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"TU" Becomes "Decibel"

By R. V. L. HARTLEY
Transmission Research Director

SOME years ago the mile of standard cable was displaced as the unit of transmission in the Bell System by a younger brother. This newcomer in the family of transmission units, being without a given name, adopted that of the family and became known as the "transmission unit" or "TU". It has now been given the more distinctive title of "decibel", commonly abbreviated "db". The prefix "deci" indicates one-tenth, while "bel" is derived from the name of Alexander Graham Bell.

The members of the transmission unit family resemble each other in that they all measure the logarithm of the ratio of two powers, currents or other quantities which express the magnitudes of the waves being compared. This is a desirable property from two standpoints. First, it insures that two sounds of the same general nature and quality which differ by a given number of transmission units have the same difference in loudness regardless of their absolute loudness. The difference in loudness of two sounds may be measured by the number of intermediate steps that can be distinguished in passing from one loudness to the other. Within the limits of accuracy of Weber's law, in order to produce a recognizable increase in loudness, the intensity must be multiplied by a factor which is independent of the actual intensity. Hence, the number of recognizable steps is equal to the number of times which the smaller intensity must be multiplied by this factor to give the larger. This is the exponent to which the factor must be raised to equal the ratio of the two intensities, and by definition is the logarithm of the ratio of the intensities to a base equal to the minimum recognizable intensity ratio. It follows, therefore, that the logarithm of the intensity ratio to any base will always be proportional to the difference in loudness and so a logarithmic unit becomes a suitable measure by which to express the effect of a transmission system on the loudness of the received sound.

In the second place, the use of a logarithmic unit facilitates the deduction of the overall transmission properties of a system from those of its parts. Suppose, for example, that some telephone system is being compared with a reference system. We may picture the test system as being derived from the reference system by successively replacing each part. Each change causes the received power to change in a particular ratio. By multiplying together all these ratios we get the ratio in which the power is changed in going from the reference to the test system. If, however, we measure the effect of each replacement by the logarithm of the corresponding ratio, we have only to add the effects of the individual steps to get the overall effect.

The members of the family, while alike in being logarithmic, differ in the base to which the logarithm is taken. However we may go from one base to another by introducing the proper multiplying factor. Hence the difference between the various units is effectively one of size only. Among the units in use when the TU was chosen, the 800 cycle mile of standard cable is of such size that the number of miles is given by 10.56 $\log_{10} P_1/P_2$, where P_1 and P_2 are the two powers involved. For the so-called βl unit then in use in parts of Europe the number is $\frac{1}{2} \log_e P_1/P_2$, or what is equivalent, $\log_e J_1/J_2$, where J_1 and J_2 are the currents involved. (When currents are used it is assumed that they flow in equal impedances.) If we transform the βl unit to common logarithms the number is given by 1.151 $\log_{10} P_1/P_2$. In order that the TU might be roughly equal to the "mile of standard cable," the size selected for the TU was so chosen that the number of TU is 10 $\log_{10} P_1/P_2$.

In view of the desirability of the universal use of one unit for telephone transmission work, the Bell System took up this matter with various foreign telephone administrations and suggested that they consider the TU for this purpose. This led to considerable discussion as to the relative merits of a transmission unit based on common logarithms such as the

> *The International Advisory Committee unanimously recommends the following definitions:*
>
> The unit of transmission expresses the ratios of apparent or real power, of potentials or of currents in transmission systems. In practice, the number of units of transmission in a given case is expressed in terms of a logarithm.
>
> If it is a case of two powers P_1 and P_2, the number of units is,
> in the naperian system, $\frac{1}{2} \log_e|P_1/P_2|$;
> in the decimal system, $\log_{10}|P_1/P_2|$.
>
> If it is a case of two voltages V_1 and V_2 or of two currents J_1 and J_2, the number of units is,
> in the naperian system, $\log_e|V_1/V_2|$ or $\log_e|J_1/J_2|$;
> in the decimal system, $2 \log_{10}|V_1/V_2|$ or $2 \log_{10}|J_1/J_2|$.
>
> The naperian unit is called "neper". The decimal unit is called "bel". A decimal sub-multiple of these units may be used, as "decineper" and "decibel".

TU, and one based on natural logarithms such as the βl unit. Action was finally taken in the form of a recommendation by the International Advisory Committee on Long Distance Telephony of Europe to the effect that the use of both units be recognized as standard in Europe.

It was also recommended that distinguishing names be assigned to the two transmission units. For the βl unit, which is so defined that the number of units is given directly by the natural logarithm of a *current* ratio, the term "neper" was chosen in honor of John Neper,* who first conceived the idea of logarithms. In the case of the TU, however, the common logarithm of a *power* ratio is multiplied by ten to get the number of units. This suggests that the TU is in the nature of a derived unit and that the primary unit should bear the same relation to the common logarithm that the neper does to the natural logarithm. The name "bel" was accordingly assigned to this primary unit. Since the number of TU corresponding to a given ratio is ten times the number of bels, the TU itself is equal to one-tenth of a bel, and so it became the "decibel".

In view of this recommendation, the Bell System has decided to use the term "decibel" as a name for the transmission unit. The transition from the old to the new will naturally be a gradual one. There will be no occasion to make changes in existing apparatus or written material, but rather the db will replace the TU in new work.

** While this spelling may appear unfamiliar, the form "Napier" is comparatively modern. The name appears to have been going through a transition during the mathematician's lifetime and while his signatures show a variety of spellings, he generally used the oldest form "Neper."*

The Comstock Prize

The National Academy of Sciences has awarded the Comstock Prize to Clinton J. Davisson, for experiments carried out in these Laboratories. This prize is given each five years for "the most important discovery or investigation in electricity or magnetism or radiant energy"; this year it amounts to $2,300. *It was granted "for experimental work demonstrating that under certain conditions electrons behave as trains of waves might be expected to behave."*

Presentation of the award was made at the Autumn Meeting held at Schenectady, November twentieth, by Dr. Thomas Hunt Morgan, President of the Academy.

Composite Telegraphy

By J. H. BELL
Systems Development Department

WHEN a business firm has considerable daily telegraph communication with one or more distant correspondents — perhaps branch houses or factories — handling its own telegraph communications becomes a much speedier and oftentimes more economical plan than the generally used message plan familiar to the public. A very large amount of telegraph business connected with banks, brokers, packers, news-distributing agencies, and large manufacturing corporations is handled in this manner, and nearly all of it passes over Bell System lines. The telephone company leases a telegraph channel or channels between the points desired, and installs apparatus in the lessee's offices. The lessee furnishes his own operators and may send as much telegraph traffic as the channel will carry.

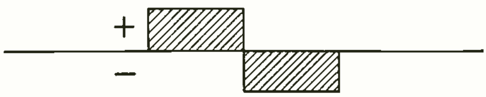


Fig. 1—With the printing telegraph a dot is formed by a short positive impulse followed immediately by an equal negative impulse

In the January, 1926 issue of the RECORD the writer described briefly the method of providing such telegraph facilities by means of the Carrier Telegraph System. It is the purpose of this article to describe another method of obtaining such facilities. This method, which is used extensively in the Bell System, is called "compositing." By "compositing" is meant the joint use of a circuit for telephone and telegraph purposes, the telegraph utilizing the frequency range below that required for the telephone and its signaling currents. How this is possible will be more evident after a consideration of some of the elements of telegraphy.

A telegraph sounder consists of an electromagnet with an armature pivoted at one end, which is drawn downward when current flows through the electromagnet and is restored by means of a fairly strong spring. The sounds made on the up and down strokes differ sufficiently to enable the trained ear of a telegraph operator to distinguish between them easily. If such a device be connected in series with a suitable source of electrical power and a key for closing and opening the circuit, a momentary depression of the key, termed a dot, will produce two clicks on the sounder, the down click and the up click. If the key be held down for a longer period, termed a dash, the time interval between the down and the up clicks will be lengthened.

If an attempt were made to telegraph by using only dots, say one dot for a, two dots for b, three dots for c, and so on, we would find that the transmission of a group of words such as "you were very lazy" becomes a somewhat laborious process, involving the making of 246 dots. By the use of a suitable code, however, comprising combinations of short and long impulses, that is, dots and dashes, the same sentence could be transmitted by 40 key depressions.

In the Morse code, for example, the letters most commonly used are given the shortest combinations, such as dot-dash for "a", dot for "e", and dash for "t", while the longer combinations are reserved for the less frequently used letters such as dash-dot-dot-dot for "b". The spaces between the impulses in a letter are of the same length as a dot mark. The dashes are made three times the length of a dot mark. The space interval between the letters of a word is equal in length to three dot marks, and the space between words themselves, equal to five dot marks. If the frequency of recurrences of the letters in ordinary English is studied, it is found that the average letter combination with its letter space interval is equal in length to eight dot marks or four complete dots, a complete dot being regarded as the mark and the succeeding space of the same length. As the average word in the English language consists of between 5 and 6 letters, it has been accepted in the telegraph art that the length of an average word with its word space interval is equal to twenty-four complete dots. Transmitting at the rate of 100 words per minute using this code would, therefore, be sending the equivalent of 2400 complete dots per minute or 40 per second. Hand sending, however, does not usually exceed 40 words per minute or 16 complete dots per second.

Within the past few years the use of the start-stop printing-telegraph system has been greatly increased. This system makes use of a telegraph code of current combinations different from those of the Morse code, but like them in consisting of short and long current impulses. Being automatic it can be operated at higher speeds than the hand operated system, and usually the speed is set at 60 words per minute which requires that the line shall carry about 24 complete dots per second.

The instrument used to receive signals is a sensitive polarized relay, the armature of which moves between two contact points, the direction of motion being dependent upon the polarity of the current. The transmitting device sends out a current of one polarity for the marks and of the opposite polarity for the spaces. Hence to transmit a dot with its succeeding space there is sent out a current reversal as shown in Figure 1. Such a "square wave" signal is really a combination of a sine wave of fundamental frequency and an infinite

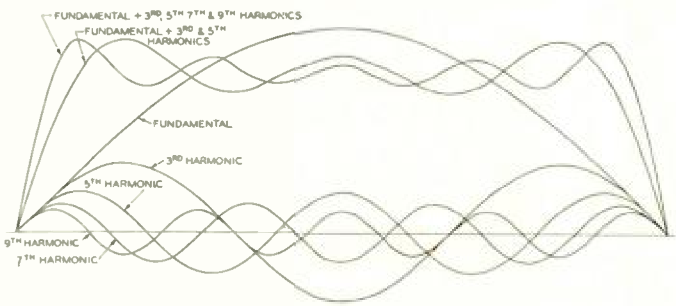


Fig. 2—Harmonics of a fundamental wave tend to square its shape, making it approach more nearly the ideal form given in Figure 1

number of its harmonics. It will be seen from Figure 2 how the addition to its harmonics tends to square up the shape of a sine wave.

If these higher harmonics, however, were to reach the telephone part of a composited circuit they would produce considerable noise, so that means must be provided for shutting them out. This is done by means of coils and condensers of suitable value

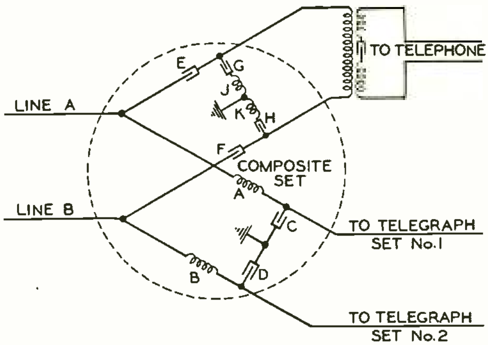


Fig. 3—Separation of telephone and telegraph signals is obtained by the filters, one passing only the low frequencies and the other, only the high

which form a low-pass filter, allowing only frequencies up to about 80 or 100 cycles per second to pass. Further discrimination between the telegraph and telephone currents is obtained by connecting condensers in series with the telephone equipment, which allow the high frequencies of the voice range to pass through but act as a barrier to the low frequencies of the telegraph.

Figure 3 shows in schematic form how this division of the telephone and telegraph current is effected on open-wire composited circuits. Over one pair of wires two separate telegraph circuits and one telephone channel can be provided. If a second pair of wires exists on the same pole line these facilities can be duplicated and in addition a phantom telephone circuit obtained. Since the low-pass filter in the telegraph branch offers little impedance to the passage of frequencies up to about 80 cycles per second, telegraph signals at 24 complete dots per second which are made up of sine waves at 24 cycles per second and their third harmonics (72 cycles per second) can be transmitted. The wave shape is not so good for telegraph purposes as it would be if more harmonics were present to square out the wave form, but on the other hand if the separating point between the telegraph and telephone were moved to a higher frequency the transmitting quality of the telephone channel would suffer.

The compositing set thus serves to separate the telegraph from the telephone message. With the usual connection the subscriber can not tell that the wires over which he is talking are being used also to transmit a telegraph message. Likewise the telegraph message, except for the slight rounding off of the corners of the wave, is unaffected by the arrangement of the circuit to carry telephone conversations as well.

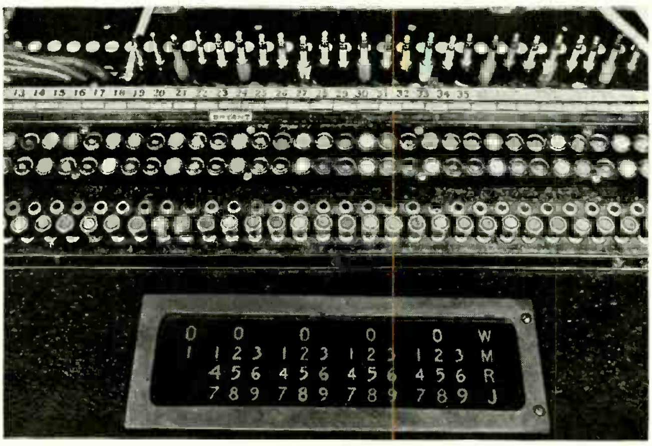
Although it is not generally known to the public, a large part of the entire telegraph traffic handled in this country is passed over leased wires and is not included in the category of public-message business. The American Telephone and Telegraph Company does not handle public-message business but leases wires for telegraph uses; and this leased wire telegraph business of the Bell System is quite extensive as there are nearly a million miles of two-way telegraph channels in operation.

