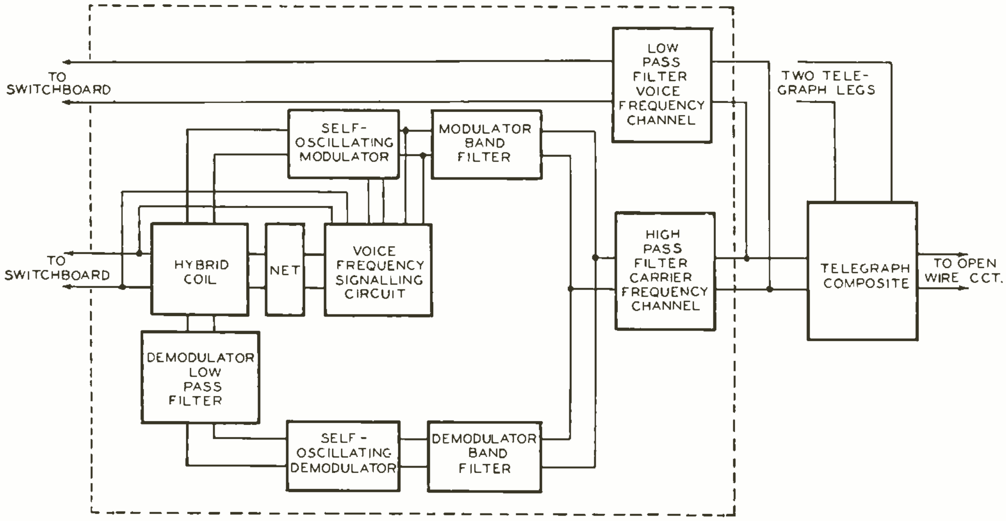


Fig. 1—Equipment symbolized inside the dotted lines is that for the D-1 System

be coordinated with other types of carrier systems present and future.

From the design standpoint these requirements called for the use of a minimum of apparatus, and the substitution of less expensive materials wherever possible. Ease of manufacture and control of product had to be considered. To reduce maintenance, few adjustments should be required and these should be made at the factory in order to simplify installation.

A system which met these requirements was developed and tested in the Laboratories. Following this work two models were placed at the disposal of the American Company for experimental studies and for tests of various transposition schemes on lines between Linden and Byram, New Jersey. Two more models were installed between Watertown and Syracuse, New York, for a commercial service trial. After successful completion of the service trial, manufacture and use of the system were approved for the more important applications throughout all parts of the the Bell System.

Technically, the Type D-1 single channel system is a self-oscillating, single sideband, two-carrier circuit employing only four vacuum tubes and a ballast lamp per terminal. The system as a whole is noteworthy because of the reduction which has been effected in the number of circuit elements. Among its new features are special methods of shielding, a new thousand-cycle relay, a new grid leak, and a new ballast lamp. Especially developed for the modulator and demodulator circuits are inexpensive paper condensers to replace the customary and more costly mica condensers, and inexpensive inductance coils not potted. These contributions, drawn from many groups of engineers, demonstrate anew how advances in the art are aided by the diversified skill to be found in the Laboratories.

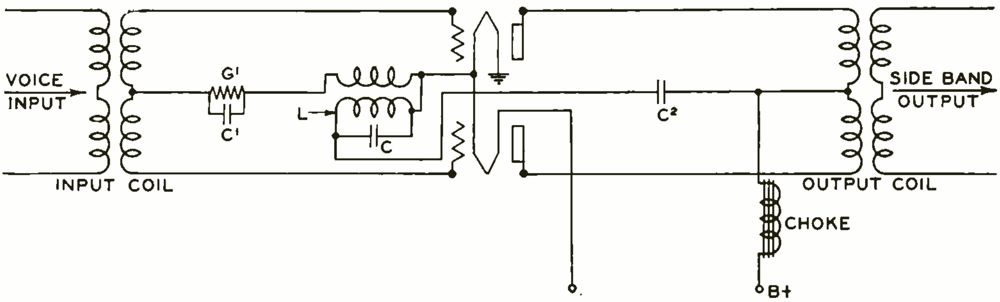


Fig. 2—Modulator circuit of the D-1 System

Like all recent carrier systems, this one transmits in opposite directions on different frequencies. Westbound or southbound channels employ a carrier frequency of 10,300 cycles; transmission in the opposite direction employs 6867 cycles. These frequencies were selected for their bearing on transposition costs and to secure coordination with other types of carrier systems.

An ordinary two-wire telephone circuit is connected to each end of the system through a hybrid coil associated with a network to balance the impedance of this two wire circuit. Voice currents from the two-way telephone circuit are directed into the outward carrier channel, while voice currents from the incoming carrier channel are directed into the two-way circuit in such a manner that neither interferes with the other.

The outward channel begins with a modulator—a device which displaces the voice band supplied to it, without alteration of its relative frequency intervals, to a higher position in the frequency spectrum. Instead of a group of frequencies in the voice range, we now have two groups—the two sidebands—one extending up, the other down, from the carrier-frequency as illustrated in Figure 4.

An outstanding feature of the Type D-1 system is found in its modulator which includes the carrier-frequency generator within itself. Complete scission of the two functions of oscillation and modulation is no longer considered necessary. The two tubes of Figure 2 working in parallel generate carrier oscillations whose frequency is controlled by the tuned circuit LC. The carrier-frequency output of the two tubes is coupled to the grid circuit and applies the same alternating voltage to each grid. This voltage is amplified by the tubes and the circuit oscillates stably in the customary manner. During a small portion of each positive half-cycle of the carrier wave, the grids are positive to the filaments as indicated by the black areas of Figure 3. During this period, electrons are drawn to the grids. From the grids they gradually flow back to the filament through the high resistance leak G[1], thereby establishing a steady negative grid bias (Figure 3).

With respect to the carrier oscillations, the tubes are in parallel but the primary windings of the output transformer are in opposition. Carrier oscillations, therefore, will not appear in the secondary of the transformer for transmission to the line. However, with respect to the voice-frequency band, the tubes and transformers form a push-pull circuit. The output of this circuit consists of three main parts—an amplified copy of the original voice currents, and two sidebands which are products of modulation. Only one of these sidebands—the lower one—is transmitted, all other frequencies being rejected by the output filter. This filter also rejects the sideband coming in from the distant terminal and diverts it into the demodulator circuit.

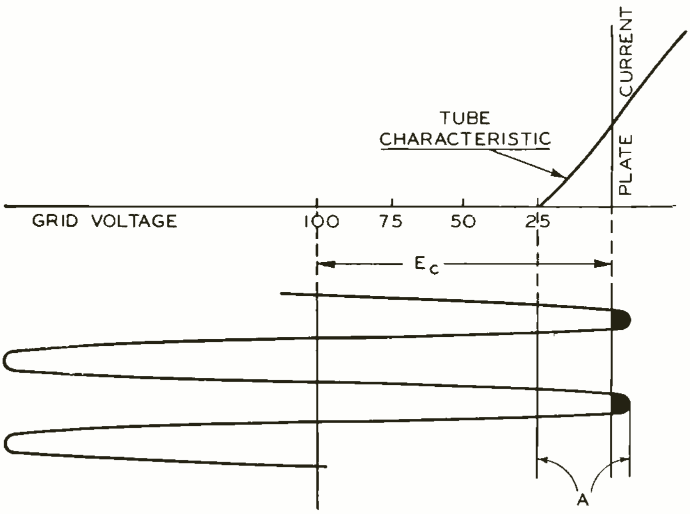
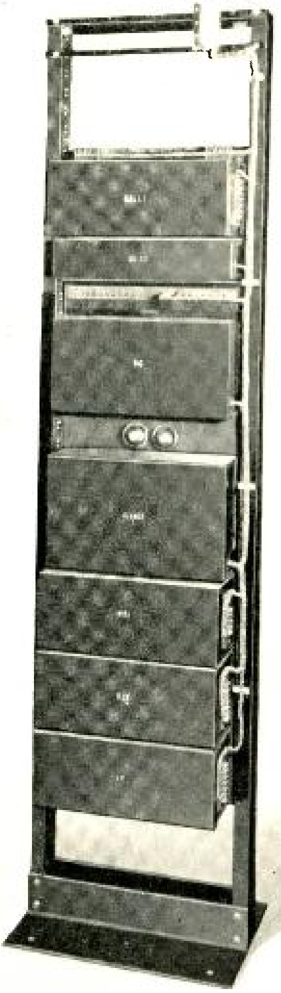


Fig. 3—Production of carrier-frequency oscillations by the oscillator-modulator tubes

Interposed between the terminal apparatus and the line is another filter which passes carrier currents in both directions but rejects the low frequency talking and signalling currents of the voice-frequency circuit on the same pair of wires. It is of great importance that these filters have the proper impedance to the currents which they are intended to pass, otherwise reflections will occur, and crosstalk with other systems on the same pole line will be seriously increased. Hence the design of these filters was one of the major problems in the development. Shielding was accomplished by sealing these filters in copper containers; thus interaction between adjacent filters was reduced to less than one part in a million.



A single terminal equipment, mounted on a floor-type unit

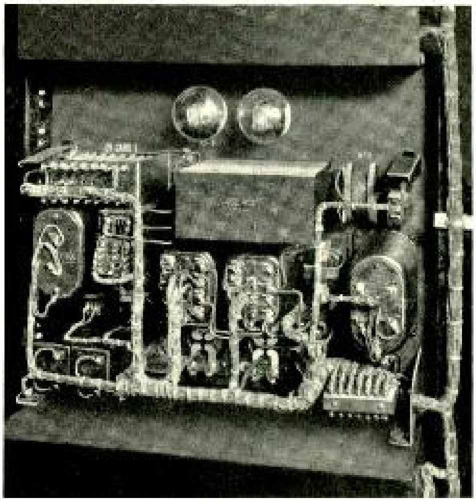
At the receiving end, the sideband is transmitted without very great attenuation through the high-pass filter and demodulator band filter. The demodulator circuit is, in principle, a counterpart of the modulator circuit and oscillates at the same frequency. The sideband being impressed on the grids along with the local oscillations, there result in the output coil three principal groups of frequencies; an amplified copy of the sideband; a group of currents of still higher frequencies; and a group which is a duplicate of the original voice-frequency band. The first two groups are suppressed by the demodulator low-pass filter and only the voice-frequency band reaches the hybrid coil and ultimately the listener.

