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Thermal Agitation of Electricity

By J. B. JOHNSON

WE are accustomed to the idea that in an electrical conductor there are electrons or ions in a state of random motion which has partly to do with the temperature of the conductor. We have had less occasion to consider that this motion may result in a spontaneous fluctuation of potential between points in the conductor. This thermal agitation, this motion of electric charges, this potential fluctuation, does exist and can be measured under suitable conditions.

The effect is most readily detected in a conductor having high electrical resistance. It is characterized by a continually changing or fluctuating voltage generated by the resistance itself, unconnected to any other sources of potential. An alternating current instrument is therefore required to measure the effect, an instrument which reads the root-mean-square or effective voltage.

If an ordinary voltmeter is connected to a resistance as shown in Fig. 1, of course, nothing happens. The effect is far too feeble to be thus detected. A vacuum-tube amplifier capable of multiplying the voltage by about one million must be inserted, between the resistance and the meter, as shown in Fig. 2. The amplifier and the meter, which may be formed by the combination of a thermo-couple and galvanometer, then constitute a sensitive voltmeter which can be used for accurate measurements.

With such a system measurements have been made on resistances composed of a wide range of materials, including advance wire, carbon filament, metallic films, and various electrolytes. In all cases a mean-square-voltage, proportional to the resistance, was observed. In all the materials the ratio of this mean-square voltage to the value of the resistance was the same and was independent of the shape or dimensions of the resistance.

This voltage effect might be caused by the thermal agitation of the electrical constituents of the material or it might arise from some property of the amplifier whereby its own noise is increased when resistance is connected to its input. In order to settle this point a measurement was made on the resistance at liquid-air temperature, and the ratio of mean-square voltage to resistance was found to be less than that at room temperature in the proportion of the absolute temperatures. This relation held accurately in the case of advance-wire resistances over the temperature range from liquid oxygen to boiling water.

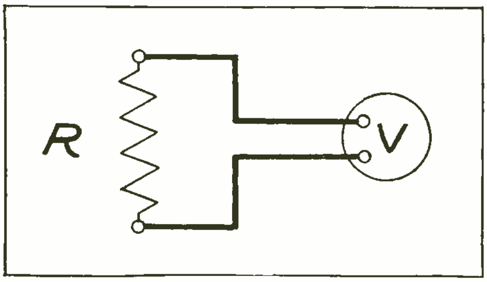


Figure 1

The same satisfactory agreement was obtained with other resistances, including electrolytes. There can therefore be no question about the fluctuation originating in the resistance and not in the amplifier.

When a different amplifier is used a different value is obtained for the ratio of mean-square voltage to resistance. For the purpose of determining the value of this ratio the frequency characteristic only of the amplifier must be known. This means its amplification squared must have been measured at a sufficient number of frequencies to plot a complete characteristic curve. The mean-square output-current, induced in the thermocouple of Figure 2 by the voltage fluctuations in the input resistance, is then proportional to the area under the frequency characteristic. Since there is proportionality also to the resistance and the absolute temperature, the empirically derived expression for the mean-square output-current is proportional to the product of these factors. The introduction of a fourth factor —a numerical multiplier which turns out to be closely connected with Boltzmann's gas constant and with the energy of a gas molecule at a given temperature—completes the expression. A knowledge, therefore, of the resistance in the input and of the frequency characteristic of the amplifier is all that is necessary for predicting, in any particular case, how much current will be induced in the output branch by the resistance in the input of an amplifier.

This thermal agitation of electricity in a conductor has certain very practical aspects. When a telephone is connected to the output of a sensitive amplifier a characteristic sound may be heard—the "sh-sh-sh", commonly called "tube noise". At least a part of this is the spontaneous noise arising from the input resistance itself. *In fact, if the input resistance is high and the tubes are of the best, the noise due to thermal agitation in the resistance is so large as entirely to mask the noise contributed by the tubes.* To the smallness of the voltage which can be successfully amplified, there is then set a limit by the very nature of the substance of which electrical circuits are built.

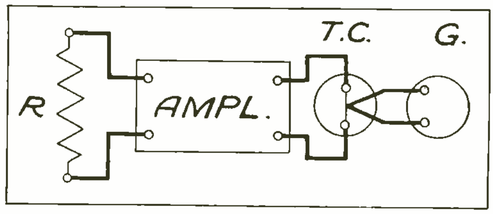
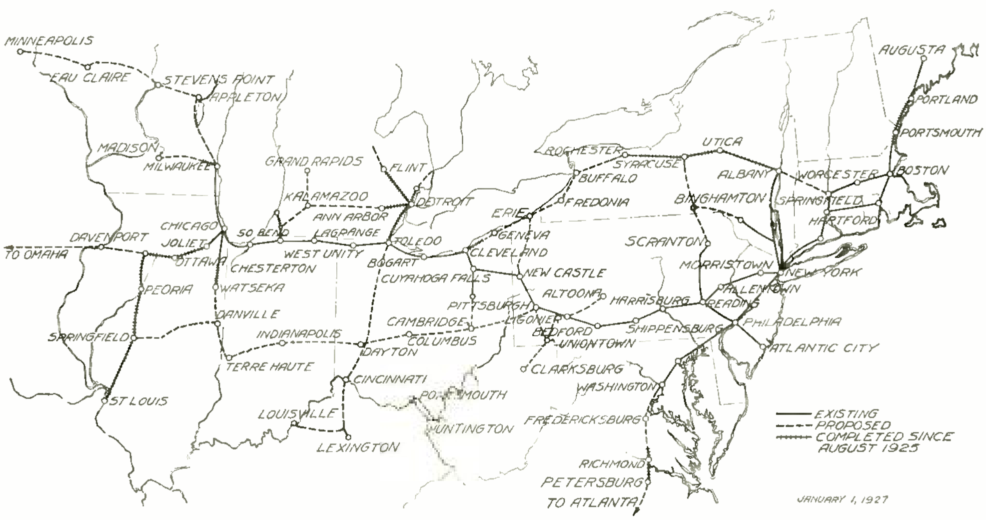


Figure 2

In order to give the exact magnitude of the effect both the resistance and the amplifier would have to be specified in the terms described above. Approximate figures may be given, however, for a usual type of circuit, with which comparisons can then be made. Such a circuit is an amplifier which covers the voice-frequency range, to the input of which a resistance of one-half megohm is connected. There then appears to exist across the resistance a root-mean-square voltage of the order of a few microvolts. This is equivalent to a "power level" of about −140 T. U., and this power level is independent of the resistance. The smallest power which can be usefully amplified by this system depends upon the amount of distortion and superimposed noise which can be tolerated, but it cannot be much less than the power of the noise itself. It is possible, of course, to handle smaller powers in proportion as the frequency range of the amplifier can be made narrower; that is, to have a smaller area under its frequency characteristic.