Panel Senders

By W. J. SCULLY
Systems Development Department

SENDERS have been called the brains of the panel system, their action in putting through a call being likened to that of the operator of the manual system. How the sender operates when the subscriber called is also in a dial office has already been described in the RECORD.* Many calls to the central office, however, are for subscribers in a manual office or for special service, and to manage these the sender must employ mental faculties of a higher order such as memory, discrimination, and reason. A brief description of the part the sender plays in the completion of this class of calls will round out the picture.

On a call to a manual telephone the sender registers the dial pulses, a form of mechanical memorizing, consults the decoder for information regarding the route to the desired telephone, and then proceeds to superintend the selection by the district selector — or office selector if used — of a trunk terminating in a manual office before an operator. After the trunk has been found, a lamp, associated with it, lights — indicating to the operator that there is a call waiting on the trunk. The sender now waits for the operator, who signifies that she is ready to complete the call by pressing a trunk-assignment key associated with the lighted lamp. Upon receiving this signal the sender transmits a series of current pulses of differing polarities and strengths which are received and recorded on relays at the manual office. The operation of these relays causes certain lamps to light and display the called subscriber's number, including the party letter, in characters illuminated upon a translucent glass screen set in the keyshelf of the operator's position.



On calls to a manual office the sender causes the desired number, 4259 *in the above illustration, to be displayed in front of the operator*

Handling a call that must be reached through a manually operated tandem switchboard is somewhat similar.

* *"A Mechanical Brain,"* BELL LABORATORIES RECORD, *Vol.* 3, *pp.* 78-81, *November,* 1926.

The sender causes the numerical code of the terminating office to be displayed as well as that of the number called so that the tandem office may know to which office the call is to be routed.

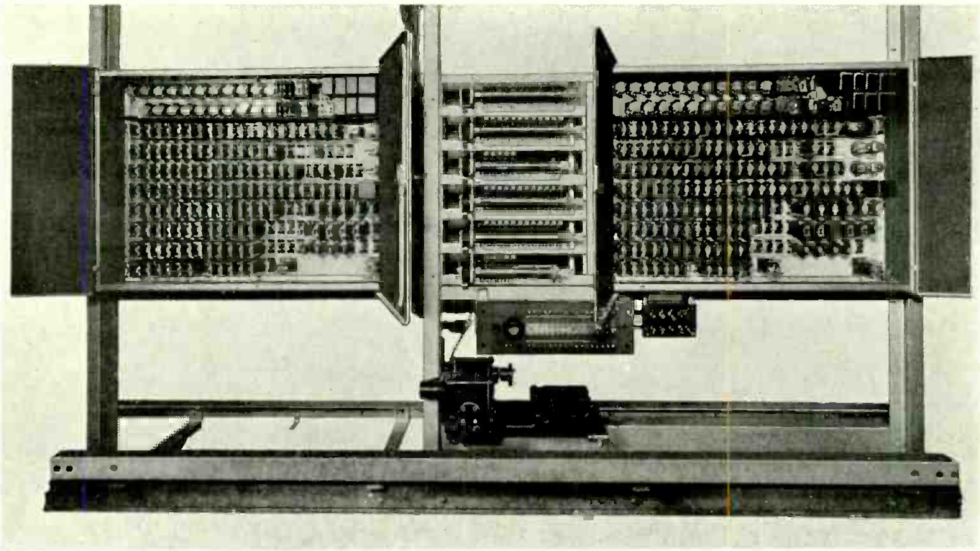
If in the called office there are party lines having letter designations or lines having five digit numbers, the sender is so informed by the decoder which it has consulted regarding the routing of the call. The sender will then wait for approximately four seconds after receiving the dial pulses for the units digit to see whether the calling subscriber wishes to dial a station letter or fifth numerical digit. At the end of that time it assumes that nothing further will be dialed and proceeds with the call. Should a station letter or numerical digit be dialed before the end of the four-second interval the sender immediately continues with the call. If there are no party lines with letter designations or lines having five digit numbers in the called office the sender will be so informed by the decoder and proceed without waiting the four seconds.

When the subscriber desires to reach Long Distance or Information, he dials a special code of three digits such as 211, and the decoder is again consulted regarding the routing of the call. Often it is necessary for the operator to know the class of service of the subscriber's line that is calling, whether for example it is a coin or non-coin subscriber. In such cases the sender passes this information on to the operator by causing the district and office selectors to complete connections from different classes of subscribers to the desired operator over different groups of trunks.

If the subscriber desires to reach the "Special Service" operator he dials "Operator." In this case the sender will if necessary send calls over different groups of trunks to the operator, depending on the class of subscriber calling. On these "Special Service" calls it is desirable that the connection between the subscriber's line and the operator's cord circuit should not have any intervening repeating coils or other apparatus. This is necessary when the call is from a coin subscriber, for example, so that the collection or refund of the coin may be under direct control of the operator. On such calls the sender causes the district selector to connect the tip and ring of the line directly through to the trunk without any bridging apparatus.

A group of senders may serve different classes of subscribers' lines, that is, lines requiring different treatment of their originating calls. For example, coin subscribers must be recognized as a separate class in order to provide for the proper routing of their calls to operators as indicated above and also to insure that a coin has been deposited on a local call before it is allowed to proceed.

The existence of different local dialing areas for different subscribers also requires a distinction to provide for the proper routing of the calls. For instance, one subscriber may have a contract which permits him to dial directly a particular group of local offices while his neighbor is permitted, by the terms of a different contract, to dial directly an additional group of offices. The first of these subscribers, if he should in error dial one of the second group of offices, must be routed to the special operator while the second subscriber dialing the same office must be permitted to go through. For this purpose the sender is required to recognize the class of service of the calling line. This is



Opened doors displaying scores of relays do not reveal the intelligence of the panel sender

accomplished by having each group of subscribers of the same class of service served by its own group of "link" circuits. When a call is made one of these "link" circuits connects to the sender the particular line finder and district selector circuit that is handling the call, and notifies the sender of the class of service of the line which is calling.

The sender passes this information on to the decoder together with the code of the office to which the call is being made. The decoder then decides whether the call should be allowed to proceed to the destination as called for by the office code dialed, or diverted to the "Special Service" operator for final disposition. The sender upon being informed by the decoder of the proper routing for the call proceeds to superintend its completion. This recognition of the class of call by the sender and its correct routing is one of the sender's important functions. An illustration may be cited in the case of a non-coin subscriber calling a number for which this particular subscriber is required to pay an extra charge. The sender with the aid of the decoder will cause the subscriber's line to be connected to the "Special Service" operator who will make the connection for him and also record the necessary information for properly billing the call.

While supervising the work of the selectors in setting up a connection the sender is ever on the alert to detect the presence of irregularities. Should a selector be unable to go ahead with the call because, for instance, all of the trunks in the desired group are busy, it tells the sender this by a reversal of current over the trunk. The sender immediately causes the district selector to send a "busy" tone to the calling subscriber which he recognizes as a request to hang up his receiver for a moment and then try again.

On a call to a dial telephone the sender receives a reversal of current after the called line has been found. It recognizes the reversal, in this instance, as an indication that the call has progressed satisfactorily, and promptly notifies the district selector to complete the connection. Should this reversal of current be received at an earlier stage of the call, however, the sender would very correctly construe it as an "all trunks busy" signal and act accordingly. The sender in this case might be said to use discrimination.

A situation requiring the use of reason on the part of the sender arises when a subscriber, in moving his telephone about on his desk, inadvertently sets it down with the receiver resting on some books or papers in such a way that the receiver is raised from the hook. In this case the subscriber's line is immediately connected to a sender just as for a regular call, and the sender prepares to record the number desired. Time passes, however, and no dialing occurs. After waiting a reasonable length of time the sender, by the use of reason, correctly comes to the conclusion: "This is not a subscriber desiring a telephone connection otherwise he would make known his wants by dialing." Having made up its mind, the sender causes the subscriber's line to be connected to a trouble-desk where the test man determines the trouble.

It may happen that after the subscriber's line has been "cut through" to the sender and before the subscriber starts to dial, a momentary opening of the circuit occurs due, quite likely, to an accidental jarring of the switchhook. This is called a "preliminary pulse" and is received on the first office-code register. However, the sender knows that the first office-code digit is never 1 and as soon as it is sure that this pulse is not the first of a train of pulses comprising a legitimate digit it prepares a circuit which will absorb the first of the dialed pulses and cause the remaining pulses of the first digit to be received on the first office-code register. This register is thus caused to take a setting corresponding to the first dialed digit. The sender in this case not only recognizes an erroneous condition but proceeds to rectify it at once so that the call may not be delayed in reaching its destination.

Should the subscriber abandon the call at any time after the sender has started but before it has completed its functions the sender notifies the district selector to free the subscriber's line at once so that it will be available for immediate use for another call. In all cases of "abandoned" calls the sender acts to insure the return to normal of the other apparatus used. When necessary it waits a definite time before starting the process of disconnection to permit certain apparatus to return to normal.

Situations occasionally arise, however, where the sender, in spite of its versatility, feels the need of help and it then does not hesitate to call for human aid in the person of a "sender monitor." For example, the subscriber may inadvertently dial only two digits of the three digit office-code followed by the correct number. This constitutes a "partial dialed" condition. The sender knows that the subscriber has not completed his dialing but it is asking a little too much to expect it to correctly guess what the missing digit is. In this case the sender causes a lamp to light before a sender monitor, who plugs in on the circuit and renders such assistance as may be necessary. Also if a coin subscriber fails to deposit the coin or if the call is blocked for any reason whatever for too long a time the sender calls on the monitor for aid.

The Mechanical Delay-Network

By R. L. WEGEL
Research Department

SOMEWHAT reminiscent of the string telephones of our youth is an entertaining offshoot of the Laboratories' research in acoustics, the recently developed mechanical delay-network. Essentially the device is a helical spring, hanging loosely between a transmitting and a receiving element. Wandering through the connecting wire coil, sound vibrations impressed at one end appear at the other some time later.

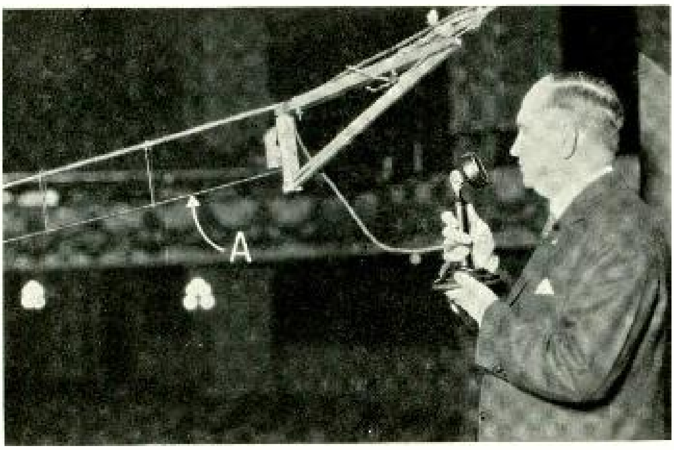
When recently shown by S. P. Grace to the regional meeting of the American Institute of Electrical Engineers in Atlanta, and to the annual convention of Telephone Pioneers in Boston, the delay-spring was incorporated in a demonstration apparatus. From a microphone transmitter Mr. Grace's voice proceeded to the spring, whose output, translated into electrical vibrations and amplified, was reproduced by a loudspeaker. The audience thus heard the same words twice: directly from Mr. Grace's mouth and one second later from the loud-speaker.

Due to the physical complexity of even their simplest forms, the theoretical explanation of this sort of apparatus is at best difficult. It is not always safe to make simplifying assumptions in discussing these problems; questions of speech transmission especially must be treated in considerable detail, for many of the most curious and important properties of mechanical structures vibrating at voice-frequencies result precisely from this complexity. Fortunately much assistance can be derived from the use of the familiar analogy between electrical and mechanical vibratory systems. Reference to the analogy, even if only qualitative, often makes it possible to predict from telephone experience the nature of the effects which may be expected of the analogous mechanical apparatus.

Treated in this way, the famous problem of beads on a string illustrates well the aspects of vibrating systems which occasion their apparently strange behavior. And, simpler than that of the delay-spring, it is yet sufficiently similar to make possible some significant comparisons between them.

In the idealized form of this classical problem, first discussed by Lagrange and recently interpreted in terms of its electrical counterpart, the string is supposed to have negligible weight and the beads, arranged equidistantly in succession along it, to be infinitesimally small. The resulting model is a series of masses, concentrated at mathematical points, connected by pure weightless elasticity, and vibrating transversely to the direction of the string. Its electrical analog is a low-pass filter, with series inductances corresponding to the masses and shunt capacities to the segments of the connecting elastic string. More generally the mass-points could, of course, vibrate in three independent directions, the three mutually perpendicular coordinates of space, two of them transverse to the direction of the string and one along it. The corresponding analog is three low-pass filters, through any of which impulses could be independently propagated.

When, however, beads are actually placed on a string, the ideal condition cannot ordinarily be realized sufficiently closely to permit its assumption in simplifying the study of voice transmission over the string. The beads must have length, breadth and thickness, the string must have appreciable weight, and the beads cannot be exactly centered on the string.



Mr. Grace at transmitter end of the network. Spring is shown at "A"

Introducing these complicating realities gradually, it is simplest to consider first real beads on an ideal string: a weightless string, bearing beads possessed of dimensions and mounted off their centers of mass. It is apparent that a force applied through the elastic string to one of the beads at a point not on its center of mass will tend not only to move the bead in the direction of the force but to rotate it as well. The beads may travel in circles or ellipses rather than in a straight line along the direction of the drive. Each bead must, therefore, be considered as an extended body, requiring six coordinates to specify its position or velocity at any particular time: the three coordinates of its center of mass and the three angular rotations about its center of mass. A string has elasticity to twisting as well as to stretching, so that a disturbance of one bead, consisting of rotational as well as back-and-forth motions, will be transmitted in a modified form to the next bead.

Thus there are six ways in which disturbances may be propagated over the string, and, because they are interrelated through the inertia of the mass on account of its off-center mounting these modes of disturbance are mass-coupled. The complete electrical analog comprises six low-pass channels, inductively coupled to a degree dependent on the distance of the bead's mounting point from its center of mass. If the beads were mounted on their centers, the propagation characteristics of each channel would be independent of those of every other. Impulses started over one such channel would proceed without being augmented or diminished by contribution from or to other channels. Practically, however, the mass or "inductive" coupling causes the system to exhibit effects analogous to inductive interference by each channel with every other. This coupling, negligible when the frequency of the vibration to which the system is subjected is low, increases as the frequency becomes higher. Thus, whereas the visible waves of pendulum-frequency, with which classical investigators were concerned, advance intact along loaded strings, waves of voice-frequency are passed about from channel to channel and much modified. These six channels have, furthermore, different velocities of propagation.