In the tuned circuit of the modulator are paper-insulated condensers having a number of taps. This permits adustment of the modulator frequency in steps of ten cycles. In the demodulator circuit an additional tapped condenser permits the oscillating frequency to be adjusted so as to agree with that of the distant modulator to within one cycle per second. The oscillating circuits are carefully adjusted at Hawthorne and are synchronized after the installation of the system.

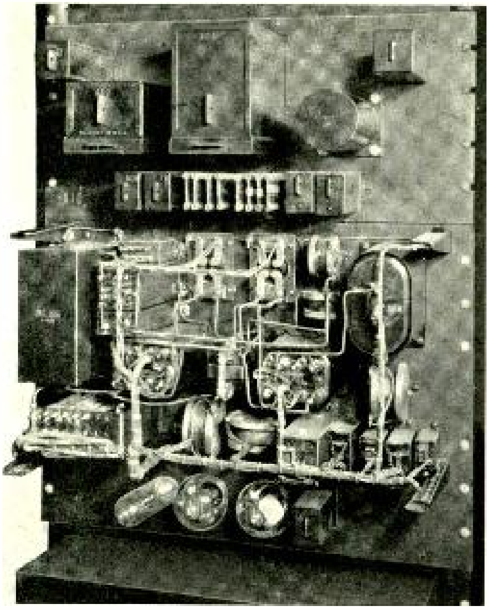
Filaments of the modulating and demodulating tubes — four in all at each terminal — are connected in series with a retardation coil, a ballast lamp, and the central office battery. Although the battery voltage may vary in the course of the day between twenty and twenty-eight volts, the ballast lamp holds the filament current variations within satisfactory limits.

The method of signalling corresponds, in general, to standard voice-frequency signalling methods in current use on toll circuits, with the exception that no thousand-cycle generator is required. Twenty-cycle ringing current from the toll switchboard is received by the signalling unit at the sending end, where it operates a relay chain. This relay chain serves to lower the frequency of the carrier oscillations by a thousand cycles and unbalances the modulator so that the carrier current may be freely transmitted to the line. Simultaneously the modulator output is short-circuited twenty times a second, so that the net result of an outgoing twenty-cycle signal is to transmit spurts of carrier current over the line. At the distant end the received carrier current differs by one thousand cycles from the local oscillations, so it appears in the demodulator output as thousand-cycle current interrupted at a twenty-cycle rate. This current after selection and amplification operates a thousand-cycle relay. If the rate of interruption of the 1000-cycle signal differs but little from twenty cycles, if the amplitude of the received signal exceeds a predetermined value, and if the signal endures for at least one-half second, then a chain of relays is operated and twenty-cycle ringing current from a local source is connected to the toll switchboard. These safeguards make the signalling system practically free from false operation on speech components but do not interfere with its reliability for signalling.

Supplementing the development in our Laboratories of the terminal



Reverse of lower panel, showing the modulator circuit



Upper panel carries signalling apparatus of the D-1 Carrier System; lower panel carries, on the side shown, the demodulator circuit equipment, an economical scheme of transpositions has been designed by the engineers of the American Telephone and Telegraph Company which will permit the operation of a number of Type D-1 systems on the same pole lead and which is also expected to provide coordination with a limited number of Type C systems. One feature of this design is that it permits individual side circuits on an existing line to be retransposed as required for carrier operation with a minimum number of changes in the transpositions in other pairs not used for carrier operation.

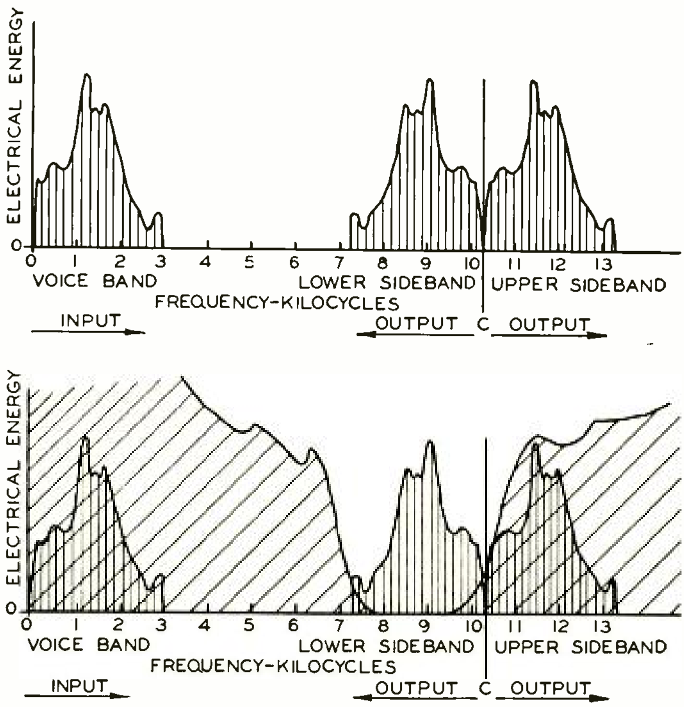


Fig. 4—Above, the location on the frequency spectrum of input and output currents of the modulator; below, how the band-pass filter eliminates all but the lower side band

Terminal equipment of the Type D-1 carrier system is furnished in two forms. One of these is for mounting two systems on a relay rack bay of standard height. The other, a self-contained floor type unit, is adapted to installation on short notice, and it is possible to cut a single system into commercial service a few hours after its arrival on the job. As an illustration of the utility of this general type of service, the discovery of oil in the vicinity of Amarillo and Borger, Texas, resulted in a sudden overload on the telephone facilities between those points. Using experimental parts mounted on circuit-boards, together with other equipment furnished by Hawthorne, the Laboratories assembled and cabled a complete Type D-1 system in the course of a few days. Ten days after the system had been shipped from New York it was cut into commercial service and fifteen calls were routed over it during the first half hour.

Determining Short-Wave Paths

By H. T. FRIIS
Research Department

SHORT waves do not travel so directly to their destination as the very long waves of the transatlantic telephone service do. The existence of skip distances* was discovered when short waves were first being experimented with but there still exists a lack of complete information on the actual path they follow in journeying between two points. Efforts have recently been made, however, to obtain some of the missing information by determining the direction in which the waves approach the receiving station. Complete information regarding the receiving angle will greatly help the computation of the actual path; it will add to the understanding of factors affecting short wave transmission; and it will give data of value in designing receiving antennae.

Two receiving antennae spaced a short distance apart will in general receive an incoming wave at slightly different times depending on the direction of reception. If the output of these receivers is each connected to a pair of deflection electrodes of a cathode ray oscillograph† the pattern traced on the face of the tube by the stream of electrons will be different for each direction of the incoming wave. In recent experiments a local oscillator was added to obtain a beat note of five hundred cycles with the incoming waves. This is necessary so that the signal may be amplified to operate the cathode ray oscillograph.

The method of determining the direction of reception may be readily understood by reference to Figure 1. The two receivers R_1 and R_2 are at right angles to the direction of the transmitter whereas the local oscillator is in line with it. If the signal

** In an article in* BELL LABORATORIES RECORD *for June, 1927, Vol. IV, pp. 349-354, J. C. Schelleng discusses this phenomenon at some length.*

† For a general description of the Western Electric 224-A Oscillograph used for the studies refer to BELL LABORATORIES RECORD *for April, 1926, Vol. 2, pp. 57-59.*

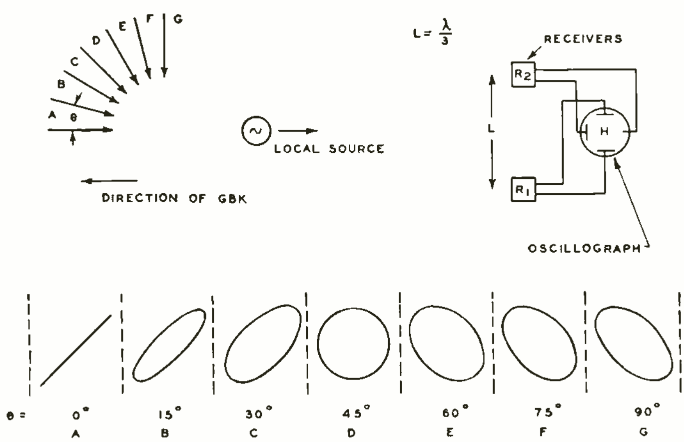


Fig. 1—Arrangement of receivers and local oscillators for determining horizontal-plane angle of reception

is received in the vertical plane passing through the transmitting station, the local oscillator, and the center of a line joining R_1 and R_2, there will be no phase difference between the received beat signal at R_1 and

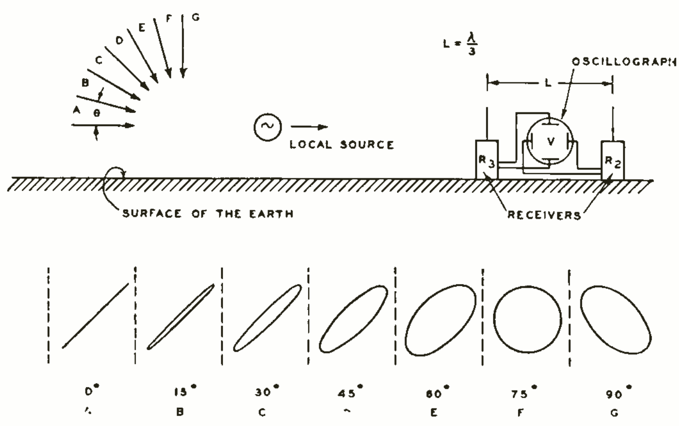


Fig. 2—Arrangement of apparatus for detecting vertical-plane angles

that at R_2, and the figure shown on the oscillograph will be a straight line as given at "A" in Figure 1. As the receiving angle increases through positions indicated as "B", "C", "D", etc., of Figure 1 the phase difference between the received signal at R_1 and R_2 increases and the figures on the oscillograph change as shown in Figure 1.