Returning to the physical facts involved, these can now be summarized: Every resistance is a source of random voltage fluctuations, the effects of which can be heard or measured with suitable amplifying apparatus. Experiments at different temperatures prove conclusively that in an amplifier a component of "noise" comes from the resistance in addition to that from the vacuum tube or other elements. The discovery of this phenomenon, in our laboratories, therefore, is not only of scientific interest but finds an application in the practical problems with which we deal.



Long-distance cable network of the Bell System. Completion of the Chicago-St. Louis link is noted on page 198 *of this issue*

The Loudness of Pure Tones

By B. A. KINGSBURY

"LISTEN to the band, marching up the street," as a song of the Gay Nineties advised: a curious effect is noticeable. As the band approaches and its music grows louder the bass notes come out most strongly. The same band, the same music, but there is a different emphasis to the notes when the band is near and the music loud than there is when it sounds faintly from far away. The explanation of this and other anomalies of hearing is to be found in some recent measurements of loudness which have been conducted in our Laboratories.

Loudness is a psychological phenomenon depending upon the structure and action of the human ear. Physically, behind the impression which a listener receives is the alternating pressure of the train of sound waves upon the ear drum. Loudness does not inhere in the sound waves; they transmit energy and exert on the ear drum an effective or so-called "root-mean-square" pressure which the physicist measures in units of force (dynes) per square centimeter of area affected.

How does loudness, which is a sensation, correspond to effective pressure, which is the physical characteristic of a compressional wave in air? At first thought it might appear that the two should be directly proportional, that is, have a linear relation between them. Not so readily would one expect that there would be a linear relationship between loudness and pitch, since the receptive fibres of the basilar membrane are not equally distributed with reference to pitch, as the "piano model" of the ear so plainly illustrates. Having two notes of different pitches, that is different frequencies, and of equal effective pressures will they produce similar sensations of loudness? Or, in other words, having two notes of different frequencies both equally loud, will their effective pressures be the same?

The experiments answer that, in general, they will not be; and more than that, the difference of effective pressure between notes of two pitches, which seem equally loud, is not a constant difference but depends upon the pressure. These somewhat complicated and unexpected relationships are illustrated in the accompanying graphs which give the results of comparisons of the sensation of loudness for various pure tones, differing in pressure and frequency.

The observers listened to pure musical notes from a telephone receiver driven by current from a vacuum-tube oscillator. The listeners compared different notes, two at a time, as to the sensation of loudness and by adjustment of the current brought them to perceptibly equal loudness. The value of current corresponding to any note, and hence the pressure exerted by its sound wave, was known from the setting of the current control.

In Figure 1 is shown the arrangement of apparatus for the tests. The observers listened alternately to notes on circuits A and B. That on circuit A was kept constant at a pitch about an octave and a half above Middle C. Its intensity was set to some value unknown to the listener who was participating in the test. This was conveniently done by turning the dial of the attenuator marked "A". The note of circuit B was then set to some other pitch; and the listener varied its intensity by turning attenuator B until it seemed just as loud as that of the comparison note of circuit A. To make sure that his settings, which were repeated several times, were uninfluenced except by the sensation of loudness, the attenuator dial B was hidden by a loosely fitting screen through which the knob projected.

The comparison note of "A" was successively set at nine different intensities; and a family of notes of other pitches, but of equal loudness, determined for each listener. There were as listeners eleven men and an equal number of women. The average determinations of each listener were then averaged to obtain the curves of Figure 2.

All the points on one of these curves represent in terms of the root-mean-square pressure the physical stimuli, corresponding to the indicated pitches, which acting on the human ear will give sensations of equal loudness. This follows from the assumption that the old axiom of "things equal to the same thing are equal to