If account be now taken of the weight of the string, the six-channel inductively coupled low-pass structure becomes a six-channel inductively coupled multi-band-pass structure. If the elasticity of the string to bending is included in the consideration, the frequency-limits of the passed bands are shifted. Viewed finally in light of the inability to make beads all with exactly the same mass, and to mount them at exactly equal distances from one another and with their points of attachment at the same eccentricities from their centers of mass, each channel exhibits different propagation characteristics in different sections of the string.

In summary, then, the progressive embodiment of our theoretical bead-loaded string into a piece of equipment modifies one after another all its properties. Giving our beads dimensions, we invest them with the three rotatory degrees of freedom, multiplying the system's channels from three to six. Giving weight to our string, we add to the low-pass region of each channel an infinite number of higher pass-bands. Mounting our beads off-center, we couple the channels to one another. Permitting irregularities among the beads and their mountings, we give, to the properties of each channel, variation in differing sections like that of a non-uniform telephone line.

Obviously complication such as this may readily give rise to quite singular phenomena. Methods of actuating the structure can no more be idealized than the structure itself; a real driving mechanism cannot confine its motion rigidly to one dimension, its influence to one channel of the system. The attempt so to confine its action in practice, even when nearly successful, is considerably vitiated of advantage by the parasitic leakages sapping the driven channel through its couplings. When operated, therefore, the system receives initial impulses from the driver in all six channels, which these channels then feed back and forth to one another through their couplings and propagate at their different speeds and in their several ways. When the impulses reach the far end of the string, they have suffered extensive change.

The helical spring, different from the bead-loaded string in effect, is fundamentally similar in principle. It too is a six-channel structure. Its propagation characteristics, however, suit it especially for achieving large delays with compact apparatus.

The steadily increasing importance of mechanical vibrating systems is justifying persistent attention to the theory explaining their properties and to experiments with typical models. The delay-apparatus, interesting in itself, is yet more so as a sprig off the main limb of mechanical vibrators.

Development of the Impedance Bridge

By S. J. ZAMMATARO
Apparatus Development Department

Electrical measurements were in their infancy when Sir Charles Wheatstone devised a circuit for the comparison of electrical resistances. Figure 1 illustrates the principle on which it is based. A battery is connected across the junction points of two parallel resistances and as the total potential drop is the same in each branch, there must be for any point in one branch, a point in the other at the same potential. These equipotential points may be found by connecting one terminal of a galvanometer at any point "A" in branch BAD, and sliding the other terminal along branch BCD until a point is reached ("C") when the galvanometer shows no deflection. These points divide the branch resistances into four components R_a, R_b, R_x and R_s, whose relation, derived from the application of Ohm's law, is $R_x = R_b/R_a \times R_s$.

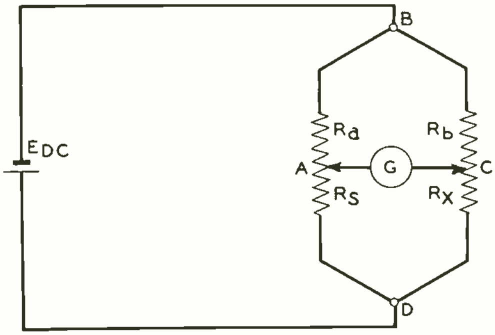


Fig. 1—The principle of a "bridge" illustrated by two parallel circuits with a galvanometer connecting equipotential points

The more familiar arrangement is shown in Figure 2 where R_a and R_b are fixed resistances and R_x is the unknown resistance to be compared with the standard, R_s. By adjusting the standard zero deflection of the galvanometer is obtained, and the value of the unknown will then be equal to the setting of the standard multiplied by the ratio of the fixed resistances. Establishing the zero deflection may be likened to the process of weighing with a chemical balance in which known weights are added to the standard pan until the pointer registers zero. For this reason Wheatstone called his arrangement a "resistance balance" and the fixed resistances the "arms" of the balance, now more specifically termed "ratio arms." Because the points "A" and "C" are bridged by the detecting device, the detecting branch was known as the "bridge," and this term combined with the inventor's name was used later to designate the whole network.

At the time Wheatstone devised his bridge the only practical sources of electricity were electro-chemical batteries so that the currents were all of the direct or steady type. To the flow of such a current the only impedance offered by a circuit is resistance, a property of the circuit that depends mainly on the material and size of the conductors. As time passed, however, leaving behind a more fully developed telegraph system and the rapidly growing telephone, currents that varied with time became of greater and greater importance. Circuits with a definite resistance measured with a steady current were found to offer much greater resistance to the flow of a varying current. Evidently some quality was present which increased the opposition to the flow of current when the current was constantly changing in value.

It was found that when varying potentials were used, the current that flowed into a circuit depended not only on its resistance but also on other quantities called inductance and capacitance, and the effective combination of these three was called impedance. The values of both reactance and capacitance were found to vary with the rapidity with which the current changed in value or, when alternating current was used, with the frequency.

To measure these new quantities Maxwell, in 1865, introduced the Induction Balance, a form of Wheatstone bridge in which the inductance as well as the resistance of the standard could be adjusted. He used a ballistic galvanometer to detect the transient current caused by the rapid opening of the battery switch. The process of measurement consisted of first balancing for direct-current with the switch closed and a steady

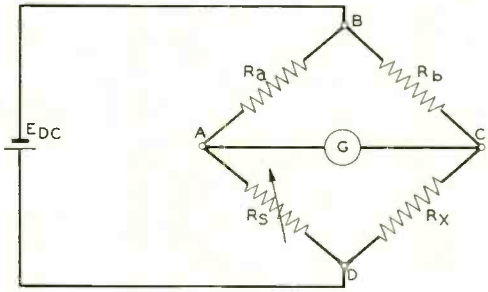
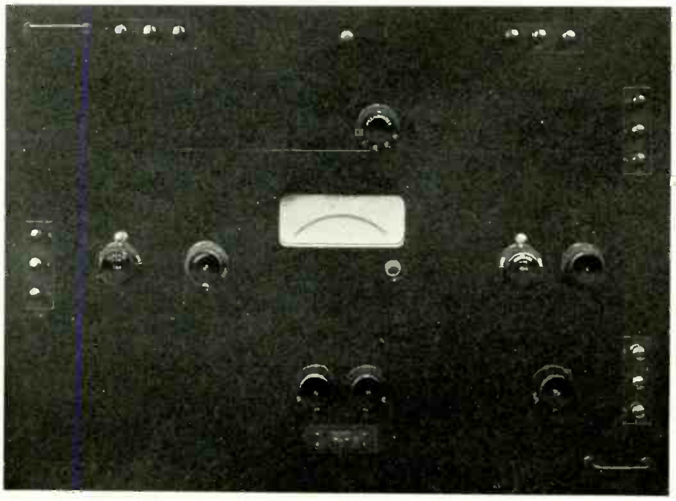


Fig. 2—A more familiar diagram of the bridge bends the parallel circuits into a rhombus with a galvanometer as one of the diagonals

current flowing through the bridge, and of then quickly opening the switch and observing the throw of the ballistic indicator. By readjusting the inductance standard and repeating this process, the ballistic throw could be reduced to zero, when the setting of the inductance standard determined the value of the unknown inductance. The same method could be used for measuring capacitance if a capacitance standard were substituted for the inductance.

Ayrton and Perry improved the sensitivity of the ballistic induction balance by applying the principle of



Looked at from the operator's position an impedance bridge presents only a collection of dials and terminals the secohmmeter, a commutating device which simultaneously reverses the connections of battery and galvanometer so that twice the deflection will be obtained. This scheme

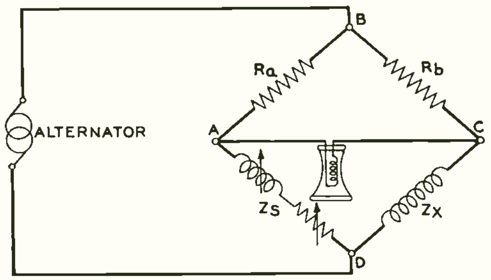


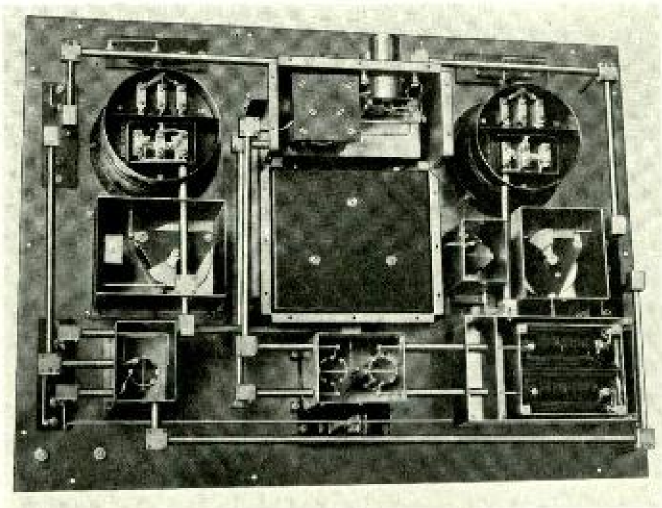
Fig. 3—For measuring impedances a similar bridge may be used but with an alternator replacing the battery and a telephone receiver, the galvanometer

actually amounted to the employment of an impure alternating current in the network and in this light might be considered the forerunner of the modern alternating-current bridge.

Close upon the heels of the Ayrton and Perry arrangement came the use of a small induction coil as the source of current and the replacement by the telephone receiver of Bell, of the ballistic galvanometer which had been employed in the experiments of Lord Rayleigh, Heaviside, Kohlrausch and others. The induction coil, however, gave a current of irregular waveform and indefinite frequency, so that in 1891 Max Wien introduced the use of a small alternator to supply an approximately sinusoidal current of steady frequency.

The evolution of the modern precision impedance bridge is the direct result of the application of minute refinements to the bridge of Wien in order to meet the severe requirements of high-frequency measurements and a general demand for greater precision of results. The open bridge of Wien, shown in Figure 3, and similar types were satisfactorily accurate for the low frequencies used at that time but when it became necessary to measure high frequencies the situation was found to be radically changed.

In an open bridge capacitances exist between each part of the circuit and every other part, also between each part and ground. These are too small to be harmful when the frequency is low but become sources of error as it increases. A bridge of the Wien type, therefore, used with a high-frequency source has an infinite number of stray capacitances, partially indicated by the dotted lines of Figure 4, which become effective and



Viewed from beneath, the shields of an impedance bridge are prominent although in the above view their covers have been removed cause currents to flow that make it impossible to obtain a correct balance. Another source of error is the capacitance between the bridge and the operator's body, which varies, of course, with every move the operator makes.

In 1904, therefore, Dr. G. A. Campbell devised a shielding scheme whereby the stray currents were not only stabilized but made of definite value so that they could be properly compensated for. Briefly, the arrangement consists of surrounding the individual bridge elements with inner shields connected at one end of the respective elements and with outer floating shields which could be grounded or not, at will. This is commonly known as double-shielding. To isolate the bridge from external disturbances, double shielded transformers or repeating coils are inserted between the bridge network and both the generator and the detector, and as a further precaution all the parts enclosed in an overall grounded shield. A schematic of a typical double-shielded bridge is shown in Figure 5. W. J. Shackleton has described such a bridge in some detail and discussed the general principles of bridge shielding in a recently published paper.*

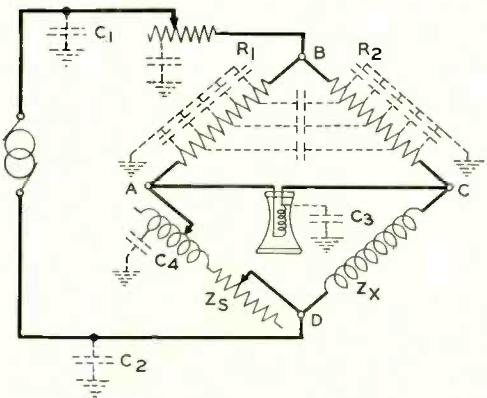


Fig. 4—Used with alternating current an infinite number of stray capacitances exist as indicated above

Although the introduction of shielding materially advanced the technique of bridge measurements, there was considerable room left for improving the wave form of the generator supply and for increasing the sensitivity of the detector. Early sources of alternating current, beginning with the first induction coils and running through a diversified array of buzzers, interrupters, microphone hummers, and alternators, all involved some mechanical motion and were consequently limited in both frequency range and purity of wave form. These means were soon supplanted by the Vreeland oscillator, a mercury arc device which, for the first time, employed a purely oscillatory circuit to produce the electrical vibrations. The arrival of the thermionic valve, however, solved both the generator and detector problems to perfection so that even the Vreeland oscillator has almost ceased to be used.

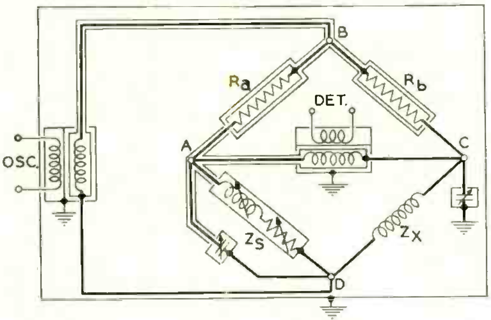


Fig. 5—The shielded bridge controls the stray capacitances so they do not prevent accurate measurement

The vacuum-tube oscillator, one of the most familiar pieces of apparatus in our Laboratories, is the best obtainable source of current for

* *Bell System Technical Journal, Vol. VI, pp.* 142-171, *January,* 1927.

bridge work. It is capable of furnishing an ample output of alternating current at constant and accurately known frequency, and with a very nearly sinusoidal wave form, throughout a wide range of frequencies. Besides its use as an oscillator the vacuum tube may serve as an amplifier to increase the currents to the detecting receiver, or, when the frequncies are beyond the audible range, as a detector-amplifier of the heterodyne type. By these means the telephone receiver may be employed under conditions that, without the aid of the vacuum tube, would be impossible.