If, on the other hand, two receivers R_2 and R_3 are placed in line with the transmitter and the local oscillator as shown in Figure 2 a phase difference between them will also exist depending on the direction from which the received signal arrives. In the arrangement of receivers of Figure 1 only the horizontal plane component of the reception angle will produce a phase difference between the two receivers. In the arrangement of Figure 2, however, either a horizontal or vertical component of the angle of reception will produce a phase difference. If only angles in the horizontal plane are to be determined the set-up of Fig. 1 will give the data. To determine angles in a vertical plane both arrangements of receivers must be used together. Arrangement 2 is not sufficient in itself as this arrangement is responsive to a change of angle in either the vertical or horizontal plane.

By using arrangements 1 and 2 together, however, with receiver R_2 common to both, it is possible to determine both the horizontal and vertical components of the angle of reception. Extensive observations have been made using the British beam sta-

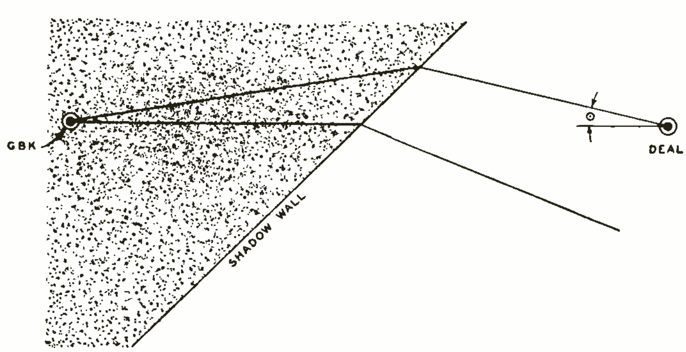


Fig. 3—Suggested way in which the shadow wall affects the receiving angle

tion GBK as the transmitter and much interesting data has been collected. It has been found that when daylight exists over the entire transmission path the horizontal angle of reception is small; the figure on the oscillograph is a straight line or a very thin ellipse. When the sunset or sunrise shadow-wall lies across the path of transmission, however, the angles increase at times to as much as thirty degrees, which seems to indicate a refraction of the short waves along the shadow wall.

The vertical plane component of the reception angles varies from time to time and occasionally reaches as high as sixty degrees. In the mornings the figures would indicate small angles. Towards noon they would change rapidly showing much variation in the height of the reflecting layer and this variation would continue on into the afternoon. Occasionally large angles were found in the mornings also which indicated an extreme variability. So variable is this vertical angle that any regular laws of variation of height could be determined only after a very long series of observations.

The possible significance of the horizontal component of the angle of reception is illustrated by Figure 3. The sunset shadow-wall is shown about half-way between the transmitting and receiving stations and the sketch shows how refraction along this line could account for the horizontal angles of reception noticed. To determine the actual laws of refraction at the shadow-wall, however, will require the collection of much additional data.

In watching the patterns traced by the two cathode ray oscillographs it was noticed that they changed not only from straight lines to ellipses but in size as well. As there was no change in strength of the local oscillator this could mean only a fading of the received signal. In many cases there seemed to be a cycle from large to small figures taking from one to

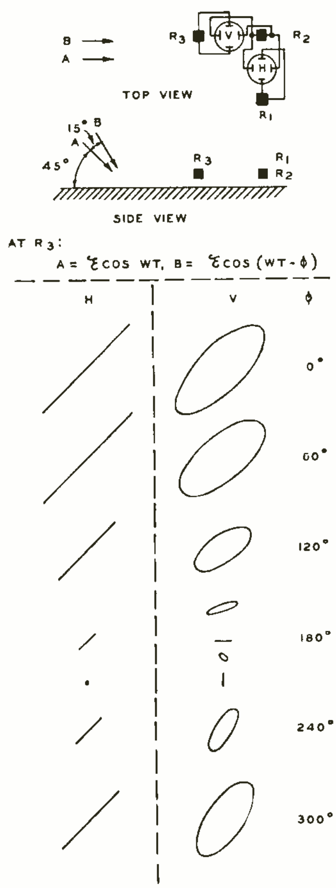


Fig. 4—Illustration of fading effects due to reception of two waves at slightly different angles

five seconds. The small figures seemed at first very irregular in shape but careful observation proved that usually they consisted of a small line or ellipse rotating rapidly one way or the other.

These rotating figures and the constant change in the direction of reception suggest that fading is caused by changing wave interference. Two waves travelling by slightly different and constantly changing paths would suffer continually changing interference and produce a changing series of figures on the oscillograph. Figure 4 shows such a series of calculated figures for two equal waves arriving at the angles given at the top. These calculated figures bear a striking resemblance to the actual figures observed at times on signals from G B K. The signal figures are sometimes much more complicated but this may be caused by interference between more than two waves, or between two waves of different amplitude. Although fading of short waves may be caused also by rapid changes in absorption it is believed that changes in wave interference are by far the commonest cause of this phenomenon.

The Terms of Settlement

Whenever the purpose of life insurance is to supply protection for dependents, the stipulations by the insured as to the terms of payment to the beneficiary are of paramount importance. Failure on the part of the insured to specify some plan of payment means the sudden placing of a large sum of money in the hands of the beneficiary for investment. It all too often happens that a widow and her insurance money are soon parted. One of the attractive features about the employees' insurance plan recently adopted by our Laboratories is that it stations in our midst an insurance expert whom we may consult in regard to such important matters as terms of settlement. This applies to those whose insurance antedates the plan as well as those who are coming in under it. So many plans are available that almost any combination of events may be intelligently anticipated. Neglect is inexcusable, since it means the throwing of heavy responsibilities on survivors when they are least able to bear it.

A New Non-Multiple P.B.X.

By V. I. CRUSER
Systems Development Department

WHEN the need for private branch exchange service first originated most of the Telephone Companies designed their own equipment and, as a result, a large number of different types were manufactured with an inevitably large manufacturing cost for each. However, in 1904 a non-multiple switchboard designed to meet the common needs of all the Associated Telephone Companies was developed and manufactured. This switchboard was known as the No. 4 P.B.X. Since that time many changes in the design of both the framework and circuits have been made in order to keep this part of telephone equipment abreast of the other branches as the art of communication progressed.

The demand for private branch exchange service grew rapidly and in 1916 the 550 type non-multiple P. B.X. was designed, with a framework improved both in appearance and construction, to replace the No. 4. The 550-A and 550-B boards were developed in rapid succession. This type was made in three different sizes: one with a capacity for thirty station lines, another for eighty lines, and a third for 320 lines. In 1920 the design was modified to add dialing equipment so that the boards might work into dial central offices and the board was then called the 550-C.

The 551 type P.B.X. switchboard, which replaces the 550-C, is a product of 1927. In the early part of that year the basic ideas for the new design began to crystallize. The design was completed, the manufacturing plans laid, and the production tools made up before November, when production of the new boards began. Before the end of the year the first lot was shipped and placed in service.

The 551 type P.B.X. was designed

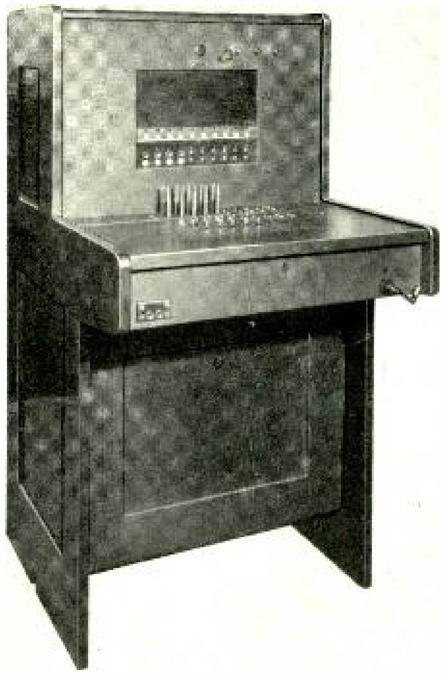


Fig. 1—Front view of 551-A P.B.X. without transmitter

to improve maintenance conditions as well as to reduce the cost of manufacture. The same operating features are employed in the new board as were used in the 550-C. However, in place of the three different 550-C framework sizes, that is the thirty, eighty, and 320 line boards, the 551 type P.B.X. is made in only two sizes but arranged for three capacities: the smaller size with a capacity for forty station lines, known as the 551-A; and the larger, with a capacity for 320 lines, known as the 551-B. The large board may be equipped for a maximum of either eighty or 320 lines. The capacity of the thirty line board was increased to forty lines in order to increase the demand for the 551-A board by absorbing a part of the demand for the discontinued eighty line size.

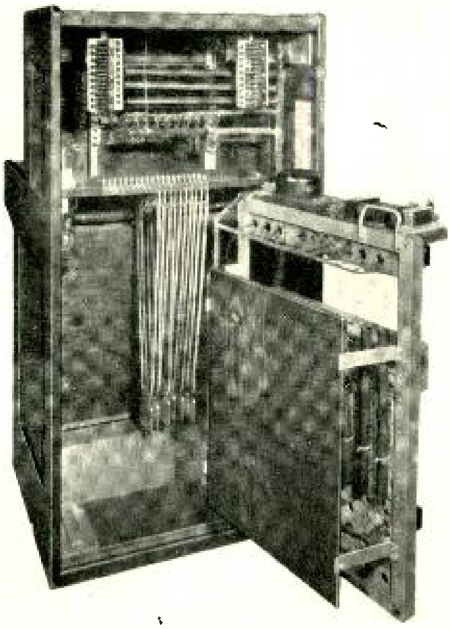


Fig. 2—Rear view of 551-A with relay gate open showing the cord-weight protection panel in place

In the new board strip-mounted jacks and lamps are used for the station lines. All apparatus inside the section, except the hand generator and ringing resistance lamp, is mounted upon a relay gate which makes the equipment immediately available for adjustment while the gate is closed and leaves the wiring fully exposed when the gate is open. The cord-weight protection panel is mounted on the relay gate rather than being fixed in the section so that when the gate is open and work is being done on the cords or hand generator the gate wiring is still protected from damage.