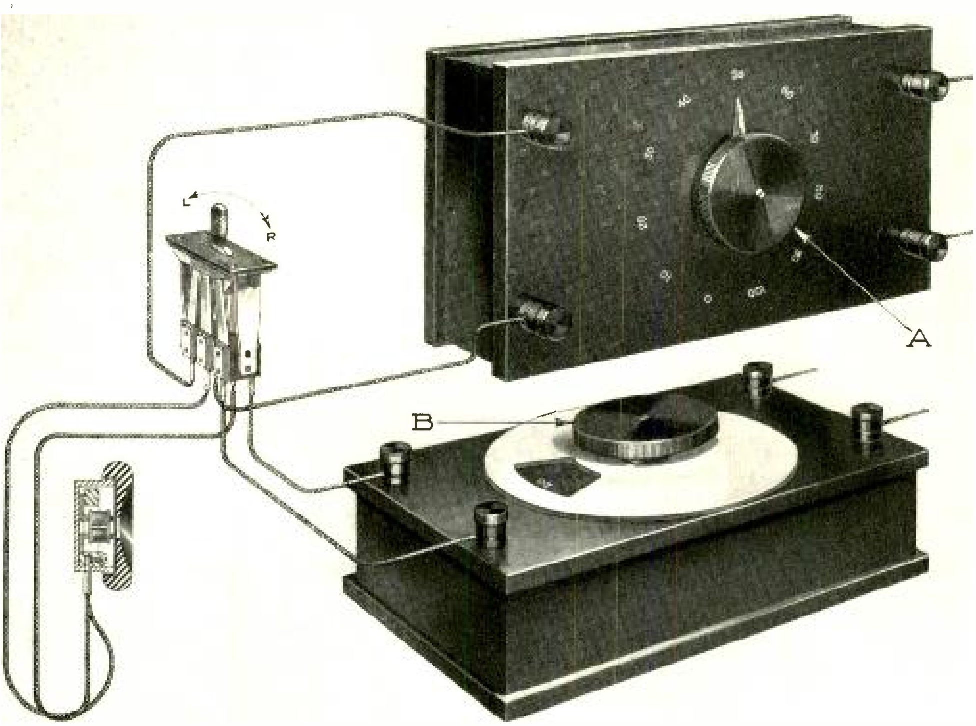


Fig. 1—The attenuators which vary the intensity of tone in the receiver. With the switch in left-hand position, "A" tone is heard; in right-hand, "B" tone is heard

each other" applies to the sensation of hearing. Each of the various notes represented by a curve sounded just as loud as the comparison note, and hence was assumed to be equally loud. As a check of the application of the axiom in this particular case, one of the lower tones was directly compared with one of the higher tones. The result was found to agree with the determination previously made by comparing these same tones through the medium of the "A" test-tone.

The curves now show why the band sounds as it does. The loudness of the low-pitch tones increases more rapidly than does that of the high-pitch tones, for equal increments in pressure ratios. That is, suppose aural observation to start with wave pressures only just sufficient to give audibility. As hearing begins the ear is not at all equally sensitive to all notes. At the highest level of loudness which was studied, however, there is approximately equal sensitivity over the entire frequency range.

That is one of the causes for the booming effect produced sometimes by loud speakers when the volume is increased. Even though the intensities of all the pitch components of the music are amplified nearly equally, a relatively increased effect on the ear then comes from the bass portion of the music. The remedy for the condition is the reduction of the volume until the music, as a whole, is of about the volume to which the listener is accustomed for music of its type. Then the various components do not give rise to unusual relative sensations of loudness and hence to an apparent distortion.

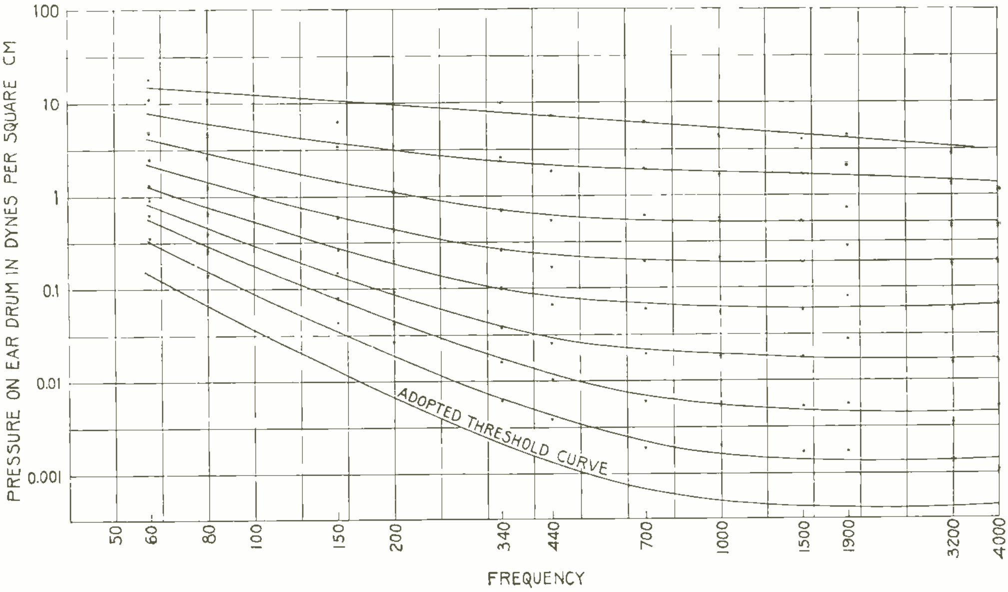


Fig. 2—Points on one of these curves represent, for the indicated frequencies, the physical stimuli which, acting on the ear drum, give sensations of equal loudness

Power Supply for Radio Receivers

By H. C. CURL

THE single-tube radio receiver, popular five years ago, demanded but a modest battery equipment to supply its filament and plate circuits. As the art developed, receiving sets became more complex; reliable operation on weaker radio field-strengths and ample volume on loud speakers became essential. The number of tubes increased, and with it the need not only for more power, but for higher plate-circuit voltages. While the need can be met, as originally, by batteries, they require a certain amount of attention in the way of inspection, replacement and recharging. Of this responsibility most radio listeners would gladly be relieved, even at some additional first cost and operating expense. In effect, they ask for a power supply which needs no attention other than to turn the set on and off. As a result, there have appeared many different forms of "battery eliminators" intended to supply suitable power by conversion from the commercial supply of 110-volt 60-cycle alternating current.

In some cases this "conversion" is the simple one of voltage-reduction through a transformer. More often it requires conversion of alternating current into direct, by means of a rectifying element which will pass current in one direction only. The vacuum-tube is itself a rectifying element; through it current can flow only when the plate is positive to the filament. When three-element tubes are used, as for example the 205-D in the 25-B amplifier, the grid plays no part in controlling electron-flow and it is strapped to the plate. No grid is provided in rectifier tubes, such as the 217-A. The rectified output of a tube is limited as to current by permissible heating and by filament-life. It is limited as to voltage by the potential-difference which the tube will block when its plate is negative to its filament.

Another type of rectifying element involves an electrolytic cell, in which one electrode is of an inert material, frequently lead, and the other is aluminum or tantalum. Both of the latter metals have the property of forming a film of oxide on their surfaces which blocks current-flow from electrode to electrolyte, but allows current to flow in the opposite direction. With the aluminum electrode, a solution of borax is commonly used; with the tantalum electrode, a dilute solution of sulphuric acid. The current through either type of cell is limited by heating, which decreases the life of the active electrode, and by excessive loss of water due to electrolysis.