The latest step in the steady advance in bridge measurements is the development of suitable standards of comparison. The resistance, inductance, and capacitance standards used in precision bridges are specially constructed and shielded to secure a maximum stability and flexibility of operation. Their values are determined by a system of calibration based on standards maintained at the Bureau of Standards in Washington. The application of a thorough system of shielding, the use of vacuum-tube oscillators and detectors, and the special construction of accurately calibrated standards are the major contributions that have brought the technique of impedance measurements to its present state of refinements.

Correcting A Mistaken Idea

Although radio has been used for over twenty years for intercommunication, there still remains in the public mind some confusion about the relation of radio and wires. In a recent address on Communications before the Conference of Major Industries, Walter S. Gifford sought to correct the impression that radio and wires, broadly speaking, are competitive. President Gifford regretted that "the public's attention, instead of being directed toward the satisfactory and prompt transmission of communications, has been focused on the means by which such transmission is achieved." He observed that "from its very nature, radio is not and cannot be a substitute for intercommunication by wire. Radio, however, has been and will continue to be of great importance. It has widened the range of communications — and makes possible communication where wires cannot be used, such as with ships and aeroplanes. They (radio and wires) are essentially complementary, and must be so considered if we are to have the best and cheapest intercommunication."

Coil Corrosion

By E. L. FISHER
Apparatus Development Department

In common with most development work the evolution of our electromagnetic apparatus has been attended by numerous associated problems requiring the expenditure of considerable time and effort in their solution. Some of these solutions are yet to be fully attained, the complete answer being progressively realized through increase in the general store of engineering knowledge.

One of the problems besetting the use of electromagnetic apparatus has been corrosion of the wire winding. This trouble appears in operation in the failure of apparatus to function due to the winding having become open-circuited as a result of chemical or electrochemical attack at some point of imperfect protection by the insulating materials.

Failures due to this action, with a few exceptions, are confined to coils wound with enameled wire of 34 gauge or smaller, enamel insulation being particularly liable to corrosive attack because of the presence of occasional minute holes in its surface, at which points corrosive action appears to concentrate.

In the early investigations of coil corrosion it was usually found that this activity became serious only in the presence of a uni-directional potential between two or more windings or between a winding and the iron core. The activity was therefore seen to be mainly electrolytic in character. The electrolyte necessary to the promotion of this action was chiefly moisture from the atmosphere which penetrated the outer insulating materials, taking certain of their impurities into solution.

The severity of the corrosive action being, therefore, controllable to a large extent through improvement in the insulating materials, the history of our wound apparatus design, and especially of relay coils, abounds with records of experimental tests and resultant changes in coil insulation and structure. In fact, in the case of the present-day relay, few of the insulating materials present in the original development of these coils are found.

Improvements have included changes from untreated to impregnated manila papers and thence to varnished and impregnated Kraft papers (high grade chemical wood paper made by the sulphate process); from cotton fibre spoolheads, which contained objectionable chlorides, to phenol fibre; and from coil coverings, containing a starch loading paste which rapidly promoted corrosion in the presence of moisture, to a shellacked serving of dyed cotton thread.

As the corrosive action is electrolytic, a solution of the problem has also been sought by means of a high degree of moisture exclusion from the coil structure. During the early development of the flat type relay, coils were vacuum-impregnated with a special moisture-proofing compound developed for the purpose. Although this treatment improved the resistance of the coils to corrosion, the comparatively low melting point (140° F) of the wax used became the cause of added difficulties in the field due to leaking of the impregnating compound from the coil onto the operating structure and other apparatus. This led to the discontinuance of the general practice of impregnating and to the re-adoption of a dry coil using improved insulating papers.

As the use of extremely fine gauges of enameled wire became increasingly desirable from a standpoint of electrical efficiency, further improvement in the corrosion-resisting characteristics of wound apparatus was sought. Because the advantages to be realized through the use of finer gauges of wire are especially attractive with relay coils, these again become the subject of experimental investigations intended to improve their moisture-resisting properties.

These investigations have dealt with moisture-proofing attained by surrounding the structure with a surface seal which is highly impervious to moisture rather than by completely impregnating the coil with a high-melting-point moisture-proof compound. Efforts along this line that have shown promise have mainly included tests on the use of a single wrapping of a highly moisture-proofed insulator between the coil winding and the cotton serving.

In actual practice this general type of protection is applied in a somewhat different manner, as illustrated in the covering recently standardized for relay coils. It consists of the replacement of the present covering of shellacked cotton thread by a serving of cellulose acetate silk. This covering is applied directly over the winding in the form of a number of threads, as is usually done with the cotton serving, and a skin is then formed over the entire surface by subjecting the covering to a fine spray of acetone which softens the outer layer and allows it to solidify subsequently into a continuous film that is highly impervious to moisture. This covering also provides a seal at the spoolheads by adhesion to a spoolhead washer composed of a special cellulose cement which is cheaper than the red rope-paper washers as well as an improvement from a corrosion standpoint.

The last mentioned development represents the most efficient means of corrosion prevention now incorporated in the manufacture of our wound apparatus (with the possible exception of the comparatively expensive practice of potting the coils in a metal case) in that it permits, with less corrosion hazard, the use of enameled wire several gauges finer than could be used in older impregnated coils.

A fairly satisfactory solution of the general problem of corrosion of the type of wound apparatus most commonly used in telephone equipment appears to lie, therefore, in the use of surface coverings that are highly impervious to moisture, together with the continued use of properly restricted insulating materials which experience has shown to withstand the test of time.

BELL LABORATORIES CLUB

BLC

ACTIVITIES

OF THE YEAR

1928

Past Presidents

Harry E. Young	Burton W. Kendall
William Wilson	Edward J. Johnson

Club Officers for 1928

Donald A. Quarles	*President*
George F. Fowler	*First Vice-President*
Marie Boman	*Second Vice-President*
David D. Haggerty	*Secretary-Treasurer*

Departmental Representatives

J. C. Kennelty	*Commercial*
A. L. Johnsrud	*Research*
T. J. O'Neil	*Systems Development*
S. J. Stranahan	*Apparatus Development*
G. Rupp	*Plant and Shops*
T. C. Rice	*Patent and Inspection*
P. J. Higgins	*Tube Shop*

Activity Directors

A. F. Gilson	*Bowling*
L. P. Bartheld	*Men's Interests*
Natalie Skinner	*Women's Interests*
C. F. Gittenberger	*Basketball*

Foreword

The Bell Laboratories Club was formed about five years ago to organize and coordinate those recreational activities which are of interest to considerable groups of the Laboratories personnel. The Laboratories' only concern in the project was and is to promote the well-being of its members, recognizing as it does that the effectiveness and productivity of the organization as a whole is largely dependent upon the physical health and wholesome mental attitude of the individual contributors to its output. This interest makes it sound policy to encourage recreational activities by providing a permanent staff to administer the numerous details and by relieving the membership of a portion of the expense in the case of those activities which cannot be expected to be entirely self-supporting.

In order to insure the most general use of the facilities offered by the Club our constitution provides that any member of the Laboratories may become a member of the Club simply by indicating his desire to do so. Aside from the permanent Secretary-Treasurer who devotes his time to the affairs of the Club, all the officers and representatives on the executive board are elected by the members they represent. Within the limitations imposed by a budget, which quite naturally must have approval of Laboratories executives in view of its financial assistance, the officers of the Club are free to promote and support those activities that seem likely to be of maximum benefit to the Club members.

While the number of such activities already organized and in successful operation is considerable and the number of members taking part in one or more of them is large, it seems probable that many more might be glad to participate if the nature and scope of the activities were more generally known. With this in mind a report has been prepared showing what the Club has been doing during the past year. This is being sent to all Club members with the thought that they are entitled to full information as to its performance and plans.

The election of Club officers and representatives will be held as usual the latter part of the year. Departmental Representatives on the Club board, acting with the present officers of the Club as a nominating committee, will nominate two candidates for each of the vacancies to be filled. In advance of the election and as a means of informing the electorate there will appear in the December issue of Bell Laboratories Record a statement descriptive of the candidates, and their qualifications for the offices to which they aspire.

Donald A. Quarles,
President, Bell Laboratories Club.

October 31, 1928.

Recreational Activities For Men and Women

Symphony Orchestra and Glee Club

The Club Symphony Orchestra, conducted by Professor Egon Eibert, opened its fifth season on Thursday evening, October 4. This, the second year of Professor Eibert's direction, finds the Club orchestra proficient in playing quite difficult compositions. At all times, however, new members may be admitted. This season's first rehearsal of the Glee Club took place on Wednesday evening, October 10, under the direction of Professor V. S. Richards.

Both groups are rehearsing weekly (the Glee Club Wednesdays, the Orchestra Thursdays) in the 11th floor Rest Room for twenty-five weeks, in preparation for a joint concert to be held at one of the New York hotels in the spring of 1929.

Bell System Athletic League

In 1926 the first Bell System baseball league, chess league and handball league were organized. To them was added in 1927 a men's basketball league of eight teams. The application of fourteen teams for admission into the baseball league at the start of the 1928 season, and the appearance in the offing of the same number for the basketball league, suggested bringing all intercompany activities for men and women under the supervision of the organization.

At a meeting in May, the Bell System Athletic League of New York was organized, to promote intercompany athletics among the employees of the Bell System in the metropolitan district. D. D. Haggerty of Bell Telephone Laboratories was elected President to serve until June 30, 1929.

Entertainment

Three Club dances spangled the year 1928. The Grand Ballroom of the Hotel Pennsylvania housed the first on February 2. Music was furnished by the Vagabonds, one of the well-known orchestras of the air. At the end of April, the spring dance was held in the Grand Ballroom of the Waldorf. Entertainment by the National Broadcasting Company featured a number of radio stars; Ben

Bernie made the dance music. On Friday evening, November 2, the Club ascended to the McAlpin Roof and danced to Herbert Hood's music.

It has been the policy of the Entertainment Committee to hold at least three dances each year; plans have already been completed for a dance atop the McAlpin on Friday evening, February 1, and a concert and dance in the Grand Ballroom of the Hotel Pennsylvania the latter part of April.

Track and Field

On Saturday, May 26, tryouts determined the twenty-seven men and women to represent the Club in the thirteen events of the track and field meet. The meet was held on Saturday afternoon, June 16, at Erasmus Hall Field, Brooklyn; the Laboratories' team won with a total of thirty-two and one-half points.

While the Club has held intramural track meets in the past, this was the first year of competition with other branches of the Bell System in the metropolitan district. The meet was such a success that plans are now being made by the athletic league to promote an indoor meet for men and women in one of the New York armories the latter part of February.

Swimming

For five years Club members have been enabled to secure tickets for the Brighton Beach Baths at one-half the rate regularly charged at the gate; eleven hundred of them were purchased during the 1928 season. These tickets obviate standing in line at the bath houses, and paying double the regular rate during unusually hot weather, similar arrangements have been made for the summer of 1929.

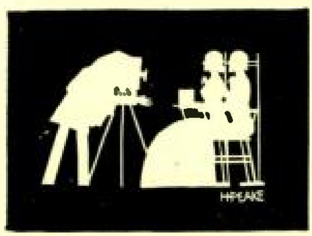
Club members may also purchase at half price from the Secretary tickets for the pool in the Shelton Hotel. Over seven hundred of these tickets have been sold since January; the chilly weeks of winter and spring will see the sale of more.

Hiking Club

The hikers strike out weekly during the eight snow-free months of the year, on an evening, Saturday afternoon, Sunday, or a holiday. A definite schedule of the hikes is printed and distributed twice a year. In addition to walking the scheduled walks, the hikers supped a number of campfire suppers during the past summer.

Photographic Contest

The Club's second annual photographic contest closed with the judging of the pictures by Dr. Zerbe of the Brooklyn Institute of Arts and Sciences on Monday evening, March 12. Prizes were taken by the best three pictures in each of the landscape, still-life and portrait groups. Thirty-nine contestants submitted three hundred prints, some of them very fine indeed. Following the judging, all entries were exhibited in Room 1103.



Plans are now under way for a 1929 contest, to close on January 21. Pictures will be exhibited during an early week of February.

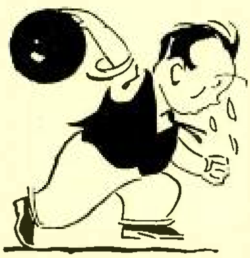
Christmas Poster Contest

Each year the Club holds a Christmas poster contest to secure a poster for exhibition on the Laboratories' bulletin boards during the holiday season. Fifteen posters were submitted in the last contest, all worth the judges' attention and several so good as to make difficult a choice of the ten-dollar prize winner. Each year notification of the contest is given Club members in November; completed posters must be submitted not later than December first.

RECREATIONAL ACTIVITIES FOR MEN

Bowling

The Club Bowling League officially closed its seventh season on April 16 with a banquet at the Hotel Manger, the distribution of prizes by Mr. Craft, and a theater party at the Winter Garden. The two hundred people present were by no means all of those who wished to attend.



During the past eight years, the popularity of bowling has greatly increased. Thirty-two alleys were at the disposal of our bowlers at the opening of the 1928-29 season on Friday evening, September 28. From three groups of forty men each and a fourth group of twenty men, the league has grown to four groups, each with eight five-man teams. In addition to the alleys contracted for the twenty-eight weeks of league bowling, the committee has engaged four alleys for men who wish to bowl regularly but who cannot be accommodated in the league.

The substitute committee is always glad to hear from men who wish to bowl part time in place of absentees.