As the new type of P.B.X. was developed, features were incorporated in it so that it could be manufactured on a progressive assembly basis in line with the general tendency for mass production. An assembly plan has been worked out in conjunction with the engineers of the Western Electric Company so that the interval of manufacture for the 551 is ap-

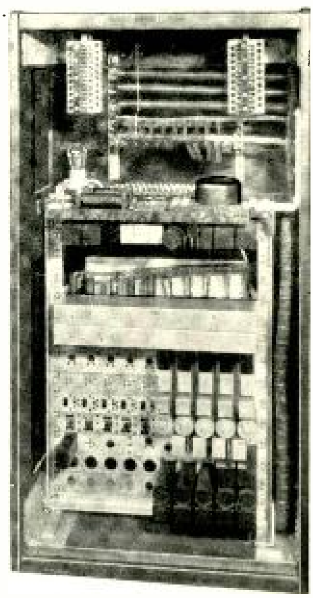


Fig. 3—Rear view of 551-A with gate closed showing relays mounted on outer side

preciably less than that of its predecessor. In place of carrying on the different phases of manufacture in various departments throughout the manufacturing plant, the new boards are completely assembled, wired, tested, inspected, and even crated in one department. All of these operations are concentrated in one shop and are so timed that one follows on the heels of another, in proper order in the progressive assembly line.

The framework for the new switchboard is made up of a minimum number of parts. Essentially it is formed of a floor, a roof, and two end panels of wood assembled together by means of large bent angles of sheet steel screwed in the four corners. To this are added the keyshelf, front panels, and rear door to complete the housing for the equipment. The rear equipment in both the 551-A and the 551-B is mounted upon the welded angle-iron gate. This gate is so placed in the framework that it not only serves to mount the equipment in a position easy for maintenance but, when locked in a closed position, reinforces the framework.

One of the chief objects of the new design was to eliminate as far as possible the repair work on the woodwork required after the boards are placed in service. After studying conditions at various branch houses it was found that the keyshelf and face of a P.B.X. were the first to become worn and that repairs on these parts made up the larger part of all framework repairs. To avoid this and to give the new boards a longer field life, both the keyshelves and the fronts of the 551 P.B.X.'s have been faced with phenol fibre rubbed a dull

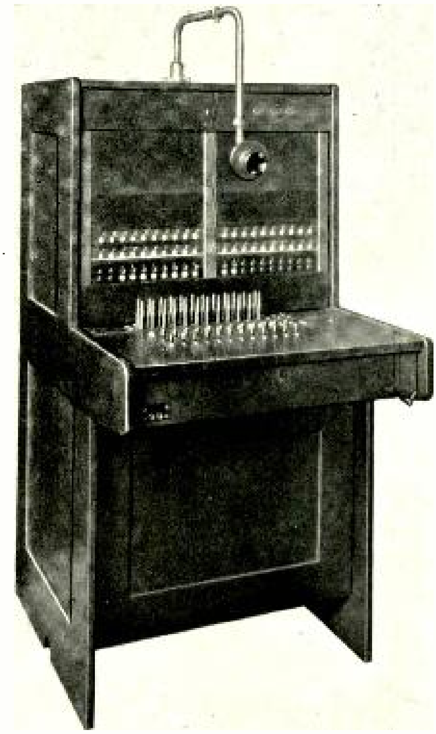


Fig. 4—Front view of 551-B P.B.X. equipped with standard transmitter

black which not only results in a pleasing rich appearance but provides a very hard and durable surface.

As is so often the case, the development of this new P.B.X. has resulted in a board easier and cheaper to manufacture as well as one that is more pleasing in appearance and that is easier to maintain in the field than the board it replaces.

Some Early Cable Terminals

By A. F. GILSON
Assistant Apparatus Development Engineer

AMONG the many problems arising from the use of lead covered cables is that of providing a suitable termination. The conductors of ordinary lead covered telephone cable are insulated with unimpregnated paper which is a very effective insulator when dry but a very poor one when wet. Measures must be taken, therefore, to prevent moisture from reaching the paper, and the lead sheath does this very effectively. At the ends of the cable, however, where the lead sheath ends and the conductors are connected to line or distribution wires, or to other cables where a sheath splice cannot be made, moisture could readily enter and impair the insulation if special steps were not taken to prevent it. Cable terminals are the devices used for this purpose and many types have been developed to meet a large variety of requirements.

The first solution of the terminal problem was direct and simple. A lead sleeve somewhat larger than the sheath of the cable and perhaps fifteen inches long was slipped over the end of the cable and slid back a few feet to be temporarily out of the way. The cable sheath was then cut back a short distance, the wires spread out, and paired rubber-covered wires were spliced on to them. Following this the loose sleeve was moved back till it covered the splices and the cable end of it was formed around the sheath and a straight wiped joint was made to prevent the entrance of moisture. The sleeve was then filled with a sealing compound which after cooling was covered with a layer of asphalt compound as a further seal against the entrance of moisture at the open end. In con-

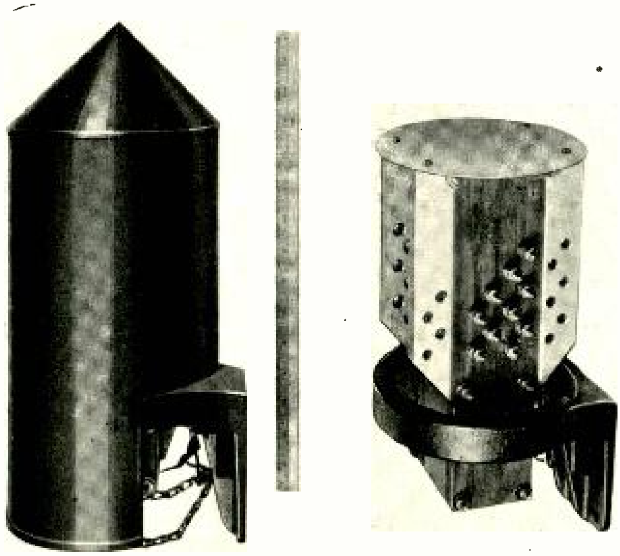


Fig. 1—Early 8-A cable terminal with protecting cover in place on the left, and with cover removed on the right

nection with the pothead the Telephone Companies used various types of boxes equipped with connecting blocks or fuse mountings to which the wires from the pothead were con-

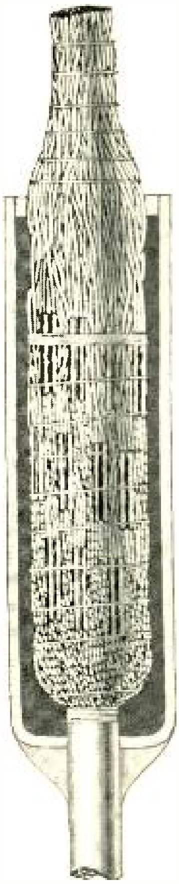


Fig. 2—Diagrammatic sketch showing method of forming pothead

nected. The drop wires were then run from these connections to the subscriber's stations.

The pothead, as it was called, accomplished its purpose of protecting the interior of the cable from moisture and did it very simply. It has certain obvious failings, however, which another early type, called sealed chambers, attempted to avoid. These were iron chambers mounted in wooden boxes, the former being provided at the bottom with brass nipples through which the cable entered and to which its sheath was soldered to exclude moisture. Through the side walls of the chamber extended insulated binding posts and the conductors of the cable were fastened to their inner ends. After all the connections were made the chamber was usually filled with a sealing compound. From the projections of the binding posts on the outside of these chambers connections were taken for the subscribers' stations. By this means, therefore, the cable was not only satisfactorily sealed but points

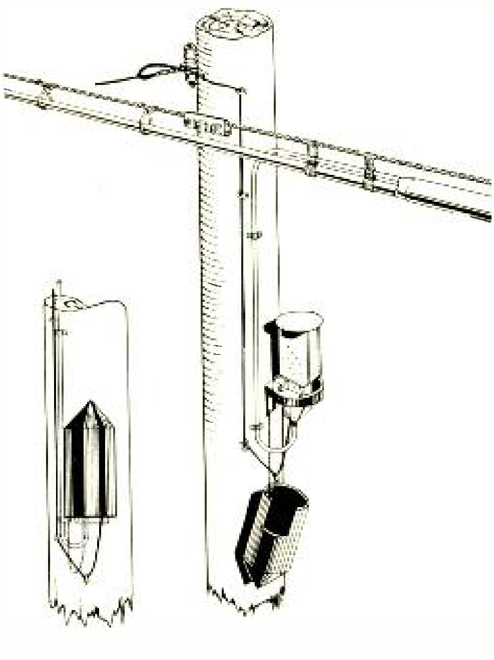


Fig. 3—Method of mounting No. 8 type terminal on telephone pole

of attachment were provided for the connecting wires.