Another limitation to the usefulness of the electrolytic rectifier is the low value of reverse-voltage which it can be depended on to block. This is of the order of forty volts for the aluminum type and sixty-five for the tantalum type. For higher voltages, it is necessary to use an appropriate number of cells in series. When output voltages up to 135 are desired this is not a serious factor. Much higher voltages are required for the power tubes now coming into use; and for this service the number of electrolytic cells becomes excessive. On the other hand, a single vacuum tube may be selected from available types for use in rectifier circuits delivering as high as 10,000 volts. As a practical example in the field of radio reception were an aluminum rectifier to be used in place of the single 205-D rectifier tube in the 25-B amplifier, as many as twenty cells in series might be required to supply sufficient voltage.

How a rectifier operates is illustrated by Fig. 1, which shows a circuit commonly designated as "half-wave" since only one half of each cycle produces current-flow. In circuits of this type the heating effect of the current through the rectifier is equivalent to that of a steady current twice as great as that which is delivered to the load. The peak voltage across the tube during the non-conducting half-cycle is equal to the peak value of the alternating e.m.f. plus the voltage of the first filter-condenser; the total will approach at light loads twice the peak voltage.

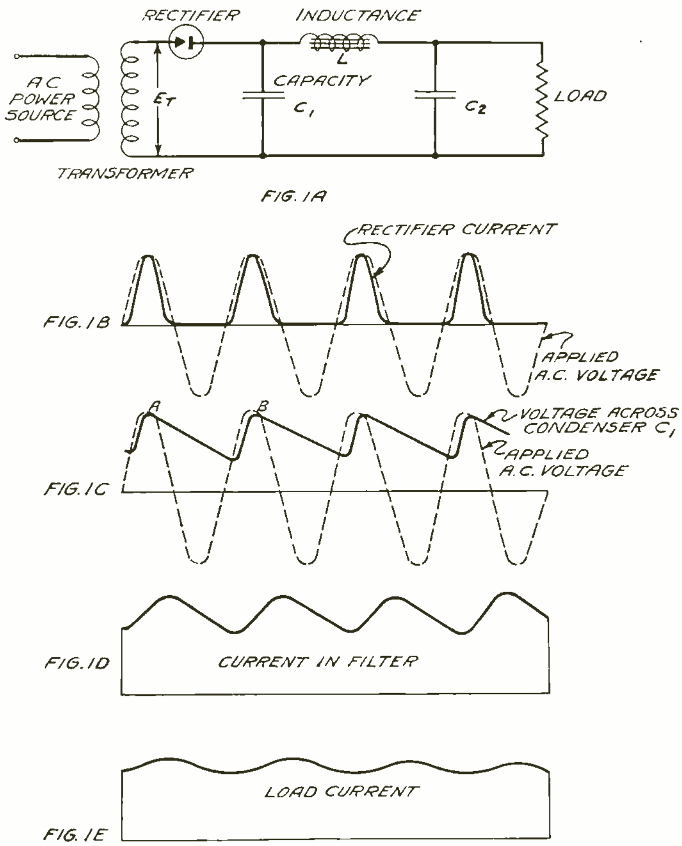


Fig. 1—A "half wave" rectifier; (a) its circuit; (b, c, d, e) wave-forms of current and voltage

An alternating component in the rectified current is quite objectionable in the plate circuits of an audio-frequency amplifier. It may be greatly reduced by inserting one section of a simple low-pass filter as shown in Fig. 1. The proportion of alternating current which remains in the output of the filter can be calculated from the filter constants, but its effect on the operation of the amplifier can be determined exactly only by experience or trial. Any degree of filtering can be obtained by using more capacity, more inductance, or both; and by using more than one section of filter. For a given amount of capacity, the "ripple" will be a minimum when that capacity is equally divided between C_1 and C_2. On the other hand, the larger is C_2, the lower is the output impedance of the rectifier circuit, and the less likely is "singing" when several stages of an amplifier are fed in parallel from a single rectifier.

Condenser C_1 may be omitted from the filter; this has the effect of making the wave-form of the rectifier current much less peaked. In turn this reduces the heating of the rectifier element for the same quantity of electricity through it,* but the impedance of the filter is increased, so that a higher alternating voltage must be impressed. In the case of a vacuum tube the decrease in heating may more than compensate for the increase in reverse voltage to be blocked, but no advantage is secured

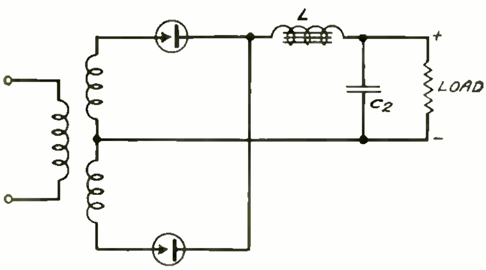


Fig. 2—Another form of filter from which the condenser C_1 has been removed

when electrolytic cells are used because the increase in voltage will require a proportionate increase in the number of cells.

In the so-called "full-wave" rectifier both halves of the alternating current cycle are used, with advantages in both efficiency and lower noise-level. The most common type of circuit is shown in Fig. 3; it employs a transformer with a mid-tap on the secondary winding, and two rectifying elements. To deliver the same voltage to the load this circuit requires twice as many turns on the transformer secondary as in the circuit of Fig. 1 (a) but the current is divided between the two rectifying elements and their associated trans-

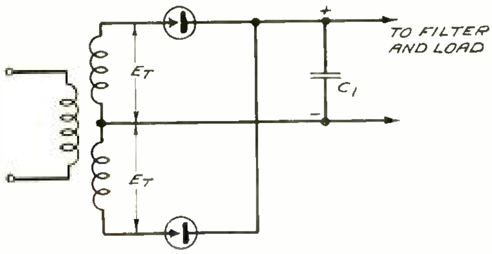


Fig. 3—A simple form of full-wave rectifier

former-windings. Hence this circuit is adapted to use with vacuum tubes where current-flow is a limiting factor. While the load can be equally balanced with tube and tantalum rectifiers, it is difficult to do this if aluminum cells are used. This difficulty is avoided if the circuit of Fig. 4 is used. No transformer mid-tap, and only half as many secondary turns, are needed. At least four rectifying elements are used, instead of two, but since two elements are always in series to oppose the reverse voltage, the circuit has an advantage when the breakdown voltage of the rectifying elements is a consideration. Where four elements would be required in the circuit of Fig. 3, they could be rearranged according to Fig. 4 with a transformer of half the secondary voltage to give the same output voltage.