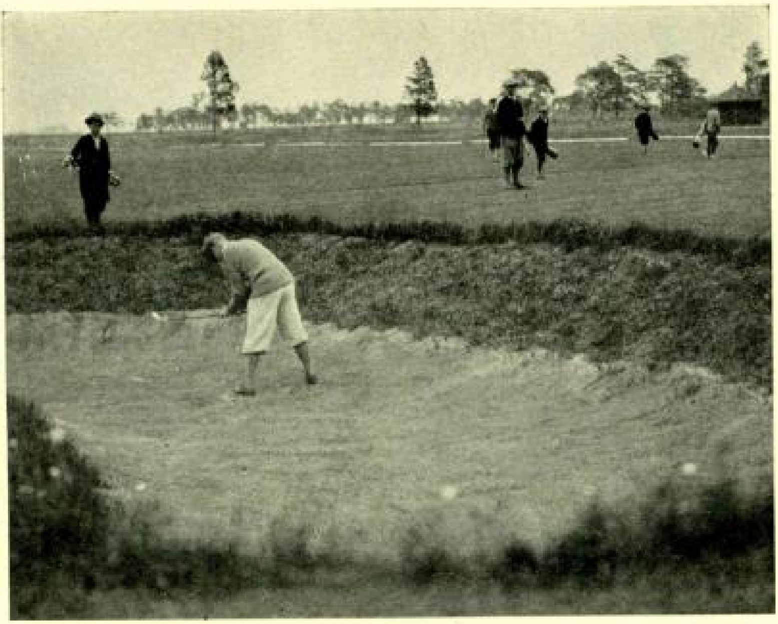
Basketball

Again, in contest with nine other branches of the Bell System in the metropolitan district, the Club will enter a team in the basketball tournament of the athletic league, to play Monday and Friday evenings in Stuyvesant High School and Wednesday evenings in Erasmus Hall High School from November 12 to January 30. Season tickets admitting their holders to all twenty-seven sessions of the league, and to the dancing which will follow the games, will cost one dollar each. Schedules may be had from the Secretary.

Each year the Club organizes an eight-team interdepartmental basketball league and provides it with gymnasium, equipment, referee and prizes. Its 1928-29 season opened October 30 at Labor Temple, 14th Street and Second Avenue. Two games will be played every Tuesday and Thursday evening from November through February, the first of the pair starting promptly at 5:30.

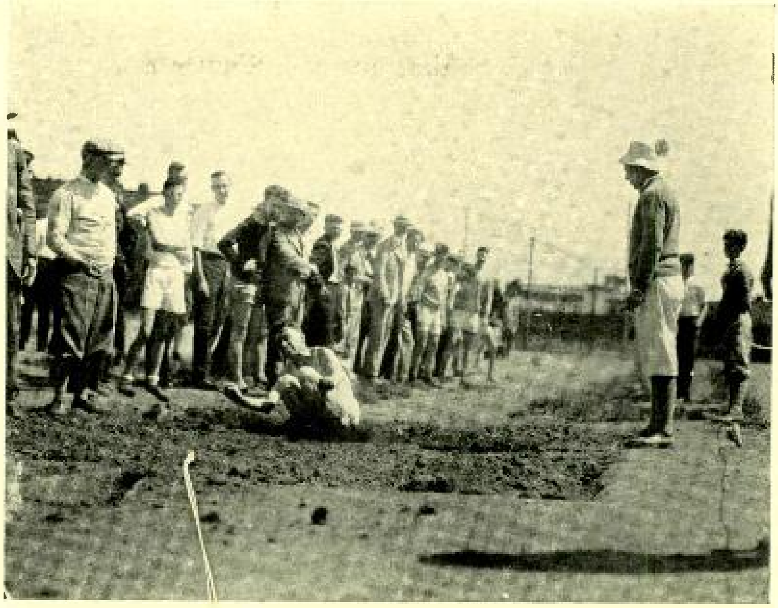
Chess

Steadily improving its fine record, the Laboratories' team won the championship in the Commercial Chess League of New York for the fifth consecutive year. It goes into action in November against the ten other teams of the Commercial Chess



A sad moment during the golf tournament

Finish of the girls' sixty-yard dash



Talented broad-jumping at the track meet

Finish of one of the dashes

League, in the hope of repeating its victories of previous seasons and obtaining for the second time permanent possession of the trophy, which must be won three years before going out of competition.

In their annual telegraphic chess match, the Laboratories' team was defeated by the Hawthorne Chess Club for the second time in ten years. It won, however, the first of the annually-planned telegraphic chess matches with the Bell Telephone Company of Canada's Montreal office. In addition to these outside activities, the chess players hold each year a tournament among themselves, dividing into two classes for weekly matches.

Golf

Indoor golf, at at the Vander-Built-In course, has become one of the most popular Club activities; seventy-five players took part in the tournament in January and eighty-three in March. Each man played thirty-six holes in the qualifying round and the sixty-four who qualified were divided for the finals into two groups of four classes each. More indoor contests have been scheduled for December 5, January 30 and March 27.

Spring and fall brought golfers outdoors for two tournaments at the Salisbury Country Club, Salisbury Plains, Long Island. In June, eighty men went the qualifying round of eighteen holes of handicap medal play; in September forty-seven men, a record fall turnout, handicapped from scores made in previous tournaments and divided into three groups with the same prizes for each, completed a tournament in one day. Course number five at Salisbury will be the scene of two Club tournaments in 1929, on June 1 and 8, and September 21 and 28.

Tennis

This fall the Club's first tennis tournament attracted to the Mammoth Courts in Brooklyn, forty aspirants to doubles honors. Singles and doubles championship tournaments have been planned for 1929.

Bridge

The men's bridge club plays two ten-week tournaments annually; the first for this season started October 8 and is meeting on Monday evenings at six o'clock. Each player pays a weekly fee of fifty cents, and the

Club donates the prizes. In this year's year's edition of the annual tournament at 195 Broadway with the men's bridge club of the Western Electric Company, forty men from each organization took part. The 1929 match will be played the latter part of January.

Four or five mixed bridge parties with the women's bridge club take place each season.

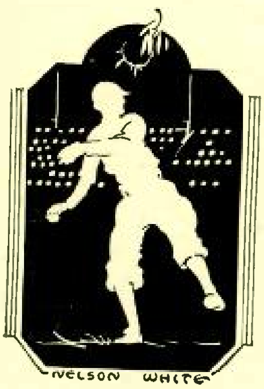
Handball

From the twenty-four men who

took part in the second annual Club handball tournament at Labor Temple, a team for the Bell System matches tournament was picked. This tournament, staged during April in the gymnasium of the Western Electric Company's Hudson Street building, was won by the American Telephone and Telegraph Company team. Again in 1929 the Club handball tournament, in Labor Temple on Tuesday and Thursday evenings during March, will be followed by the Bell System tournament early in April.

Baseball

The Bell System Baseball League of New York opened its 1928 season on April 30 at Erasmus Hall Athletic Field. In order to provide a sufficient number of playing days for the fourteen teams, it was necessary to organize them into two leagues and hold a post-season series between the winners. The large number of spectators attending most of the games found them well worth seeing, for competition was exceptionally keen,



and the teams were close rivals to the last. The season closed with a banquet, and the distribution of the player prizes and the trophy, on September 20.

Teams representing the eight major groups of the Laboratories composed the Club interdepartmental baseball league for 1928, playing at Erasmus Field from May 5 to July 31. To Mr. Dixon, representing the unbeaten Systems Development Department team, the Spalding championship trophy was presented, and he in turn distributed the individual prizes. Option for the rental of Erasmus Field assures it for 1929.

RECREATIONAL ACTIVITIES FOR WOMEN

Bowling

Bowling for women, a new activity, attracted fifty-three to the elimination contest in February. From them twenty women were picked; they played, as four teams, every Friday evening until April 13. Contract with Dwyers Bowling Alleys reserves four alleys for our women each Friday evening from October 19 to April 12.

Golf

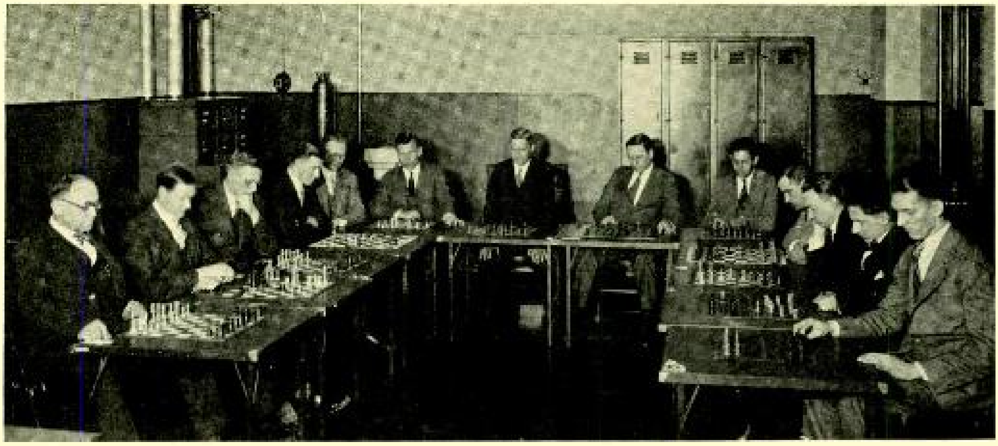
Indoor golf for women is another new activity of the Club. Twenty-eight women took part in the first tournament, at the Vander-Built-In golf course in March. Two similar tournaments will be held during the coming winter.

Bridge

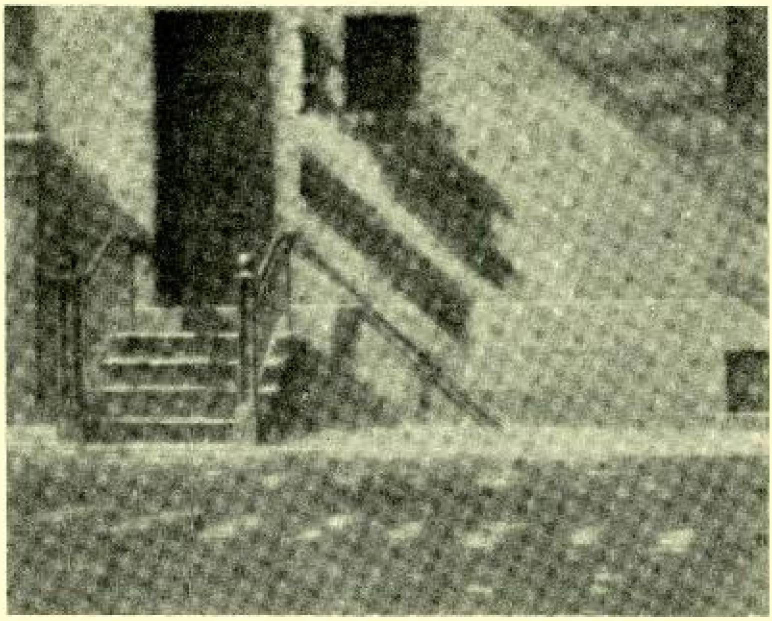
For ten weeks the women of the bridge club meet every Tuesday evening to compete in their midwinter tournament for prizes donated by the

Girls' basketball team, 1927-28

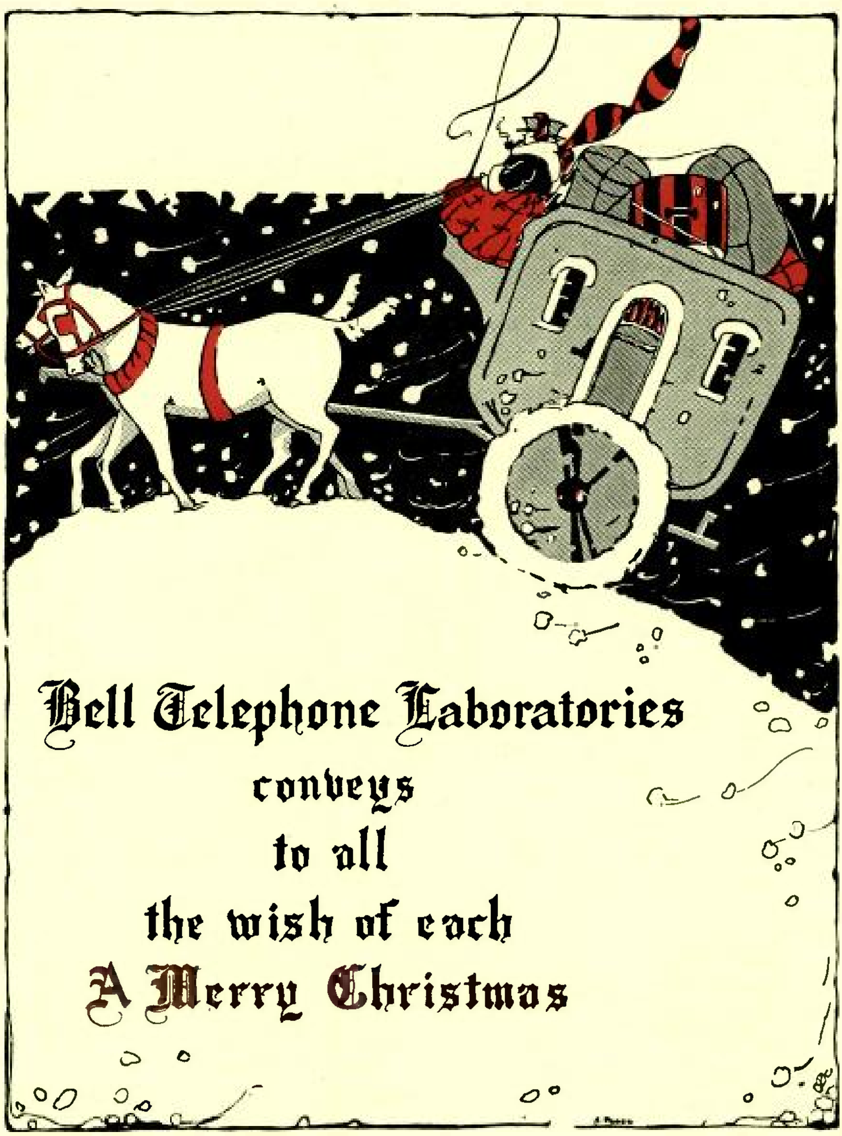
At one of the baseball games



The Laboratories' chess team



A prize-winning photograph



The 1927 prize Christmas poster

Club. In February the women from West Street won the first annual bridge tournament with the women from the Western Electric Company at 195 Broadway, twenty from each company contesting. Since October 5, the bridge enthusiasts have been playing in this season's tournament for the weekly and season prizes.

Physical Training for Women

The physical training course for women consists of ten lessons in athletic dancing; two such courses are held each year. The classes for the fall and winter season started on Friday evening, October 19, again under the direction of Professor Louis Vecchio.

Swimming

During 1928 the Carroll Club swimming classes were more popular than ever before in their three-year history. The mid-winter classes, held two evenings a week for three months, were followed at once by two new classes, and these in turn by a third session of two classes, each

meeting once a week. The three sessions, a record number for six months, accommodated one hundred and seven women. The fourth class of the year began on September 17, and it will meet during ten weeks on Monday and Wednesday evenings.