Use of the potheads and sealed chambers resulted in a wide assortment of cable terminals, as many different arrangements were used to meet the various requirements of the

Associated Companies. To better this situation by providing a standard means to connect open wire to cabled telephone circuits the development of standard terminals was undertaken,

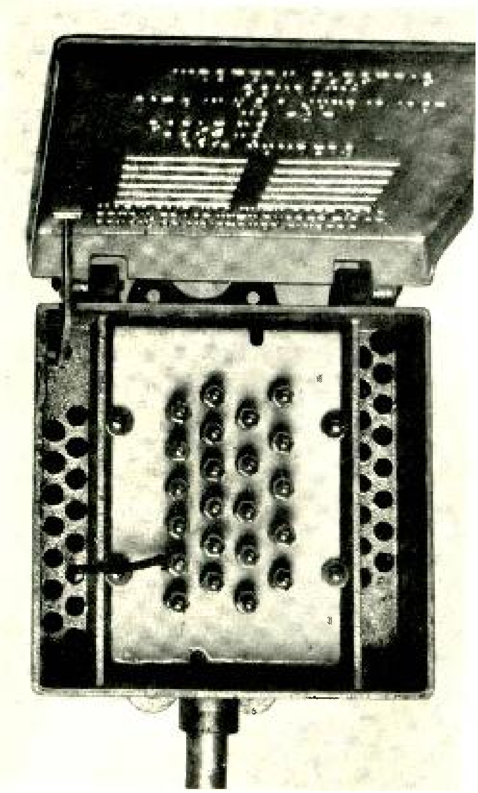


Fig. 4—No. 14 type cable terminal with porcelain block in place

leading to the various types now used.

In all the later development the sealed chamber principle was used. The cable entered a chamber of one form or another, its sheath was soldered or otherwise sealed at the entering point, its wires fastened to binding posts running through the sides, and finally the chamber filled with a compound to complete the sealing of the cable. In addition, an outer covering, usually consisting of a wooden box or metal cover, was provided to protect the terminal and its connections from direct exposure to the weather. The many forms of terminals subsequently developed were necessary because of different sizes of cable to be accommodated and because of the different classes and conditions of service.

The first two types designed, the No. 8 and the No. 14, were both primarily for connecting local cables to subscribers. The No. 8 had for its sealing chamber a rectangular wooden box about a foot long and a few inches in width and breadth. The cable entered through one end and at this place its sheath was wrapped with adhesive tape and held between wooden clamps which closed that end of the box. Through two of the opposite sides of the box projected the required number of binding posts to terminate all the wires in the cable. A six-and-a-half-foot length of 22-gauge cable was built into the box at the factory.

In assembly, the wires of the cable stub were all soldered to the inner ends of the binding posts. After this the box was bolted together, the clamp on the sheath adjusted at the lower end, and then the whole filled with sealing compound from the top, which was afterward covered over with a circular piece of sheet metal.

The wood composing the two sides containing the binding posts was cut a few inches wider than the box over the upper two-thirds of its length. These projecting flanges were drilled opposite each binding post to serve as fanning strips which allowed the entering wires to be run to their proper terminals.

The entire box was supported by a cast iron bracket as shown in Figure 1. The vertical part of this bracket was made for fastening to poles, and the annular part supported a cylindrical can, which covered the entire terminal in service, and allowed space for the entering wires to pass through it to the fanning strips. The can was chained to the supporting bracket so that it would not be dropped from the pole or lost. This No. 8 type terminal was made in 10, 16, 26, 31, and 51 pair sizes, but the two larger ones were rarely used.

The No. 14 type* reverted to the earlier forms of terminals in using a cast iron sealing chamber. It is very satisfactory for mounting on the sides of buildings or other flat surfaces as well as on poles, and is usually mounted so that the hinged cover will be closed by gravity. The movable arm shown in the accompanying photograph is used to support the cover while connections are being made.

The terminal block through which the binding posts pass is of porcelain and covers the front of the sealing chamber proper. The rear of the porcelain block has a ridge formed on all four sides which fits into a corresponding depression at the sides of the sealing chamber. The ridge is drawn into the groove against packing material to make the whole perfectly tight. This box also is assembled at the factory with a cable stub similar to that of the No. 8, which may be made other than the standard length on order.

Provision is made for the cable to enter at either the top or bottom of the box as may be specified. The end not used for the cable entrance is used to fill the sealing chamber after the cable conductors have been soldered to the binding posts and the terminal block fastened into place. This second opening is then closed with a pipe plug. To protect the cable from too sharp a bend and to provide a tight joint, a combination of brass and lead nipples are used at the entrance point.

The sealing chamber is deeper than the rest of the box and on its rear side carries the lugs at top and bottom which are used for fastening the box to the building or other support. In the back surface of the box proper,

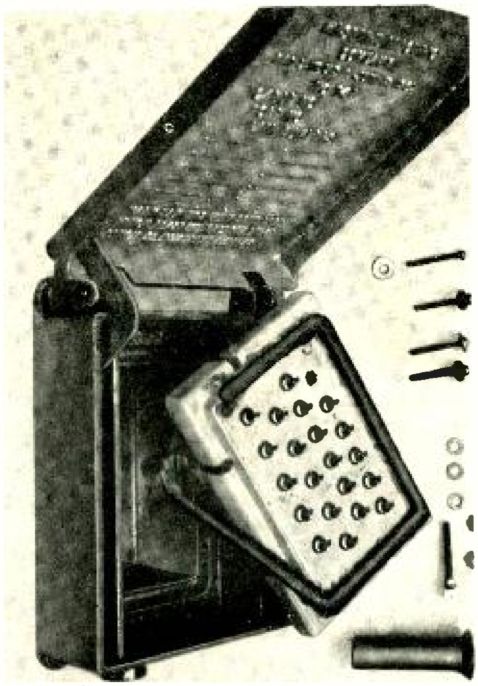


Fig. 5—No. 14 type terminal showing construction details

between the sealing chamber and the two outer sides, are holes which enable these two narrow sections to serve as fanning strips. Incoming wires thus enter from the back of these two shallow wings and are fan-

* *This terminal was originally designed by S. P. Grace, now Assistant Vice-President of Bell Telephone Laboratories but at that time Chief Engineer of the Central District and Printing Telegraph Company, and R. A. L. Snyder, his associate, who continues in the successor organization, The Bell Telephone Company of Pennsylvania.*

ned out to their proper binding posts. The No. 14 type terminal is made in 11, 16 and 26 pair sizes only.

Of the No. 14 type terminal, the Western Electric Company has made to date about two and a half million. It is the only terminal so far described that is still standard with the Bell System. The potheads and earlier boxes went out of use because the No. 8 and No. 14 were less expensive to maintain. The No. 8 has gone out of use only recently because greater experience with terminals has made it possible to design types which have higher insulation resistance and are easier to install and maintain. The terminals to be described in a later article are designed on the basis of many years experience and are in many forms to meet the increasingly complex conditions found in the field.

A Newspaper Comment From France

La Nature du premier janvier nous apprend que le recensement entrepris par l'Academie des Sciences de Washington, en excluant les laboratoires officiels et les petits laboratoires privés, relève mille laboratoires au service des grandes industries. . . . La Societé Bell, à New York, pour ses recherches de télégraphie et de téléphonie, emploie plus de deux mille techniciens, formés par les plus grands savants des plus florissantes universités et disposant de laboratoires de recherche et d'experimentation. Et nous concluons, avec notre confrère, que l'hégémonie industrielle américaine n'est pas due seulement à des avantages naturels exceptionnels, mais aussi — probablement surtout — à l'esprit de travail, de méthode et d'organisation.

— *L'Ouest (Angers)* 15 *janvier*, 1928.

Very Thin Films of Rubidium

By A. L. JOHNSRUD
Research Department

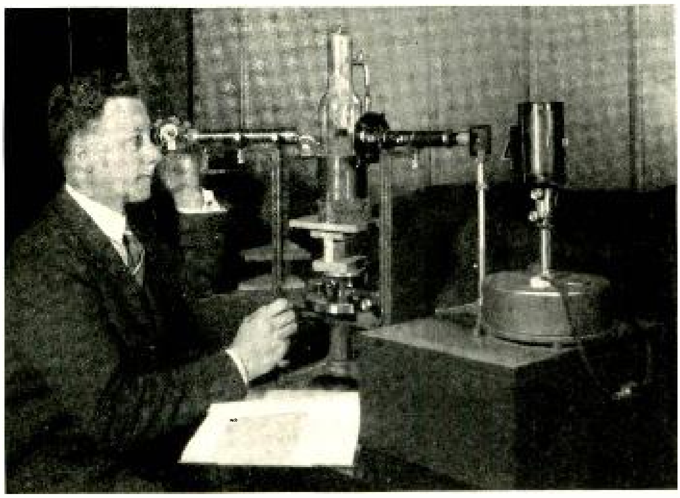
SOME of the recent developments in the art of communication, such as telephotography, talking motion-pictures, and television, have as an essential part a photoelectric cell whose function is to yield an electric current faithfully proportioned to the amount of light falling upon it. For the cell to yield this current most efficiently and in amounts large enough for practical use, a long process of development has been necessary. This in turn has been based on extensive research on fundamental problems in photoelectricity, carried on in our laboratories under the direction of H. E. Ives.

Long preceding the recent concerted efforts in bringing photoelectric cells to a high state of development, it had been noticed that alkali metals were more efficient in yielding photoelectric currents when in thin films than when in bulk. It was therefore desired to know more about the relation between film thickness and photoelectric response.

The commonly used alkali metals include sodium, potassium, rubidium and caesium, all more or less photoelectrically sensitive. Rubidium lends itself best to the study of thin films. It volatilizes, diffuses and deposits in vacuo at temperatures in a range conveniently near room temperature, and in short time-intervals suitable for experimental purposes.

For the most effective study of the phenomena involved, there was constructed a large vacuum cell containing enough rubidium to allow a spontaneous deposit to take place on all internal surfaces until equilibrium at room temperatures had been reached. This deposit, so thin that it was quite invisible, covered not only the walls but a thin square piece of glass in the interior as well. Supporting this plate at opposite ends were platinum wires, sealed onto the front surface to make contact with the metal film. A tungsten filament, supported close behind the plate, provided radiant heat for driving off the rubidium whenever desired. The photoelectric current was collected on a large nickel anode which nearly enclosed the glass plate and filament, and an area of the cell wall was kept clean with a flame to provide a window for light to pass through to the plate.