Full-wave rectification with two elements may be effected by the circuit of Fig. 5. With a transformer secondary equal to that of Fig. 1 (a),

* *Total current per cycle is the integral of the instantaneous current; heating is proportional to the integral of the second power of the current.*

approximately twice the output voltage is secured at no-load; each condenser in Fig. 5 is charged in turn to the voltage of C_1 in Fig. 1 (a) and both in series discharge through the load; each carries full load-current.

One of the advantages of full-wave rectification is that the frequency of the alternating component in the output is doubled, and to attenuate it an equal degree requires a filter of higher cut-off and therefore smaller and less expensive. On the other hand the ear is much more sensitive to the 120-cycle tone resulting from full-wave rectification than to the 60-cycle tone of half-wave rectication, so that the noise level is about the same in the two cases. Where a radio receiving system is quite insensitive to these low-frequencies, no audible hum may be heard at all in the loud speaker, yet there may be a large ripple present in the supply which under some conditions will be sufficient to modulate the received speech or music. This condition may make itself known by bad quality or a peculiar fuzziness in the program which is being received.

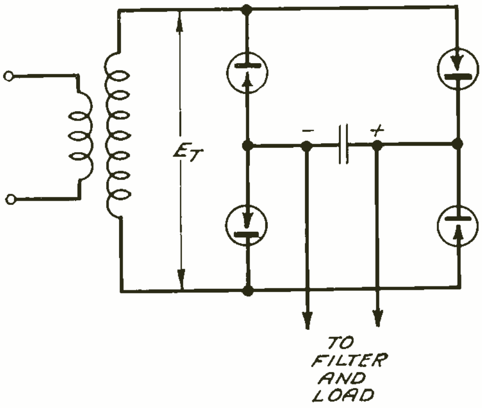


Fig. 4—A circuit which uses four elements

In the matter of voltage regulation, the rectifier is at a considerable disadvantage as compared to the dry-cell battery, since its internal resistance is so high that changes in load produce large changes in output voltage. For example, one commercial rectifier shows a 15 percent drop in voltage when the output current is increased from five to twenty-five milliamperes and another under similar circumstances gives a drop of 55 percent. Dry cells, on the contrary, have sufficiently low internal resistance, especially when new, that their output voltage will change but little over the range of loads ordinarily imposed on them.

Electric power for heating the filaments of vacuum tubes is supplied under conditions quite different from those attending its use in plate circuits. Impedance of filament circuits is relatively low: currents are relatively large and voltages small. Under these circumstances disadvantages of storage batteries are much less marked. Since most radio outfits have been designed for this source of filament power there is a decided appeal in a device which combines with a small battery a rectifier whose current can be allowed to flow through the battery continuously when the

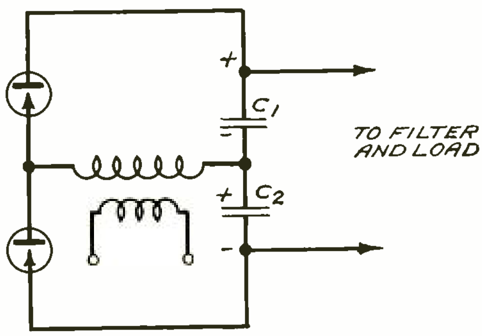


Fig. 5—A two-element rectifier for higher voltages

radio set is not in use. A battery operated in this manner requires little attention other than the addition of water at intervals; it has long life and gives good service.

Several "trickle" chargers employ rectifiers of the contact type. One of these consists of a disc of oxidized copper held in contact under pressure with lead or other soft metal. The cuprous oxide film has a low resistance to voltage in one direction and a high resistance in the other direction, thus fulfilling the requirements for a rectifier. The ordinary crystal detector is a rectifier of this general type.

A rectifier widely employed in battery chargers and capable of passing several amperes is of the hot cathode type, but the tube, instead of a vacuum, contains an inert gas which is

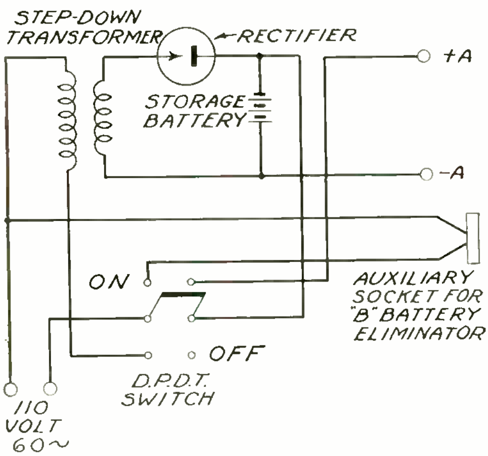


Fig. 6—Typical "trickle-charger"

ionized by the electrons emitted from the hot filament. When the anode, which is usually a piece of graphite, is positive, electrons are drawn from the filament; these ionize the gas molecules by collision, so making them conductive in the direction of anode to cathode. During the half-cycle when the anode is negative any electrons emitted from the filament are repelled and the gas in the tube is not conductive during that period. The internal resistance of a tube of this type is much lower than that of a vacuum tube and larger currents can be rectified, but on the other hand the reverse voltage which can be blocked is lower.