A definite program, bringing before the women of the Club the importance of knowing how to swim, should spur those who have not signed up with the previous classes to attend the fall, winter or spring session of 1928-29. The fee for a course of eight lessons is two dollars and fifty cents. Miss Kathryn Spranger of the Carroll Club staff is the swimming instructor in charge.

Basketball

During November and December of 1927 the Club offered the women of the building eight weeks of training in the fundamental principles of basketball. During the three following months two basketball teams represented the Club in ten games, seven of which they won, with the women from commercial houses and clubs. A game with the Hempstead High School team in the armory at Hempstead closed the season.

A similar program for 1928-29 began with four weeks of professional instruction, and will continue with a series of outside games, including those of the Bell System basketball League. A contract with St. Luke's church permits the Club to use St. Luke's gymnasium for women's basketball until early in March. The games will precede those of the men's league on Wednesday evenings in Erasmus Hall School.

D. D. Haggerty,
Secretary and Treasurer.

October 31, 1928.

Activity Directors, Managers, and Committee Chairmen for Fall and Winter Season

Bowling, men	*A. F. Gilson*
Basketball, men	*C. F. Gittenberger*
Golf, men	*F. J. Canavan*
Orchestra	*D. D. Miller*
Dances and Entertainments	*D. R. McCormack*
Chess	*E. G. Andrews*
Track and Field	*L. P. Bartheld*
Photographic Work	*Miss M. Horne, K. B. Lambert*
Hiking	*Miss P. Barton, A. Grendon*
Handball	*L. P. Bartheld*
Bowling, women	*Miss M. F. Kane*
Basketball, women	*Miss M. Boman*
Glee Club	*Miss Van Riper, P. H. Betts*
Bridge, men	*G. T. Lewis*
Bridge, women	*Miss K. Munn*
Tennis, men	*W. Kuhn*
Golf, women	*Miss N. Skinner*
Bell System Athletic League Representative	*D. D. Haggerty*
Committee Representing Men's Activities	*L. P. Bartheld*
Committee Representing Women's Activities	*Miss N. Skinner*
Swimming Classes for Women	*Miss F. Steel*
Dancing Classes for Women	*Miss Boman*
Elections Committee	*D. A. Quarles*
Special Cut Rate Privileges	*D. D. Haggerty*
Publicity	*D. D. Haggerty*

Trunk Hunting Switches

By R. L. QUASS
Systems Development Department

THERE is a very definite trend in America today towards the introduction of labor-saving machines in every line of endeavor and their use, probably more than any other thing, is responsible for our present state of prosperity. This trend is especially noticeable in our own business, where a large number of dial system offices have already been cut into service and where automatic devices are being applied more and more to replace hand operations in the manual telephone systems, both to increase their efficiency and shorten the time for making connections.

One of the more recent applications of automatic devices to the manual telephone plant is illustrated by trunk-hunting switch equipment recently installed for the Pacific Telephone and Telegraph Company at San Francisco and Oakland, California. A map of this area, shown in the accompanying illustration, gives an idea of the economic problems sometimes encountered due to geographical location in providing adequate trunking facilities. Each circle on this map represents a telephone building in which is located from one to six central-office units. Subscribers of each office must of course be able to call subscribers of any other office, thus necessitating a tie cable between San Francisco and Oakland which is nearly eight miles long, five miles of it under the bay.

Formerly this cable was made up of many separate groups of trunks to provide enough talking paths for each office on one side of the bay to reach each office on the opposite side. The number of such paths was ample to carry the inter-office traffic then existing but the number of calls so increased that additional facilities were imperative. The program adopted by the Pacific Telephone and Telegraph Company to care for this expansion and provide for future growth contains two interesting fea-

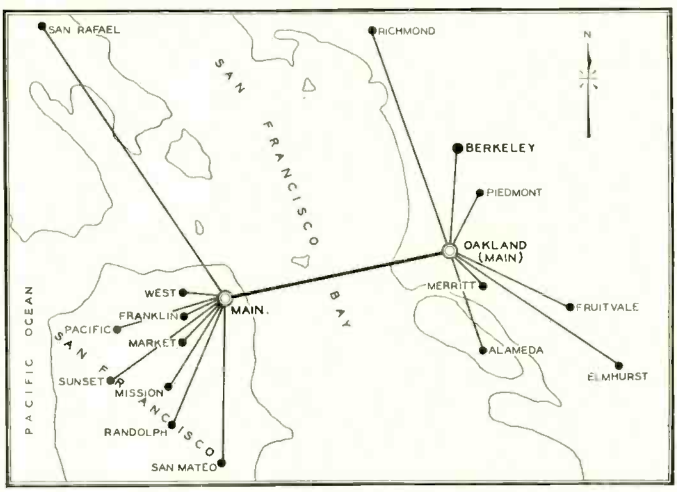


Fig. 1—Trunk hunting switches are made particularly desirable because of the long cable under San Francisco Bay

tures — first the changing over of the trunking from a call wire to a straightforward trunking basis, and second the introduction of trunk-hunting switch equipment, sometimes called trunk-grouping selectors.

Straightforward trunking enables the "A" operator herself to select the first idle trunk to a "B" operator in the distant office in which the called party is located, whereas on a call-wire basis it is first necessary for her to depress a call-circuit button on a separate circuit leading to the distant operator's telephone set and obtain by assignment the number of the idle trunk to be used. Straightforward trunking provides greater accuracy, simplifies the training of operators, and increases appreciably the overall operating efficiency of the switchboard.

The introduction of trunk-hunting switches is particularly interesting because it marks another use for automatic equipment in manual systems. Two methods of reducing the number of pairs in the cable between San Francisco and Oakland were possible. A tandem board could have been installed or trunk-hunting switches used at each end of the cable. Due largely to the concentration of traffic over a definite channel the trunk-hunting equipment proved the more desirable. The switches are not only cheaper but involve fewer operating errors and give quicker service than a tandem board although the latter would save a few more cable pairs.

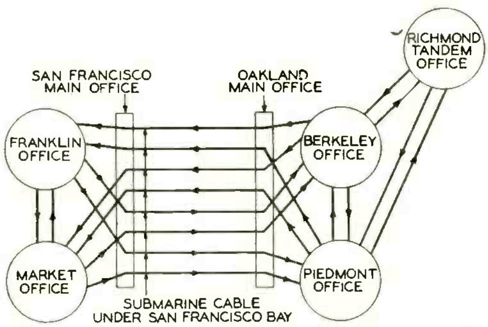


Fig. 2—Formerly each office had its own trunks to every other office

The saving in cable pairs, which more than pays for the cost of the switches, results from combining small separate groups of trunks into a larger common group. This may be illustrated by referring to Figure 2, which shows the old method of connecting two of the twenty-four San Francisco offices by direct trunks to two of the nineteen Oakland offices, each line in this figure as well as Figure 3 representing a group of one-way trunks. If mechanical means can be introduced at the San Francisco Main Office that will direct a call from the Franklin or Market Office as well as other offices in San Francisco to the Berkeley Office in Oakland over the first idle trunk of a common group of trunks, then all the economies of combining trunk groups can be obtained as indicated in Figure 3. The small circles shown in Figure 3 indicate the presence of trunk-hunting equipment with a corresponding reduction in the number of trunks required between Oakland and San Francisco.

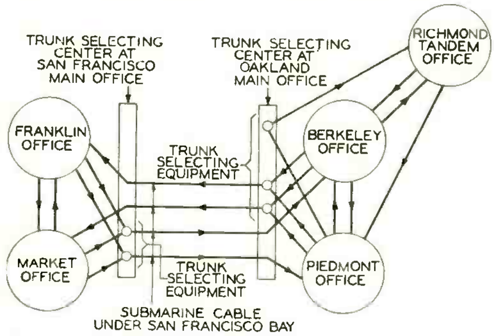


Fig. 3—With trunk-hunting switches the total number of trunks may be reduced because of the arrangement of the trunks in common groups

There are twenty-four offices in San Francisco that must be connected with any one of nineteen offices in Oakland and similarly the Oakland Offices must be connected with any one of the San Francisco Offices. If direct trunks without trunk-hunting equipment were used, approximately 156% more trunks would be required under San Francisco Bay.

The trunk-hunting switch circuit introduced on each trunk from "A" boards, as indicated in Figure 3, consists of a 200-type rotary selector switch with an associated circuit of four relays, shown in Figure 4. The rotation of the switch is started from its preceding position by the operation of the line relay. The switch is made busy to calls from other operators by the holding relay which also controls the disconnect. The trunk-hunting relay is used to provide more positive control of the switch while the cut-through relay is used to connect the talking circuit to the idle trunk after it is found. A circuit containing a supervisory and sleeve relay is also required in each common trunk leading from the switch bank to the distant office.

When the "A" operator plugs into a Berkeley trunk at Market Office, for instance, the switch of the corresponding trunk in Main Office is caused to step to the first idle trunk to Berkeley and the trunk made to test busy to all other calls for Berkeley. The corresponding trunk lamp at this office lights and an idle "B" operator is automatically connected to the trunk. This operator learns the number of the party wanted and places the plug associated with the trunk into the jack of the called line.

Trunk-hunting equipment of this character will probably find application in many multi-office areas having manual-office units. One of the uses, for instance, is in connection with trunks to outlying points as illustrated by the Richmond Office, Oakland, which is located at the most northerly edge of the Oakland area. Here it has been found economical to install switching equipment at the Main Office, in the trunks to the Richmond Office from a number of offices lo-

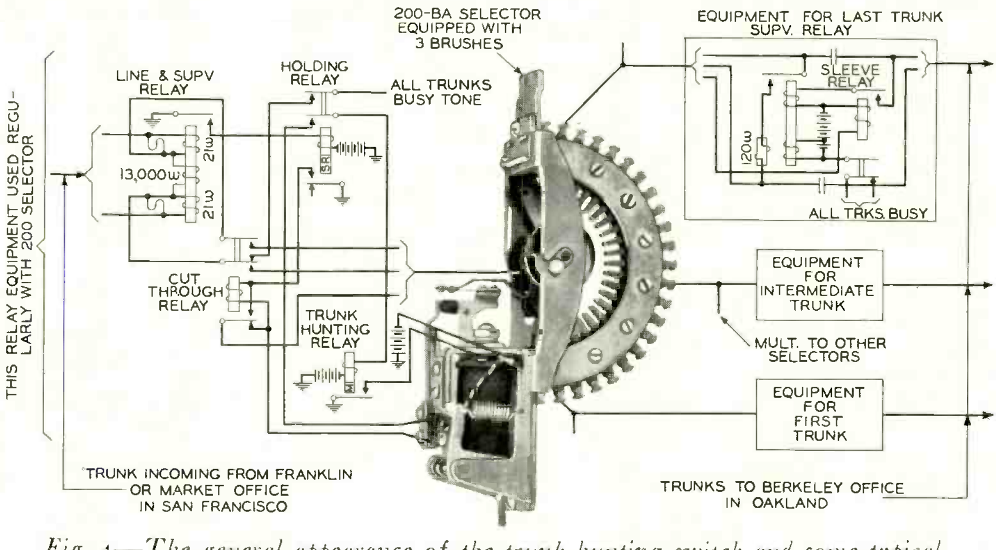


Fig. 4—The general appearance of the trunk hunting switch and some typical associated circuits are shown above

cated near the switching center, as shown in Figure 2 where the Piedmont Office is representative of one of the nearby offices. A similar situation exists in San Francisco where switching equipment is being introduced on trunks to the more distant offices of San Mateo and San Rafael.

Although trunk-hunting switches do not find general application in closely knit multi-office areas where it is impractical to carry all trunks through a trunking center, they do find application in these areas for specific purposes and are destined to play a considerable part in increasing the speed and efficiency of manual telephone systems.

New Laboratory for Sound-Film Development

Construction is soon to start on the first experimental laboratory to be built expressly for the study of problems relating to sound films. This building — of three stories — is to be erected by the Laboratories on a plot 50 by 118 feet at 151 Bank Street, in the block it now occupies. While facilities will be provided for the complete production of sound films, their use will be restricted to experimental work and no commercial production will be undertaken.

The top floor of the new building will contain a studio 67 by 45 feet, provided with adjustable acoustic treatment to control the reflection of sound from walls and ceilings. Acoustics of the adjoining monitoring room will simulate those of an acceptable theatre, so that sounds heard from the monitoring loud speaker during recording will be closely similar to those which will later be projected in theatres. Offices and dressing rooms, and laboratories for both film and disc recording will occupy the second floor. On the ground floor will be a projection room for the showing of sound-pictures, and a plant of advanced design for handling film. Air for the entire building will be cleaned and conditioned. Sprinkler protection will be provided in accordance with the most advanced principles of fire protection engineering.

Locating Faults on Toll Lines

By A. J. PASCARELLA
Systems Development Department

SERVICE over long toll lines is remarkably continuous when the almost countless things are considered that can happen to lines running over all sorts of country and subject to all possible conditions of weather. Even cables, which to a great extent are taking the place of the more vulnerable open wires, are subject to damage due to various things which sometimes create faults in conductors. Even when the damage to the sheath is not so extreme, moisture may leak in and spoil the insulation. Toll test-boards, therefore, to analyze and locate the faults which occasionally occur are always necessary and have attained a high degree of convenience and accuracy.

The type of a fault may be indicated to some extent by its effect on transmission. Grounds or foreign potentials are usually accompanied by noise; crosses or short-circuits, by no transmission and absence of noise; and opens, by noise and poor transmission. This audible evidence, however, is used only as a preliminary indication. Final testing is by a voltmeter or Wheatstone bridge. These are wired to keys, cords, or jacks and other apparatus to form convenient test circuits. The voltmeter is used for determining the type of fault, and the Wheatstone bridge for its location.