It was found, as expected, that a heavy coating of rubidium, actually constituting a solid metallic surface, gave considerably smaller photoelectric currents than those obtained from thinner films. It was likewise noted that films which had not had time to deposit to their equilibrium thickness gave smaller photoelectric currents than those that had come to equilibrium. Two series of measurements of photoelectric current were therefore required—one while the thickness was diminishing from that of the heavy opaque coating to the equilibrium value, and the other while the rubidium was depositing on the freshly-cleaned glass plate. During each process the electrical conductivity along the surface of the glass plate was being measured. This approached the same value, regardless of the direction from which the equilibrium point was approached. The question then became "How thick is the film at its equilibrium value?"



Mr. Johnsrud operates the polariscope, by which the thickness of very thin rubidium films was measured

It might be possible to calculate the thickness of the film from its lateral dimensions and its specific resistance. But was the assumption justified that such a thin layer of metal would conduct electricity in exactly the same manner as would a considerable volume of it? True, it obeyed Ohm's law in the dark, but its resistance might in some way be altered under illumination. This was especially probable since the thickness of the film was comparable to the diameter of the rubidium atoms themselves. Measurement of thickness by means of resistance was therefore considered unreliable in this particular case.

Here is where a new method of measurement had to be adopted, surpassing in fineness not only microscopes of the highest power, but interferometers as well. The measurement must reach the formerly inaccessible region between visible light and X-rays, radiations whose wave-lengths bear to each other roughly the ratio of ten thousand to one.

It seemed likely that the thickness of the film to be measured would be as little as one atomic diameter, one half of one millionth of a millimeter. Waves of light convenient to work with are a thousand times as great as that in length. It was decided, therefore, to base the measurements of thickness on the principle that plane-polarized light, in passing through any film, experiences a rotation of its plane of polarization. The extent of the rotation is governed by the thickness of the film, the wave-length of the light and the angle of incidence. By using light of a single wave length (the green line of the mercury arc spectrum), and taking a set of observations at different angles of incidence with a polarization spectrometer, we were able to obtain accurate values of the thickness of the rubidium film from the known constants of the material.* This was possible not only at the

* *The difficult task of preparing the many sets of calculations required was performed by T. C. Fry and his associates.*

equilibrium, but while the film was growing or diminishing. By interspersing optical and electrical measurements, we were able to measure the rate at which the film increased or diminished in thickness.

The following results were noted:

1. At room temperature, the thickness of the spontaneously deposited rubidium film was approximately one atomic diameter.
2. The depth of penetration of light into solid rubidium as measured by the means and in accordance with the theory described in the text was found to be as great as twenty atomic diameters.
3. In spite of this penetration of the light, the photoelectric current emitted from solid rubidium was approximately the same as that derived from a film one atomic diameter thick.
4. A film of rubidium so thin as to yield a thickness measurement of less than one atomic diameter is electrically conducting. Since the underlying glass surface under those conditions must be only sparsely covered with atoms, it appears likely that the metal atoms are in rapid motion over the surface, and that conduction is made possible by their collisions.

Instructors Entertained at Luncheon

MARKING the completion of the ninth consecutive year of the Out-of-Hour Courses those members of the technical staff who were instructors in last season's courses were entertained at lunch on May 29 by Mr. Craft.

Following the luncheon Mr. Craft, as host and toastmaster, recounted the philosophy of the Out-of-Hour Courses. He pointed out that in carrying on the work of the Laboratories consideration must be given not only to doing well to-day's job but to developing an organization to carry on to-morrow's work even more effectively. The Personnel Department was organized ten years ago as a help to this end. Studies during the first year brought out that there was a general feeling of need for some means to make available information on our work. The organization had been growing rapidly so that there were many new members who felt their limitations as compared with the seasoned veterans who had gathered their information and background through years of experience. To take care of this need some of the departments were carrying on conferences within their own organizations and a number of groups of individuals were getting together out-of-hours to exchange information or have an expert give them the benefit of his experience.

A study of the whole situation indicated that the newer members of the organization could be broken in more rapidly if means were provided whereby the information on subjects of vital interest to the Laboratories could be collected, arranged, clarified and explained so that any member of the organization might have access to the principles and practices which the experts had developed and worked out during the past years. It was felt that this information would be more effectively disseminated if classes were held. This would give the stimulation which comes from definite scheduling and from group discussion which brings out more ideas than does individual study. It was also felt that these classes should be on an opportunity basis where any member of the organization who had the proper qualifications might be enrolled in a course. It developed on consideration that the only time which would make this practicable would be outside of regular business hours.

A study of educational plans of other industries showed that much had been done. The Hawthorne Club had conducted a good many classes in which club members were enrolled. These classes were conducted as a club and not as a Western Electric activity. Other organizations were preparing for similar activities and a study of these and other plans all had the common characteristic that they were organized as separate from the business. After careful consideration it was deemed wise to set up the educational plans for out-of-hour courses in the Laboratories on the basis that they were a regular part of our work, recognizing that through these courses the Company was making available for present and future members of the organization information on past accomplishments.

Our own experience indicates that this method of considering educational work a part of the regular business gives satisfactory results. Further evidence of soundness of this plan is shown by the fact that the Western Electric Company in New York City and the New York Telephone Company recently started out-of-hour courses fashioned after those conducted in the Laboratories.

To carry out this plan the instructors must be those who are recognized experts in their respective fields. As a consequence, instructors have not been self-selected nor are they selected by any individual or a fixed group of individuals. Each is naturally selected as the one who is recognized by his associates as being the most capable and available person. As the preparation of text material requires additional work on the part of the instructor, he is not assigned to this work by his department but is invited to conduct a class.

Reviewing the accomplishments of the past nine years, M. B. Long, Educational Director, said that eighty per cent of the present Technical Staff had taken part in one or more of the courses. A total of seventy-two different courses have been given—some of them repeated several times—by 147 members of our organization as instructors. A total of 3,149 individuals have taken one or more courses; this year there were 592 enrollments.

During the year just ended twenty courses were given. One course, Theory of Telephone Transmission, has been offered each year although revised several times. The period during which any one individual has acted as instructor ranges from a minimum of one-half to a maximum of six years. During the past year twenty-eight instructors contributed to the carrying on of the plan.

In keeping account of the total load brought about through the giving of the course some basic unit of measure seems to be desirable. The student class hour has been selected as that unit and a study of the past years shows an average per year of 13,000. During the past year, 1927-1928, the total load was about 16,000 or about 30% above the average. If we are interested in the total load placed upon the members in this regard we must take into account the outside time required for preparation. It seems, therefore, that 50,000 person hours is a reasonable figure to express as being given to out-of-hour courses during the past year.

During each of the last few years sixteen of the courses have had a capacity demand and so have come to be looked upon as fundamental to the plan. They have therefore been repeated a good many times and now play such an important part in the training of new men that the text materials have been worked over and revised until in some cases they seem to have become almost an official encyclopedia. In concluding, Mr. Long expressed considerable pleasure in having the opportunity to extend his appreciation to those who this last year had acted as instructors, for their all important part which made the courses possible.

For the instructors, Timothy E. Shea discussed their efforts and their future. As a result of personal contact made in out-of-hour courses many a conference has come off more smoothly and many a memorandum has been improved. There is also opportunity for the intrinsic development of the instructor himself, through the discipline exacted by the organizing of course material and the capacity developed for sustained effort, the opportunity for self-expression in class room and in text, an increase in self-confidence which is reflected in his daily work, a widening of his mental horizon and an opportunity of studying his students. The students are also studying their instructor, and so there is opportunity for the building of professional reputation. Decidedly, the instructor profits from the time and energy put into preparing and presenting his course.

Since many of the courses cover subjects which are not suitably treated in existing books, new texts have to be evolved by the instructors. How these texts are made available for newcomers in the Laboratories, and subsequently to wider audiences, was discussed by John Mills, Director of Publication. Four books by members of the Laboratories have now been published, and several others are in preparation for publication.

Saying that the occasion would not be complete without a few words from "The Dean," Mr. Craft called upon George B. Thomas, Personnel Director. Mr. Thomas congratulated the instructors on the splendid results in their year's work, praising particularly their excellent spirit of cooperation.

Mr. Craft concluded the program with remarks on the coordinating influences of the courses. He expressed his feeling that the soundness of the plan was thoroughly evident and that the effort was thoroughly justified. He extended his thanks to the instructors for their loyal part in a job well done and predicted that the same spirit would carry us forward through the work of tomorrow.

News Notes

THE degree of Doctor of Engineering has been conferred upon F. B. Jewett by the Case School of Applied Science in Cleveland. In conferring the degree, President Charles S. Howe referred to Dr. Jewett as "a profound student of electrical engineering; skillful investigator of many engineering problems of electricity; effective and inspiring teacher of engineering, and wise and efficient administrator of a great research laboratory." Dr. Jewett also delivered the Commencement Address at Case School, the title being "The Problems and Prospects of the Young Engineer—How They Differ from Those of His Father."

On June 9, President John M. Thomas of Rutgers University awarded President Jewett the honorary degree of Doctor of Science.

ON MAY 14 Mr. Jewett attended a hearing of the Federal Radio Commission held in Washington on allocation of short waves. Other recent activities of Mr. Jewett include attendance at a Past Presidents' luncheon of the A.I.E.E. on May 22, and a dinner of the Society of Arts and Sciences, at which a gold medal was conferred on Thomas A. Edison. Mr. Jewett, representing the engineering societies, spoke on "Edison as Seen by His Fellow Engineers."

Mr. Jewett is a member of the American Committee of the World Engineering Congress that is to be held in Tokio, Japan, in October, 1929. He was recently appointed Chairman of the subcommittee on transportation.