In the battery-charging arrangements just described, the battery may be replaced by a filter of the type used in plate circuits and the direct-current output connected directly to the filament circuit of the radio set. With tube filaments in parallel the

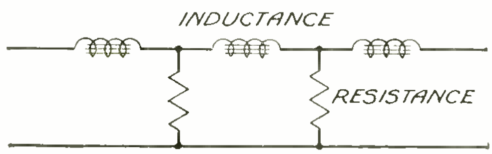


Fig. 7—Low-pass filter for filament circuits

current is of the order of two amperes, as against a few milliamperes in plate-current supply. This necessitates a costly and unwieldy choke coil in the filter. Since the impedance of the load is low, quite large values of capacity become necessary. Condensers may be replaced by resistances as shown in Fig. 7, but at a sacrifice of efficiency. The filter problem is considerably simplified by using so-called "60-mil" tubes with filaments in series with the plate circuit of the last audio-frequency stage. This raises the load impedance to a value which gives satisfactory filtering, and requires no more current than can be handled by a choke-coil of moderate size. In the typical circuit shown in Fig. 8, the plate and grid voltages of the 205-D tubes are such as to allow a current of thirty milliamperes through each of these tubes, giving sixty milliamperes through the filaments of the three tubes in preceding stages.

For the filaments of tubes in certain stages, sixty-cycle alternating current may be employed. This is particularly true of the last audio stage

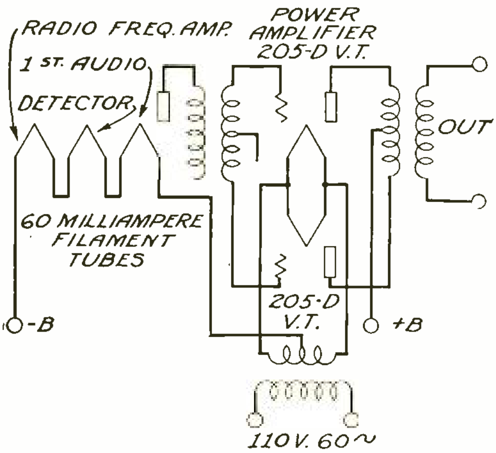


Fig. 8—How 60 milliamperes d. c., entering the circuit at "+B," may first serve as plate current for the last stage, and then as filament current for the three preceding tubes, leaving at "–B"

in which the filaments usually require more power than do the other tubes of the receiver, and where any alternating current hum will not be amplified by succeeding stages. In the 25-B amplifier, suitable voltage for this purpose is given by one of the secondary windings of the 60-cycle power transformer. To the midpoint of this winding are connected the grid and plate circuits. This balances out to a considerable degree the effect on the grid and plate circuits of the alternating voltage across the filament. The same end may be achieved by connecting a potentiometer of equal resistance across the filament leads. When necessary, a better balance can be secured with a variable potentiometer adjusted for minimum noise.

Audio-amplifier tubes of other than the last stages may also be lighted by alternating current, but naturally noise introduced in these tubes will be amplified by succeeding stages and may become objectionable. These noises may be minimized by using tubes with low-voltage filaments, such as the 215-A, and carefully adjusted potentiometers. Radio-frequency amplifier tubes may be lighted by alternating current. If the detector tube is lighted by alternating current a complicated and carefully adjusted circuit is required, else noise will be excessive.

Both plate and filament circuits require a supply of power; the grid circuit, however, requires only a voltage of proper value. Since no current flows, and no work is done, it is customary to use small dry-cells. Elimination of these batteries, desirable for maintenance reasons, may be effected by using in their place the fall-of-potential across a resistance in which direct current is flowing. This current may be that required to light single filaments, as in Fig. 9; or to light filaments in series as in Fig. 8. In the latter circuit a potential of 9

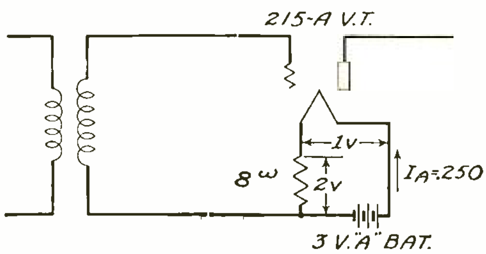


Fig. 9—How a grid bias can be supplied by potential drop in a filament circuit

volts, negative with respect to the power amplifier filament, is available at "–B". Where series filaments are not used, their place may be taken by resistance, as is done in the 25-B amplifier. It should be remembered, however, that potential thus obtained for grid bias is deducted from that available for the plate circuit of the last tube; and that a certain amount of power is lost in the resistance. This method is coming into use because it eliminates an element whose replacement is annoying and often forgotten, and because for large values of grid-potential as required by the 25-B amplifier, a resistance takes up much less space than would the equivalent number of dry-cells.

Any consideration of the relative costs of supplying power to a radio set by various methods involves the correlation of data as to the load, the number of hours' use per day, cost and life of different kinds of batteries, cost of electric power, and efficiency of each piece of apparatus through which that power must pass. All of these quantities vary over so wide a range that data of practical value would be too bulky for this article. The "practical value", even, of data is doubtful since the annual charge is probably one of the least important factors in the selection of power-sources for radio reception. Far greater weight is given to such points as low first-cost, ease of maintenance by unskilled hands, warning of impending failure, and adaptability to sets of different types. The annual charge for power is practically the only operating expense in connection with a radio set; compared with the pleasure of radio reception this expense is so moderate that it is generally ignored. After all, what the user buys is satisfactory reception of radio programs. Given this, at a price within his means, and a difference of a few dollars is counted of little importance.

Visualizing The Unaccomplished

Hard-grained scientists seldom make predictions as to developments likely to occur in their particular field of experiment and research. At least such has been the rule among responsible savants. . . . During the past three weeks, however, three venerable scientists and inventors have voiced predictions which occasioned no end of excitement. . . . Predictions are romantic and . . . furnish . . . interesting copy for newspapers . . . Unfortunately even scientists do not qualify to visualize scientific achievement as yet unaccomplished.