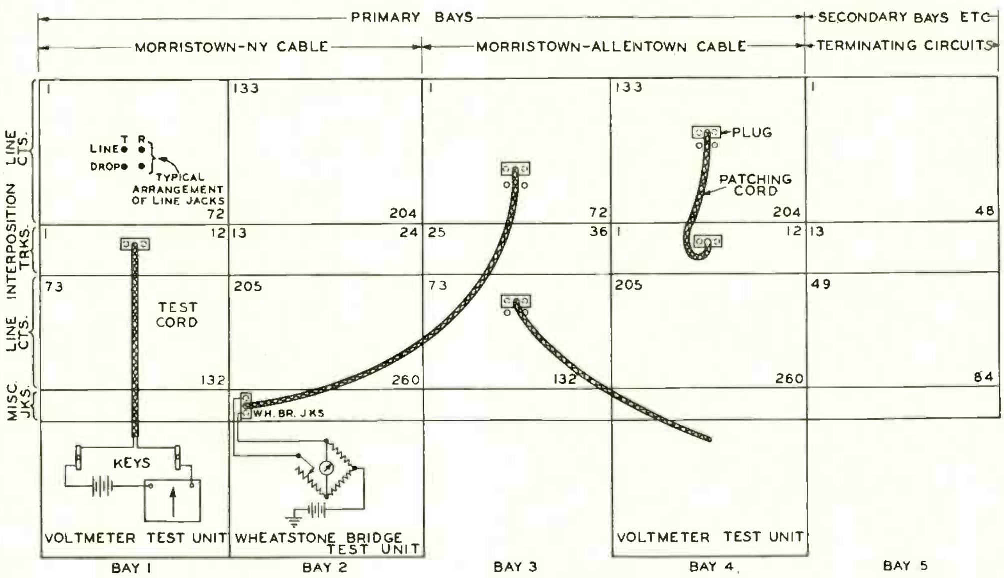


Fig. 1—Panel arrangement of a toll test board is indicated by the diagrammatic sketch above

A toll testboard, shown in Figure 1, consists essentially of a jack panel through which connections are made to the toll lines, and a unit in which is mounted the test circuit apparatus. Jack-ended trunks, extending among different positions of the board, also appear in the jack panel, and by means of them, toll lines terminating in one position may be extended to a different position when occasion demands. The flexibility of this arrangement makes all lines accessible at any position and enables several test men at the same time to test lines terminating at one position.

Jacks connected to the toll lines are of the series type in which the circuit passes through a contact normally closed. Inserting a plug opens this contact and disconnects the apparatus on one side of the jack. Testing circuits are cord-and-plug-ended on some types of boards so that only the insertion of the test plug into the line jack is required. In other types of boards the test circuits terminate in jacks, making separate patching cords necessary to connect them to the toll lines.

The test board enables an attendant not only to test either the toll lines or the equipment in the office, but to "patch" equipment to the toll line; that is, to change, add, or subtract line equipment. Patching makes possible the rapid replacement of defective terminal equipment or defective line wires in cases of emergency. Patching also becomes necessary when a severe storm affects, for example, only the cables or lines going in one direction. Under these conditions the voltmeter position associated with the bay containing the jacks of these lines would be insufficient to take care immediately of all the faults which might develop. Another attendant by means of patching cords or interposition trunks would patch, as shown in Figure 1, some of the defective lines to another voltmeter position where he would make the preliminary tests to help out.

If a toll line becomes faulty so that it is necessary to route calls over another line, the test man transfers all the circuit facilities by patching the terminal equipment, including telegraph apparatus, from the faulty pair to the new circuit. This is easily accomplished by connecting into the jacks as shown in Figure 2.

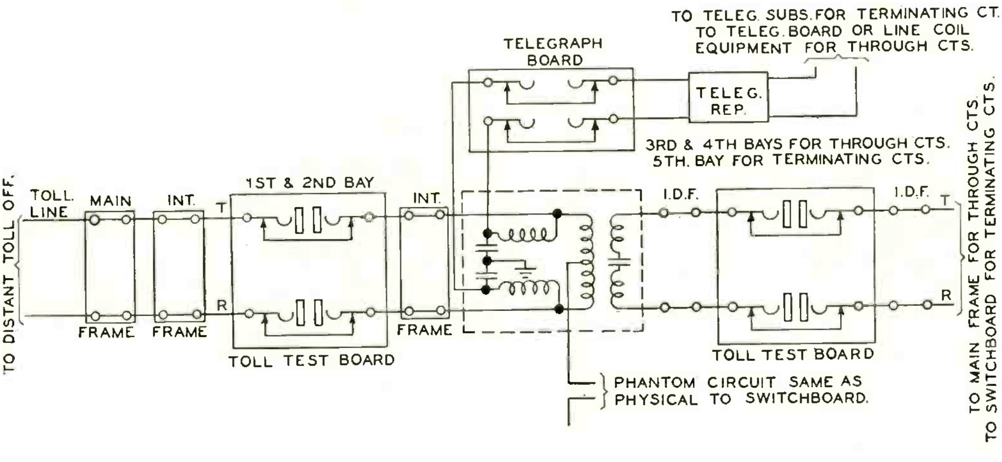
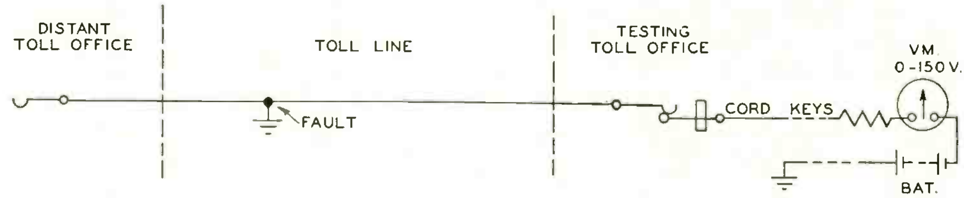


Fig. 2—Jacks on the panels are connected to the toll lines and equipment so that preparation for testing or rearranging equipment is merely a matter of inserting plugs

Test men, not only in the same office but in distant offices, cooperate in determining faults. When these occur, the test man at one station first establishes a connection with a test man at the distant station over another circuit and then attempts to at the distant station and then the circuit is connected to the Wheatstone bridge as shown in Figure 4. The pair of wires is thus connected in a bridge circuit with the battery current transmitted to the distant fault through the ground. When the bridge is bal-



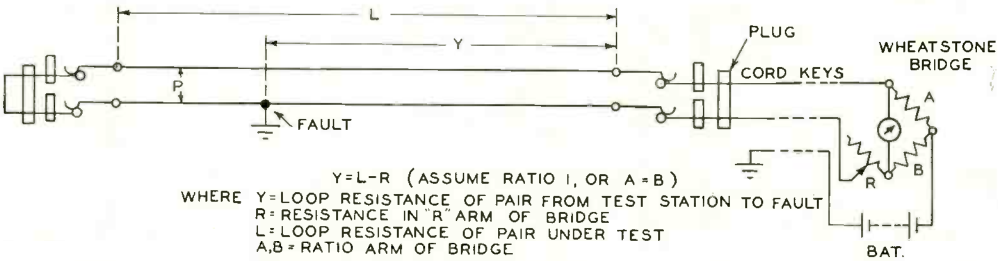


Fig. 3 (above)—Identification of a ground is obtained from a voltmeter plugged into the circuit as shown

Fig. 4 (below)—To determine the location of a ground requires the use of the bridge

carry on a conversation with him over the faulty pair. Following this the faulty pair is tested with the voltmeter to determine whether the fault is a short, open, or ground. After determining the nature of the fault, the test man uses a Wheatstone bridge to locate it. This measurement is also made by the test man at the distant station and the two results are compared for the final location.

Let us assume that the circuit is grounded as shown in Figure 3. The test cord is connected to the line jack and by means of keys the voltmeter and battery are connected in series with the ground and the faulty wire. A deflection of the voltmeter needle will show that the line is grounded. The grounded line is connected to the other wire of the pair by the test man anced, the resistance marked "R" is equal to the loop resistance from the distant station to the fault. This resistance measurement can easily be expressed in terms of wire length to determine the location of the fault.

If two wires are short-circuited, the voltmeter will again be used to determine the type of fault and the Wheatstone bridge, the location. A diagram for this condition is shown in Figure 5. Instead of using the earth to conduct current to the fault the test man employs one of the two wires which are short-circuited or crossed. A deflection on the voltmeter will indicate a short or a cross, and the resistance of the variable arm of the Wheatstone bridge will again be equal to the loop resistance from distant station to the fault.

If the line is open, the voltmeter needle will be deflected only momentarily on test and the Wheatstone bridge will be used to determine the location of the fault with the circuit which take into account the physical characteristics of the conductors as well as temperature, loading, and other factors. The results determined by calculation are usually modified

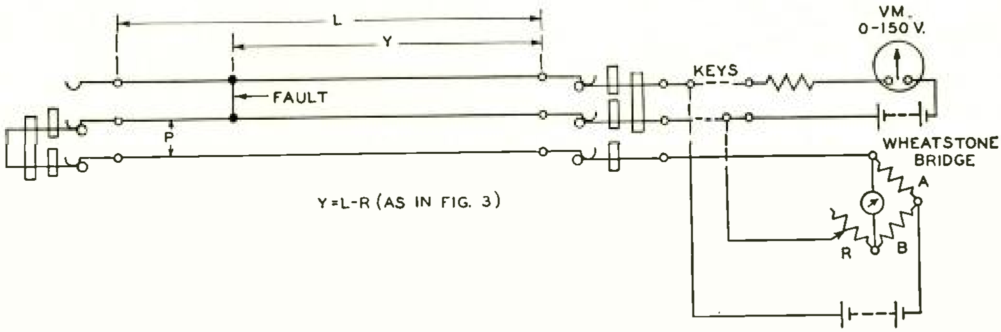


Fig. 5—The location of a short-circuit requires the use of a third wire usually selected from a good pair of the same cable

shown in Figure 6. The location test for an open circuit is primarily a method of comparing the capacity of a bad wire to that of a good wire. The Wheatstone bridge is arranged in the form of an impedance bridge to which is applied four-cycle alternating voltage. Two balances are obtained, one with the faulty wire connected to the bridge and one with a similar good wire connected to the bridge. A comparison of the readings of the "R" arm of the bridge indicates the distance to the fault.

The actual location of faults is determined by the use of formulae by the test man in accordance with his experience. Information as to the location of the fault is transmitted by the test board man to a lineman who proceeds to clear the trouble. It will be seen that accuracy in locating the fault is of great importance as it determines the out-of-service time as well as the expense of clearing the trouble. By proper use of the high-efficiency testing equipment now available it is possible under average conditions to locate faults with reasonable accuracy. The toll test man is thereby able to contribute a vital part to the quality of Bell System service.

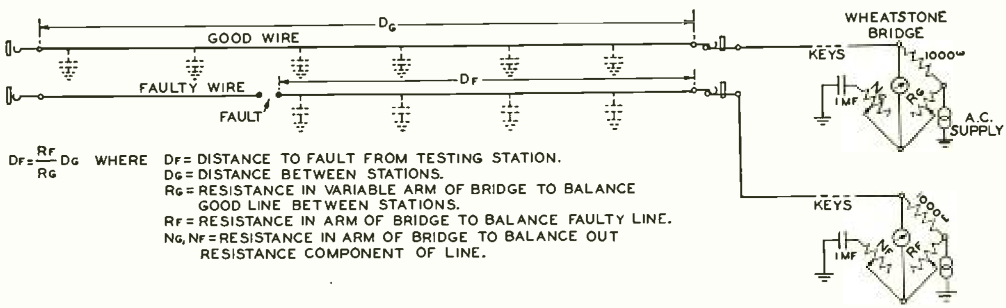


Fig. 6—To locate an open, a bridge reading is taken on each wire of the defective pair

News Notes

Dr. Jewett is chairman of the committee organized by the National Research Council to plan the theme and program for the scientific aspects of the Chicago World's Fair Centennial Celebration in 1933.

Members of the British Post Office Telegraph Committee who have been visiting the United States were entertained by Dr. Jewett at dinner at the University Club on October 20. His guests included Colonel A. G. Lee, and Messrs. L. Simon, G. T. Archibald, J. Stuart Jones and A. E. Stone. Others present were Messrs. O. B. Blackwell, M. B. French, R. W. King, T. G. Miller, L. F. Morehouse, P. Norton, H. S. Osborne, J. J. Pilliod, J. L. R. Van Meter and W. Wilson.

On November 9, Dr. Jewett visited Toronto to consult with Hon. Howard Ferguson, Prime Minister of Ontario; Hon. W. Finlayson, Minister of Lands and Forests; and Sir Joseph Flavelle, on the subject of the new Ontario Research Foundation. Sir Joseph, Chairman of the Foundation, entertained a number of the conferees at a luncheon at the York Club.

P. Norton, in addition to his present duties as Assistant to President Jewett, has been appointed Editor of the Bell System Technical Journal.

At the Michelson meeting of the Optical Society of America, held in Washington November 1 to 3, H. E. Ives presented to the society the Frederick Ives Medal. Endowed by H. E. Ives in honor of his father, a pioneer in applied optics, the medal is to be awarded by the society biennially "for distinguished work in optics." This is the disposition he has chosen for the premium which accompanied the John Scott Medal awarded to him by the City Trusts of Philadelphia in 1927 in recognition of the development of television in these Laboratories. Papers read at various sessions of the meeting included "A Camera for Making Parallax Panoramagrams" by Mr. Ives, "Optical Conditions for Direct Scanning in Television" by Frank Gray and Mr. Ives, and "The Scattering of Electrons by Crystals" by C. J. Davisson. In charge of W. A. Marrison were exhibits of the continuous film oscillograph and the polar oscillograph, instruments for recording periodic phenomena of long and short duration respectively.

At the November 5 meeting of the Colloquium, C. J. Davisson, the retiring president, spoke on "Scattering of Electrons by Crystals." R. M. Burns addressed the Colloquium on November 19 on "Recent Developments in Electroplating."

Apparatus Development

F. F. Lucas addressed the members of the Brooklyn Institute of Arts and Sciences on November 1, on "The Ultra-Violet Microscope."

V. M. Cousins spent several days at Hawthorne testing amplifiers for talking movies.

O. L. Walter visited Hawthorne in connection with manufacture of the 202-A phonograph reproducer set.

C. F. Boeck and J. D. Sarros attended the Southern District Convention of the A. I. E. E. at Atlanta.

O. F. FORSBERG visited Hawthorne during the week of October 29 for conferences on dial system apparatus.

F. H. HEWITT was at Hawthorne during the week of November 5 in connection with the manufacture of the new decoder relays. He also inspected step-by-step equipment at Champaign, Illinois.

J. ABBOTT attended a conference at the Philadelphia Instrument Shop on changes in the Type 5 dial tester.

THE FIRST WESTERN ELECTRIC fifty-kilowatt broadcasting transmitter to go on the air is that of the Crosley Radio Corporation at Mason, Ohio. Its initial program was radiated at 9 P. M. on October 20. The equipment, which is a counterpart of that in our laboratory at Whippany, was installed under the supervision of H. S. Price, W. J. Adams, J. W. Smith and R. E. Poole. E. L. Nelson was present at the opening ceremonies.