AT THE REGULAR WEEKLY MEETINGS of the Vice-Presidents of the Western Electric Company on June 6 and 13, E. B. Craft spoke on the cost-reduction work of the Bell Telephone Laboratories during the past year. On June 15 he addressed the members of the Department of Development and Research on the internal operation of the Laboratories. In May he addressed the members of the Bell System Operating Conference held at Absecon, New Jersey, on activities of the Laboratories.

DR. CRAFT was the speaker at the Commencement Exercises of Worcester Polytechnic Institute on June 18. His subject was "Industrial Research." Later he addressed a group of men at the Worcester Club, guests of Mr. Charles M. Thayer, on research and development in the communication industry.

PROFESSOR W. F. G. SWANN of the Bartol Research Foundation addressed the Colloquium on May 28. Speaking on the topic "Possible Modifications in Electrodynamics and Their Consequences," he explained the earth's charge and its magnetic field by assumption of a slow destruction of positive charges.

J. C. HUNSAKER spoke at the dedication of the Daniel Guggenheim Aeronautical Laboratory at Massachusetts Institute of Technology on June 4, outlining the history of the Department of Aeronautics, which

Graduates and instructors of the General Health Course: back row: the Misses Heiart, Menig, Cassidy, Fitzsimmons, Spindler, Beers, Mihavetz, Prouty; seated: the Misses Dunbrack, Murison, Sall, Crawford, Van Riper, Egan, Bauer. Other graduates, not in the picture, are the Misses Gregory, Paret, Rossi and Tully

was established in 1914 with Mr. Hunsaker as an instructor.

Mr. Hunsaker has been appointed to the technical committee of Trans-Continental Air Transport, Inc.

Graduates of the first two classes in the General Health Course for Women in the Laboratories attended on May 28 a tea held at the Fifth Avenue Hotel in honor of the graduates of the third class, which began October 4, 1927. This class, like the preceding ones, was taught by Statira Crawford of the Medical Department, assisted by Gratia Prouty of the Employee Service Department. Seventeen girls out of the twenty-nine registered finished the course. The certificates were distributed after the tea by George B. Thomas, Personnel Director.

A visit to these Laboratories on June 11 was part of the program of the Ninth International Cost Conference, held in this city under the auspices of the National Association of Cost Accountants.

Apparatus Development

J. J. Lyng, O. M. Glunt and E. L. Nelson visited Hadley Airport near New Brunswick, New Jersey, on June 8 to inspect the radio laboratory facilities that have been provided at that point and to witness the initial test flight undertaken by the radio development group. The Laboratories' Fairchild plane, piloted by A. R. Brooks, was equipped with a field strength measuring set and was taken up for a fifty minute flight during which observations on the strength of the signals from 3XN were made by P. H. Evans and E. F. Brooke.

D. H. NEWMAN visited Roanoke, Virginia, late in May to make the survey for the Richmond Development Corporation's one-kilowatt broadcasting station. Later he visited Chicago, where he installed the five-kilowatt transmitter of the Chicago Daily News.

H. S. PRICE recently inspected WEEI, the station of the Edison Electric Illuminating Company of Boston.

W. L. TIERNEY made the survey for the five-kilowatt installation purchased by the Western Broadasting Company to replace their 500-watt equipment at Station KNX.

C. H. GREENALL AND A. H. FALK visited the laboratories of the National Lead Company in Brooklyn on May 18 in connection with proposed tests for the lead case for submarine loading coils. C. R. Young joined them in a trip through the two National Lead plants at Perth Amboy on May 22.

J. R. TOWNSEND attended a meeting of the A. S. M. E. committee on spring design in Pittsburgh on May 16, and was appointed chairman of a subcommittee on spring materials.

H. A. ANDERSON spent some time with the Ingersoll Rand Company in Phillipsburg, New Jersey in connection with the heat treatment of climbers to eliminate the possibilities of failures from brittleness.

A. D. HARGAN visited several Boston exchanges on June 1 in connection with multiple bank problems.

H. F. DOBBIN AND W. GOFF visited the plants of Brown & Sharpe at Providence, and Pratt & Whitney at Hartford, Connecticut, on May 22 and 23, to investigate the latest methods of cutting and grinding gears.

ON JUNE 14 the Specification group tendered to H. W. Heimbach a luncheon at a nearby restaurant to mark the occasion of his transfer to the staff of W. T. Booth, Executive Assistant. Mr. Heimbach has headed the Specification group since its inception in 1919. A testimonial scroll, signed by every member of his own group, was presented with a wrist watch as concrete evidence of personal regard. Voicing the same sentiments, members of the Apparatus Files group gave Mr. Heimbach a pen and pencil set, and decorated the luncheon tables with flowers.

BASED ON THEIR EXPERIENCE IN THE LABORATORIES, the degree of Electrical Engineer has been conferred by Cooper Union on J. B. Shiel, W. J. Turney and H. L. Walter, graduates in former years of the evening courses of that institution.

GENERAL STAFF

S. P. GRACE was the guest of honor at a dinner given by Mr. C. W. Bergquist at the Union League Club of Chicago, prior to a lecture by Mr. Grace before the Western Society of Engineers.

MR. GRACE spoke before the executive and supervisory staffs of the New York Telephone Company on June 20, on recent developments of the Laboratories.

G. B. THOMAS AND JOHN MILLS attended on June 22 an educational conference arranged by the Chesapeake and Potomac Telephone Company for engineering and science professors of the colleges in its territory, and described for the conferees the work and organization of the Laboratories.

L. S. O'ROARK addressed the North Carolina Society of Engineers at Asheville on June 21, on "The

Electrical Transmission of Personality."

W. C. Toole and J. A. Joblin received degrees on June 7 after postgraduate work at the Brooklyn Law School of St. Lawrence University. The former received the degree of Doctor of Jurisprudence; the latter, that of Master of Laws.

G. F. Fowler, whose term on the Papers and Meetings Committee of the New York Electrical Society expired last month, has been reappointed for the coming year.

Miss Helen M. Craig attended the annual conference of the Special Libraries Association held recently at Washington. Miss Craig has also served as a member of the Electrical Engineering Committee of the Association in the preparation of its recently compiled Bibliography of Electrical Literature.

Inspection Engineering

W. A. Boyd attended a regular survey conference at Hawthorne during the week of May 28. H. F. Kortheuer and T. Mellors attended a similar conference at Kearny on May 7 and 8.

D. A. Quarles visited Edgerton, Wisconsin, during the early part of June, in connection with inspection methods for automotive equipment.

Outside Plant Development

C. S. Gordon conducted development studies involving small hand tools in Philadelphia on May 10.

O. B. Cook was in Lebanon, Pennsylvania, studying processes in the manufacture of manhole ladders, on May 19.

I. C. Shafer visited Trenton, New Jersey, on May 21 to obtain data on the results of a year's natural weathering on a trial installation of drop-wire attachments.

E. St. John visited Boston in connection with development studies of cable rings.

B. A. Merrick visited Binghamton, New York, and Easton, Pennsylvania during the early part of June for development studies in connection with linemen's tools.

C. H. Amadon visited Silva and Ceredo, West Virginia, and Asheville, North Carolina in connection with timber studies. On June 12 and 13 Mr. Amadon attended the summer meeting of the American Wood Preservers Association in Chattanooga, Tennessee.

Research

Frank Gray, J. W. Horton and R. C. Mathes are the recipients of the prize for the best paper on Theory and Research presented before the American Institute of Electrical Engineers during the year 1927. The award was for their joint paper entitled "The Production and Utilization of Television Signals," presented at the Summer Convention of the Institute in Detroit, June 20-24, 1927.

Harvey Fletcher contributed to the Proceedings of the Institute of Radio Engineers for May an extensive review of "The Theory of Sound," by Lord Rayleigh, from the viewpoint of its current usefulness. The original edition appeared in 1877 and revision came out in 1894, but both were out of print for a number of years, until the second edition was reprinted in the fall of 1926.

Mr. Fletcher delivered a paper entitled "Three Million Deafened School Children—Their Detection and Treatment (Further Data)" jointly with Dr. E. P. Fowler, before a meeting of the American Medical Association at Minneapolis on June 13. Mr. Fletcher also spoke at the Lions Club Luncheon on "Research Work on Speech and Hearing." He gave a similar talk at the combined luncheon meeting of the *Grafil* and Canopus Clubs. On June 18, he gave a demonstration, "Our Ears and How They Deceive Us," at a meeting of the American Federation of Organizations for the Hard of Hearing at St. Louis.

J. E. HARRIS AND E. E. SCHUMACHER attended in Philadelphia a conference on a new machine for wiping joints mechanically.

MR. HARRIS attended a meeting of the Metallurgical Advisory Committee of the Bureau of Standards in Washington, on May 11.

LIEUTENANT COLONEL A. S. ANGWIN AND MR. J. A. GRACIE, members of the British Post Office, are visiting the Laboratories for a few months in connection with radio development.

F. DE FREMERY, A. M. STEVENS, C. E. STRONG AND E. H. ULLRICH, from the International Standard Electric Corporation, are also visiting the Laboratories for several months, to study our methods.

R. M. BURNS visited the Chemistry Department of Harvard University on May 5.

C. L. HIPPENSTEEL spent the week of May 21 at Hawthorne in connection with work on diaphragms.

C. W. BORGMANN, R. M. BURNS, A. C. WALKER, J. A. LEE, A. R. KEMP, J. M. FINCH, AND H. T. REEVE attended a meeting of the A. S. T. M. at Atlantic City the week of June 25.

H. T. REEVE visited the Norton Company at Worcester, Massachusetts, on May 14 and 15 to investigate crucibles for melting precious metals.

K. K. DARROW has taken a leave of absence for a summer abroad and will spend a month in England, France and Germany. While there he will attend various electrical and physical society meetings and visit a number of laboratories.