The policy of the Western Electric Laboratories furnishes an excellent case in point. Here are employed a great number of the shrewdest engineers in the world. It is the method of these laboratories to successfully perfect new inventions, try them out secretly over a long period of time, and when they are classed as positive and fool-proof, announce them to the public. In other words they accomplish first and predict afterward. Such practice may lack the romance attached to the perfection of a publicly predicted device, but in the long run it is the best method for the good of the general public.

H. F. Wooley, in "The Radio Airshaft"—New York American.

Lead Cable Sheath

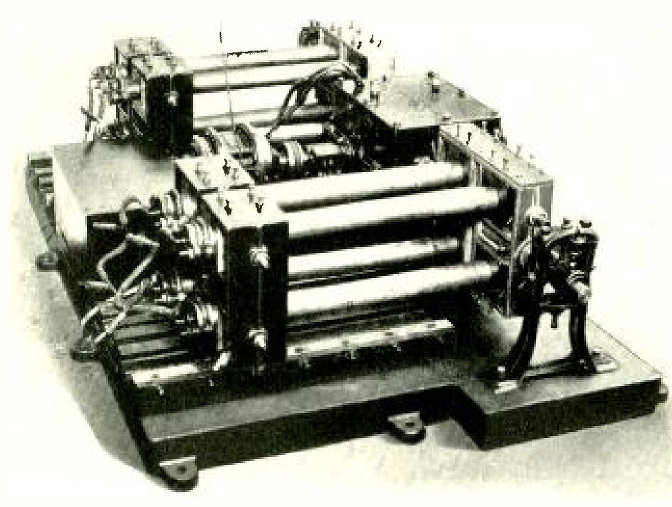
By J. R. TOWNSEND

On December 15, 1926, the long distance cable between Chicago and St. Louis was formally opened with ceremonies appropriate to the most western strand of a cable network which, paralleling the Atlantic from Portland to Washington, stretches inland to join most of the principal cities in the industrial area of the United States.

The new cable* is 344 miles long, provides more than 250 telephone and telegraph circuits and represents, with its associated apparatus, an outlay of about $7,000,000. While this project will supply circuit facilities equivalent to ten open-wire pole-lines, it was undertaken at this time to give increased protection against storm damage. Wires grouped into cable, which is in turn suspended from steel strand, offer less surface to wind and sleet and more resistance to loads imposed by both. Safe inside a leaden sheath, their paper covering maintains its insulation through good weather and bad. But the sheath must be continuous, else rain and melting ice will find their way inside, wet the paper and quickly put the cable out of service. Evaluation of the ability of cable-sheathing to maintain its integrity is a subject of continuous study in these Laboratories.

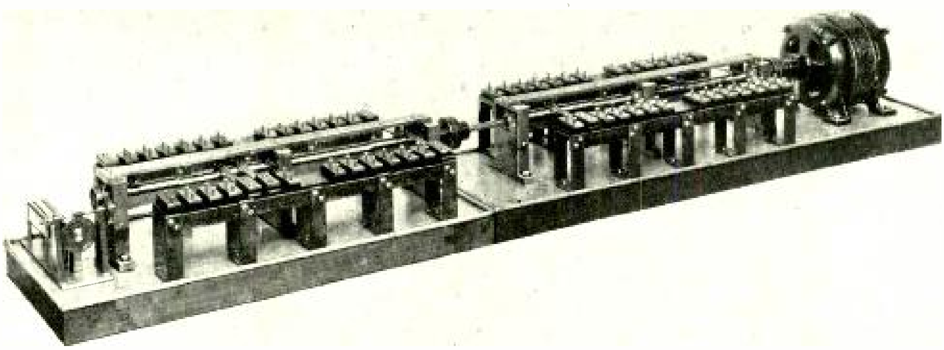
* *A map appears on page 187.*

As a material for cable sheath, lead and certain of its alloys are almost ideal. They are easily applied to the cable core; they have sufficient flexibility to allow the completed cable to be reeled, unreeled and bent into place; they are strong enough to protect the cores, impervious to moisture, and highly resistant to corrosion. Consider now the other side of the picture; thousands of miles of cable, aloft on pole lines; swinging in the wind; vibrating to the jar of passing traffic; lengthening



Machine for vibrating short lengths of cable. Cracking of any sheath admits air to a partial vacuum in the samples; a mercury manometer then closes its contact and indicates that a failure has occurred and shrinking as the sun warms them or the frost chills. Here are forces tending to open cracks in the lead sheath through which moisture may enter. For example, the rate of expansion with change of temperature is 60 per cent greater for cable than for its supporting strand. In a hundred-foot span an unstressed cable, just the length of the strand at sixty degrees Fahrenheit, at 120 degrees would be a half-inch longer than the strand. This extra length is taken care of, in part, by actual compression of the cable. But the cable also lengthens and shortens in relation to the strand, and so moves into and out of a "bow" at each pole because there the cable is already bent. These slight but repeated bendings and straightenings with vibration due to wind and road traffic, combine in tending to "fatigue" the lead sheath. Under severe conditions it may eventually crack open, with disastrous results, certainly when the next rain falls. Lead alloys differ from ferrous metals in fatigue failure in that the fracture always passes between the crystal grains. Under stresses producing this type of failure, lead alloys show no yield or plastic flow of the metal but a definite separation of the crystal grains.