RESEARCH

G. W. ELMEN lectured before the Franklin Institute in Philadelphia on November 8 on the subject "Magnetic Alloys of Iron, Nickel and Cobalt." For the benefit of members of the Laboratories, Mr. Elmen delivered the same lecture in the Auditorium on the previous evening.

K. K. DARROW addressed the New York Section of the A.I.E.E. on "Crystals and Waves."

J. R. HEFELE spoke on television before the Alpha Chapter of Omega Delta Phi at Cooper Union.

H. A. FREDERICK AND H. A. LARLEE attended a general conference on telephone instrument matters at Hawthorne. Mr. Larlee subsequently made a study of the latest developments of the handset.

W. E. ORVIS was engaged in the study of carbon manufacture at Hawthorne from October 21 to 26.

R. M. BURNS AND L. H. CAMPBELL visited the Bureau of Standards at Washington in connection with soil corrosion studies and paint investigations. They later visited the Research Laboratory of the New Jersey Zinc Company at Palmerton, Pennsylvania, for the same purpose.

R. R. WILLIAMS conferred on general engineering problems connected with the work of the chemical laboratories at Hawthorne.

H. FLETCHER AND L. J. SIVIAN viewed the Optical Exhibition held at Washington, during the Michelson Meeting, under the joint auspices of the Bureau of Standards and the Optical Society of America.

V. E. LEGG attended the November 8 meeting of the Franklin Institute in Philadelphia.

O. E. BUCKLEY addressed the Physics Seminary of Cornell on October 22 on "Researches in Ferromagnetism."

K. K. DARROW spoke on "New Knowledge Concerning the Scattering of Light" before Pi Mu Epsilon at Washington University, St. Louis.

L. J. COBB visited Hawthorne in connection with transmitter testing machines.

PATENT

I. MACDONALD, T. P. NEVILLE, J. W. SCHMIED AND P. C. SMITH visited Washington in connection with the prosecution of applications for patent. G. M. CAMPBELL visited Ottawa, and G. H. HEYDT, Montreal, for the same purpose. G. C. LORD visited Mattawan, New Jersey, and I. MACDONALD went to Philadelphia on patent matters.

CORDELIA MATTICE, an attorney of the Patent Department, was admitted to the Bar of New York State.

Systems Development

E. Vroom spent several days in Pittsburgh investigating relays for echo suppressor equipment.

R. A. Leconte inspected the new repeater stations on the Washington-Atlanta cable at Durham and Greensboro, North Carolina.

H. R. Vail spent a week at Hawthorne making tests on carrier telegraph equipment.

F. S. Entz investigated pilot wire regulators for telephone repeaters in Philadelphia.

R. S. Wilbur, E. D. Johnson and D. C. Meyer visited the repeater station at Allentown, Pennsylvania, to consider improvements in pilot wire regulating equipment.

H. T. Langabeer visited Hawthorne to discuss power plant problems.

D. H. Wetherell discussed dial equipment problems with members of the staff at Hawthorne.

V. T. Callahan has returned from Oklahoma City where the first 150 horsepower Type ATT gas engine was placed in operation.

W. W. Brown conferred with engineers of the Ohio Bell Telephone Company on problems incident to introduction of dial apparatus in Cincinnati.

R. E. Noble visited the new step-by-step dial system office in Atlantic City.

W. H. Spahn gave an illustrated talk on probability and its relation to engineering problems before the Cooper Union Mathematical Club.

General Staff

S. P. Grace addressed the Telephone Pioneers of America at Boston on November 2, the Cleveland Engineering Society on November 13, and the Baltimore Chamber of Commerce on November 27. On each occasion he spoke on the recent Laboratories developments.

S. P. Grace, W. C. F. Farnell, C. L. Goodrum, and G. F. Morrison, members of E. J. Hall Chapter of Telephone Pioneers, attended the Pioneers' convention at Boston.

L. S. O'Roark spoke to the Syracuse Section of the A.I.E.E. on "Electrical Transmission of Personality."

J. S. Hartnett has been appointed a member of the Finance Committee of the New York Junior Board of Trade.

R. W. King has been transferred to the Department of Development and Research of the American Telephone and Telegraph Company. He is to be associated with H. E. Shreeve, that Company's Technical Representative in Europe, and his headquarters will be in London.

James W. Brown, of the Personnel Department, died on Sunday, November 4. Mr Brown became a member of the Laboratories on July 14, 1926, and since that time had been on the staff of the Educational Department, engaged in instructing student assistants.

Inspection Engineering

A. F. Gilson visited Hawthorne during the week of October 29, in connection with his new duties as Assistant Inspection Engineer.

A recent change in the Field Engineering Force involves the assignment of H. J. Knowlton as Field Engineer in Chicago, replacing I. W. Whiteside, who will return to New York. G. D. Edwards visited Chicago during the week of November 12, to introduce Mr. Knowlton to Western Electric and Telephone

Company people in Chicago and Milwaukee.

As a part of the program of regular supervisory visits to Field Headquarters, A. G. Dalton spent the latter part of the week of November 5 in Atlanta with T. L. Oliver.

R. M. Moody and A. Grendon were at Hawthorne during the week of October 22 attending a regular Inspection Survey Conference on handset mounting. O. S. Markuson was at Hawthorne during the following week, also in connection with Inspection Survey Conference work.

E. G. D. Paterson represented the Inspection Engineering Department at a conference on the inspection of construction equipment, held on November 13 at the Highway Trailer Company plant in Edgemont, Wisconsin.

H. F. Kortheuer and T. Mellors attended Equipment Survey Conferences at Kearny and Hawthorne, respectively, during the early part of November.

S. H. Anderson and D. S. Bender were in Hartford on October 31 to invesigate the operation of step-by-step P.B.X. power plants.

Outside Plant Development

On October third, S. C. Miller and C. H. Amadon visited Boston where they conferred with engineers of the New England Telephone and Telegraph Company relative to requirements for chestnut poles.

J. M. Hardesty with L. B. Spengeman of the Western Electric Company visited Pittsfield, Mass., on October 26 in connection with matters relating to the manufacture of clay conduit.

On October twenty-third, E. M. Honan and F. F. Farnsworth inspected the laboratories of the New Jersey Zinc Company at Palmerton, Pennsylvania.

C. Shafer, Jr. and W. T. Jervey visited New Haven and Bridgeport on October 9 and 10 in connection with a field trial of a modified porcelain knob for parallel drop wire. From October 29 to October 31, Mr. Jervey visited the Corning Glass Works at Corning, New York, in connection with tests of Pyrex insulators.

On October twenty-second, C D. Hocker made development studies at New Britain, Connecticut, on fittings for linemen's body belts and safety straps. From October 29 to October 31, Mr. Hocker examined galvanized sheet metal samples which have been exposed to weather at Pittsburgh, Altoona, and State College, Pennsylvania, and Sandy Hook.

On October fifteenth, F. F. Farnsworth was in Washington making studies of paint testing apparatus in the Bureau of Standards laboratory and in the Henry A. Gardner Laboratories. Mr. Farnsworth attended a committee meeting of the American Society for Testing Materials at Schenectady on October 18 where the effects of outdoor exposure on zinc coated hardware and wire were discussed.

During October R. H. Colley visited Denver, Colorado, for the purpose of determining the condition of western cedar and lodge pole pine poles in service in the Limon Colorado-Sharon Springs toll line.

C. S. Gordon attended the annual convention of the American Society for Steel Treating in Philadelphia on October 9 and 10.

Election of Club Officers

THE candidates for Bell Laboratories Club offices for the year 1929 have been selected by the nominating committee. Ballots will be mailed to all club members on Friday, December 14 and must be placed in the ballot boxes Monday, December 17, between the hours of 8:30 A.M. and 6 P.M. Ballot boxes will be located in prominent places in each section on all floors of the building. No employee who is not a member of the club will receive a ballot. Club membership application forms may be obtained from Departmental Representatives or from the Club Secretary. Applications received after December 12 will not entitle new members to vote in the current elections.

The nominating committee which selected the candidates consists of D. A. Quarles, D. D. Haggerty, A. L. Johnsrud, S. J. Stranahan, J. C. Kennelty, T. J. O'Neil, P. J. Higgins, G. Rupp and T. C. Rice. The candidates:

For President

H. A. Frederick
O. M. Glunt

For First Vice-President

G. H. Heydt
H. F. Dodge

For Second Vice-President

Miss M. F. Kane
Miss M. Horne

Departmental Representatives

Two Year Term

Systems Development

P. B. Fairlamb
N. H. Thorn

Research

F. W. Hultqvist
J. G. Knapp

Commercial

J. C. Kennelty
G. A. Brodley

Tube Shop

W. D. Stratton
A. C. Thoesen

Nominated for Club President

Halsey A. Frederick

Here we show you Halsey Frederick, a candidate for the Club presidency. Mr. Frederick had his university training at Princeton, where he was prominent in undergraduate musical activities. On graduation he entered the Laboratories, where his first work was on mechanical repeaters. The war period saw him interested in submarine signalling, sound ranging, and aircraft detection. In recent years Mr. Frederick has had charge of a continuous program of research on telephone transmitters and receivers.

Mr. Frederick continues his musical interests, and is President of the Mountain Lakes Glee Club. He may be counted on to foster the Club's numerous activities in this field, and to balance the Club's program by encouraging athletic and social events.

Nominated for Club President

Omer M. Glunt

We present to you Omer M. Glunt, candidate for the Club presidency. During his undergraduate years at Ohio State University he assisted in the organization of social activities and was generally active in college affairs. Two years and more of the Manufacturing and Installation Departments served to broaden his viewpoint. In 1911 he came to the Laboratories, continuing his work of apparatus design. At present he directs the development of special products. Among these are talking motion-pictures, radio broadcasting transmitters, airplane communication by radio, and power line carrier telephone.

Mr. Glunt swings a wicked rod over the surf on the Jersey shore; when the finny monsters are not biting he takes a hand at bridge or a round at golf. He has always shown a broad interest in the Club, and may be counted on to support progressive policies.

FOR FIRST VICE-PRESIDENT

G. H. HEYDT

H. F. DODGE

HERE are the candidates for First Vice-President of the Club: Mr. Dodge is engaged in Inspection Engineering — specifically, he has charge of inspection methods and results. Mr. Heydt is a member of the Patent Department, where he protects our patent rights on talking motion picture developments. Mr. Heydt is a graduate of Lafayette, and Mr. Dodge of M. I. T. Both have served the Club as departmental representatives.

FOR SECOND VICE-PRESIDENT

Margaret Horne

Marian Kane

ABOVE are the candidates for Second Vice-President of the Club. Miss Kane is a member of the Patent Department. She has taken a keen interest in the women's activities of the Club since its beginning; she has been a regular member of the swimming class and bowling club. Miss Horne, as chairman of the committee on women's interests, has been an important factor of the Club during the year 1927, and has always been active in its behalf. She is a member of the Research Department.

For Departmental Representative

SYSTEMS DEVELOPMENT

Norman H. Thorn

Preston B. Fairlamb

TUBE SHOP

Alvin C. Thoesen

W. D. Stratton

For Departmental Representative

RESEARCH DEPARTMENT

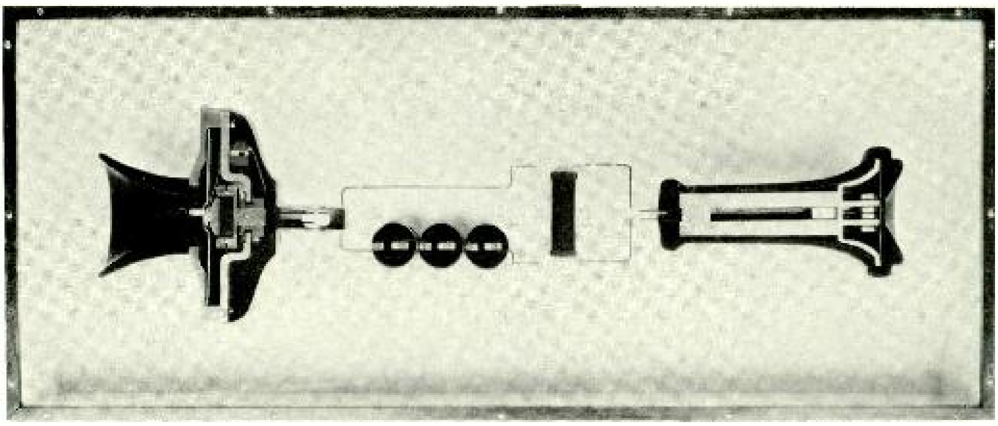
Ferdinand W. Hultqvist

John G. Knapp

COMMERCIAL DEPARTMENT

George A. Brodley

Joseph C. Kennelty



Graphic Model Presented to National Museum

Enlarged sectional models of transmitter and receiver simulate operation

FORMAL presentation of a sectional model of a telephone transmitter and receiver, whose diaphragms can be vibrated in synchronism by an observer to illustrate the fundamental mechanism of telephony, was made to the United States National Museum of the Smithsonian Institution on October 24. In the model, illustrated above, the instruments are connected by an elementary transmission circuit, such as is used where no provision is wanted for switching or amplification. Demonstration of its working is obtained by means of a lever at the bottom of the case, connected through a linkage to the diaphragms of both instruments. When moved slowly back and forth the lever vibrates the transmitter diaphragm as would sound waves impinging upon it, and thereby compresses and releases the carbon granules of the resistance button. At the same time it vibrates the receiver diaphragm by means of mechanical linkage as if voice currents were passing through the transmission circuit.

For clarity of detail, transmitter and receiver are each four times the standard size; and the dry cells and induction coil are of the normal size. The model is enclosed in a mahogany case about four and a half by two feet, with a plate glass top. Instruments and case were constructed in the Engineering Shop of the Laboratories. A special table is to be provided by the Museum on which the model will be displayed; it will adjoin the Alexander Graham Bell Exhibit.

The presentation was made on behalf of the American Telephone and Telegraph Company and Bell Telephone Laboratories by G. K. Thompson of the American Company and W. C. F. Farnell, Curator of the Bell System Historical Museum. Dr. C. G. Abbot, Secretary of the Smithsonian Institution, received the exhibit for the Museum, and subsequently wrote to Dr. Jewett to express his appreciation.