R. C. MATHES has returned from a month's trip to the west coast in connection with the installation of the power line carrier system on the 220,000 volt transmission line of the Pacific Gas and Electric Company from Pitt River to San Francisco.

W. P. MASON has received the degree of Doctor of Philosophy from Columbia University. The subject of Dr. Mason's thesis was "The Propagation and Characteristics of Sound Tubes in Acoustic Filters."

H. E. IVES lectured on television before a meeting of the Radio Division of the National Electrical Manufacturing Association at Chicago, on June 5.

MR. IVES received the honorary degrees of Doctor of Science from Dartmouth College on June 9, and from Yale University on June 20.

R. E. WATERMAN will visit Denver, Colorado; Butte, Montana; Spokane, Washington and Portland, Oregon, to conduct wood preservation tests in conjunction with the Pacific Telephone and Telegraph Company.

L. H. GERMER spoke on "Optical Experiments with Electrons" before the Physics Seminar of Cornell University on Monday, May 28.

C. J. DAVISSON AND L. H. GERMER were the authors of a paper "Reflection and Refraction of Electrons by a Crystal of Nickel," delivered before the National Academy of Sciences, and sponsored by Dr. Jewett.

E. F. KINGSBURY gave a talk on television before the Men's Club of the Rutherford, New Jersey, Methodist Episcopal Church on May 28.

J. M. FENSTERMACHER has been elected to membership in the Edward H. Hall Chapter No. 25, of the Telephone Pioneers of America.

SYSTEMS DEVELOPMENT

F. B. ANDERSON visited Harrisburg, Pennsylvania, in connection with the tests being made on cable insulation measurements.

J. B. SHIEL, F. VAN VOORHIS, W. G. SCHAER AND H. A. LEWIS visited several installations of No. 11 switchboards arranged to handle the unusually heavy summer toll traffic in the Catskill Mountains.

C. W. GREEN was one of the authors of a paper "Carrier Systems on Long-Distance Telephone Lines" presented before the Summer Convention of the A. I. E. E. at Denver.

C. L. WEIS AND F. H. CHASE made tests on the first long-haul single-channel carrier telephone system, installed between Omaha, Nebraska and Storm Lake, Iowa, during the latter part of May.

R. L. LUNSFORD visited Chicago and Detroit in connection with general power plant problems.

R. B. STEELE visited Hawthorne in connection with tests on high frequency carrier telegraph equipment.

R. E. KING spent two weeks at Minneapolis, assisting in the cutover arrangements of the new Main-Atlantic Step-by-Step Office.

M. A. FROBERG has returned from a trip on which noise conditions in the repeater stations on the new Pittsburgh-St. Louis cable were studied.

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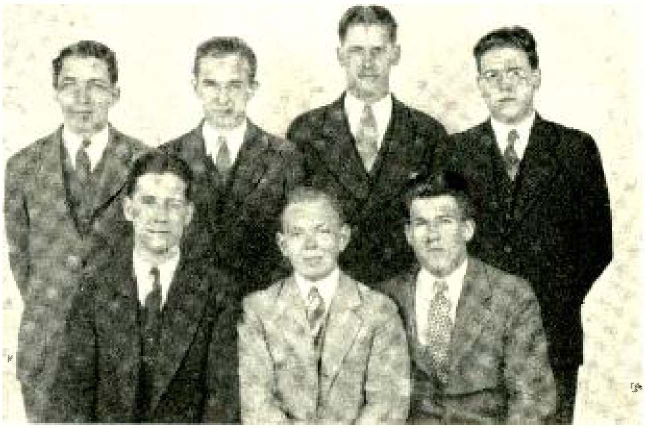
THE first group of students recently finished their period of training at the Laboratories under the new Electrical Communications Cooperative Course of Massachusetts Institute of Technology. Under this option terms at school are alternated with periods of experience provided in Western Electric Company, New York Telephone Company and Bell Telephone Laboratories during the last three years of the course. Members of this group will have another term in the Laboratories and will be graduated with M.S. degree in 1929.



Students from Massachusetts Institute of Technology who recently completed eighteen weeks' experience in the Laboratories. Seated, left to right: A. J. Carey, T. L. Bowser, J. D. Riley. Standing: J. R. Rae, T. B. Perkins, C. M. Day, C. A. Armstrong

Snap Shots from

Kontis clears the bar in the high jump

Finish of the sixty-yard dash: left to right, the Misses Fenton, De Martini, Harrer and Boman

Moffott and Thompson finishing the eight-eighty

Part of our tug-of-war team in action: Simmons, Haffner and Neilson, with Calmar coaching

the Track Meet

Club Notes

Once again West Street athletes proved their superiority when they won the Bell System Track and Field Meet at Erasmus Field, Saturday, June 16. However, the real credit of winning the meet goes to our girls, who scored fourteen of our thirty-two and one-half points. In the sixty-yard dash Marie Boman carried off first place when she won this race in eight seconds flat with Katherine Fenton, also of the Laboratories, second. In the quarter mile relay the West Street team composed of Misses Boman, Fenton, Kaempffe and Reinbold won the race by Miss Boman's spurt down the home stretch. Lillian Kaempffe finished third in the basketball throw.

First place in the one-mile relay was taken by the Laboratories' team, consisting of Pasanen, Moffot, Quinn and Toole. In the eight-eighty, Moffot came in second; Pasanen landed second in the broad jump; Quinn and Gardner took thirds in the 440-yard and the shot-put, respectively. Kontis split third honors in the high-jump. Inspired by Bill Calmar's able coaching, the Laboratories' strongmen—Neilson, Haffner, Simmons, Healey and Prachnaik—pulled a victory from Long Island Traffic's team in the tug-of-war finals.

Music from the Fifty-Ninth Artillery Band enlivened the afternoon; a note of humor was struck by the free-for-all novelty race in which contestants had to snatch up tobacco, corncob pipes and matches, and cross the finish line with smoking pipes.

D. D. Haggerty, President of the Bell System Athletic League, was Director of Games; other officials from the Laboratories were L. P. Bartheld, D. R. McCormack, F. Canavan, J. A. Waldron, C. T. Boyles, L. Drenkard, G. A. Brodley, K. B. Doherty and Marion Braillard.

TEAM SCORE

Bell Telephone Laboratories	32½
New York Telephone Co., B. & W.	17½
New York Telephone Co., L. I. T.	14
Western Electric Co., Hudson St.	9
New York Telephone Co., W. M.	9
New York Telephone Co., S. M.	9
New York Telephone Co., L. I. P.	8
New York Telephone Co., E. M.	6

BASEBALL

The baseball activities have progressed fairly well, considering the

The winning relay team: Misses Fenton, Kaempffe, Boman and Reinbold great number of rainy days since the season started. In the Club Interdepartmental League of four teams, the standing at the end of the first half of the season was as follows:

	Won	*Lost*
Systems Development Department	3	0
Tube Shop	1	2
Plant and Shop	1	2
Ringers	1	2

Baseball activities in the Bell System Athletic League are also progressing and are approaching the end of the league season with only three postponed games due to rain. The mid-season standing of the teams in this league was as follows:

National League

	Won	*Lost*	*Tied*
New York Telephone Co., L.I.P.	4	0	0
New York Telephone Co., L.I.T.	2	0	0
Bell Telephone Laboratories, Inc.	2	1	0
Western Electric Co., Hudson St.	1	2	0
Western Electric Co., G.H.Q.	1	2	0
N. Y. Telephone Co., L.I.C. & E.	0	2	0
Western Electric Co., Installation	0	3	0

American League

	Won	*Lost*	*Tied*
New York Telephone Co., E.M.	2	0	0
New York Telephone Co., C.C.	2	1	0
New York Telephone Co., B. & S.	2	1	1
American Tel. and Tel. Co.	2	2	0
New York Telephone Co., C.M.	1	2	1
New York Telephone Co., S.M.	1	2	1
New York Telephone Co., W.M.	0	2	1

Golf

The weather for our outdoor tournament was fortunately perfect on June 2 and 9, although the rainy season preceding the tournament had deprived many golfers of practice. Twenty-eight men out of the eighty starters qualified for the finals. In the qualifying round W. F. Johnson won the medal for low net score while J. Hillier and J. A. Burwell tied with a low gross score of eighty-six, which necessitated taking the best score of these two men in the finals. Burwell's eighty-eight against Hillier's ninety-three won the medal for low gross on June 2. The men qualifying for the finals are as follows:

CLASS A

Flight No. 1	*Net*	*Flight No. 2*	*Net*
J. Hillier	73	W. F. Johnson	65
J. A. Burwell	70	W. L. Kidde	76
H. W. Wood	74	F. F. Farnsworth	73
O. Cesareo	73	H. L. Downing	72
J. G. Roberts	77	C. T. Lewis	76
G. E. Kellogg	77	E. J. Johnson	75
E. H. Clark	79	E. C. Mueller	73

CLASS B

Flight No. 1	*Net*	*Flight No. 2*	*Net*
W. J. Lacerte	67	J. C. Palmer	77
E. H. Elliott	74	J. R. Kidd	77
O. H. Williford	75	T. P. Ingram	78
P. B. Fairlamb	76	A. G. Dalton	78
J. A. Lee	76	O. H. Danielson	78
R. E. Collis	77	J. Hall	79
W. E. Mougey	77	A. C. Keller	79

In the finals O. Cesareo achieved an eighty-four after consistently brilliant playing, and won the watch offered for low gross score in Class A. R. E. Collis, with a ninety-four, won the watch offered for low gross score in Class B. The other prize winners were as follows:

Class A — Flight 1

Low Net	J. A. Burwell	72
Second Low Net	G. E. Kellogg	74

Class A — Flight 2

Low Net	E. J. Johnson	73
Second Low Net	H. L. Downing	73

Class B — Flight 1

Low Net	E. H. Elliott	75
Second Low Net	W. J. Lacerte	77

Class B — Flight 2

Low Net	O. H. Danielson	72
Second Low Net	A. C. Keller	73