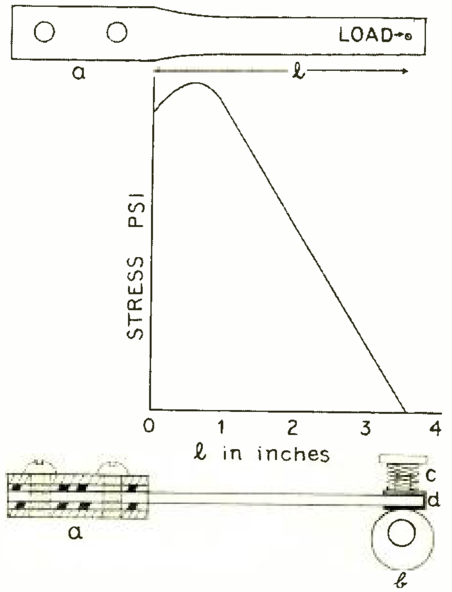
Early sheaths of commercially pure lead were not sufficiently resistant to fatigue or to corrosion to give complete satisfaction. A lead alloy containing 3 per cent tin was substituted,



Fatigue-tester with a capacity of fifty-six specimens of sheath material

since it had greater resistance to severe service stresses than had lead alone. Later due to economic conditions an alloy containing 1 per cent antimony was used in place of the lead-tin alloy. This material could be used because of its still greater resistance to fatigue and because it was satisfactory in all other respects. Each of these changes in composition of sheath was made only after exhaustive laboratory tests in which samples were exposed to vibrations and to bending under measurable conditions.

For these tests two different machines were developed to take samples of actual cable. In one machine short specimens are clamped at one end while their other ends are set into rapid vibration by motor-driven cams. In the other a bending test is given to U-shaped pieces of cable several feet long, by vibrating the free ends toward the clamped ends. These two types of machines are used in evaluating the ability of proposed sheath materials to withstand service conditions. They were seen to be

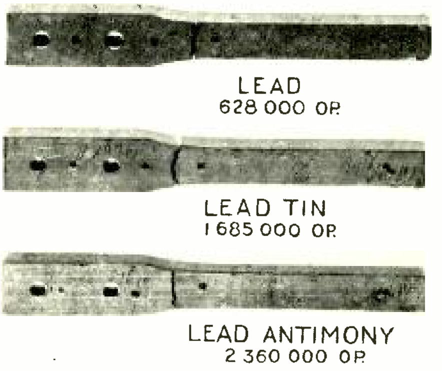


A sample; distribution of stress in it, and how the stress is applied

bulky and require considerable test material, so it was thought advisable to develop a test based on a simpler form of specimen. Careful studies of reported field conditions and comparative analysis of a large amount of data have shown that the extreme service conditions causing failures may be simulated by stressing at a reasonably rapid rate a small specimen of lead sheath.

This specimen was designed so that the maximum stress will not occur at the clamped portion, thus eliminating the unknown effect of stress due to clamping. One end of the specimen is clamped, the other end is inserted in a phosphor-bronze boot which is held against a cam by a helical spring. The machine has a capacity of fifty-six specimens. It can produce a break in a specimen of standard sheath material in three days whereas it may take the bending-machine six weeks to cause a break in a specimen cable. The high speed and large capacity of this machine permits the testing of 150 to 200 times as many specimens as the bending machine.

All of the characteristics of fatigue failure are exhibited in specimens tested on this machine. All proposed alloys and modified sheaths are investigated also by testing sample lengths of cable in the vibrating and bending machines. Decisions are based on concurrent results only. As a further precaution it is customary to make trial



How samples of the three cable-sheath materials failed under fatigue

installations of cable under actual service conditions. Such searching investigation is necessary in view of the importance of cables in our communication system and the investment in their manufacture and installation.

In addition to meeting the requirements for aerial use, all cable must be able to withstand the mechanical strain of pulling into conduits, since it is most economical to employ the same type of cable for both underground and aerial service.

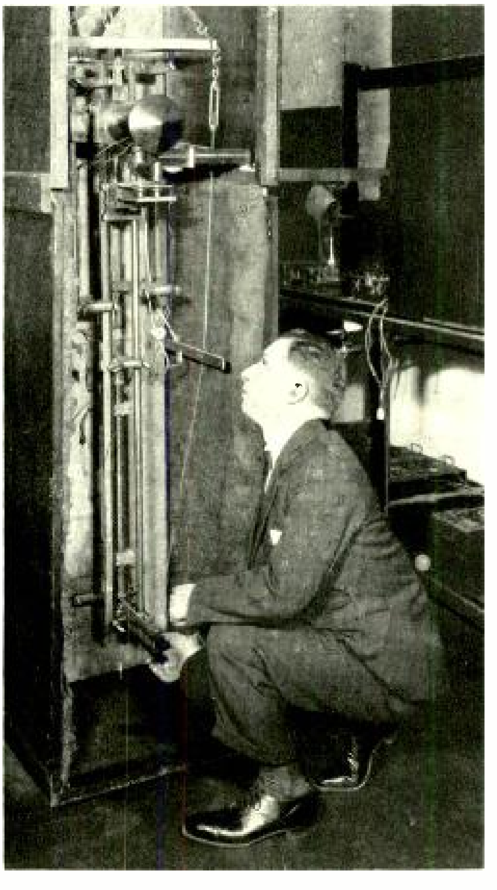
Measuring to Four Parts in a Billion

By P. P. CIOFFI

RESEARCH problems sometimes require the measurement of small displacements. For those approaching the order of one part in 100,000, simple and direct methods of measurement can no longer be applied and recourse must be had to various artifices. In a problem bearing on the physical nature of permalloy it was desired, in detecting changes of length, to extend the lower limit of measurement to a few parts in 1,000,000,000. The actual accomplishment, measuring to four parts in a billion, resulted from the development of a new method of measuring increments of length which is more sensitive and more accurate than any used heretofore.

Since 1847 it has been known that magnetic substances change their dimensions with magnetization. This phenomenon, called magnestostriction, was also early recognized as highly significant in explaining certain ferromagnetic phenomena. On the other hand within our Laboratories experiments on the effect of tension on the magnetic behavior of long thin rods had confirmed the existence of a critical composition of nickel-iron alloy which has no magnetostriction. This led L. W. McKeehan to formulate his atomic theory of magnetostriction which relates the properties of permalloy to its magnetostrictive behavior.*

To test the theory there were required measurements of magnetostriction, at low magnetizations, in iron, nickel and permalloy. Relatively large magnetostrictive effects represent only exceedingly small changes in length. To be able, therefore, to detect such effects in the case of permalloys where it is very much

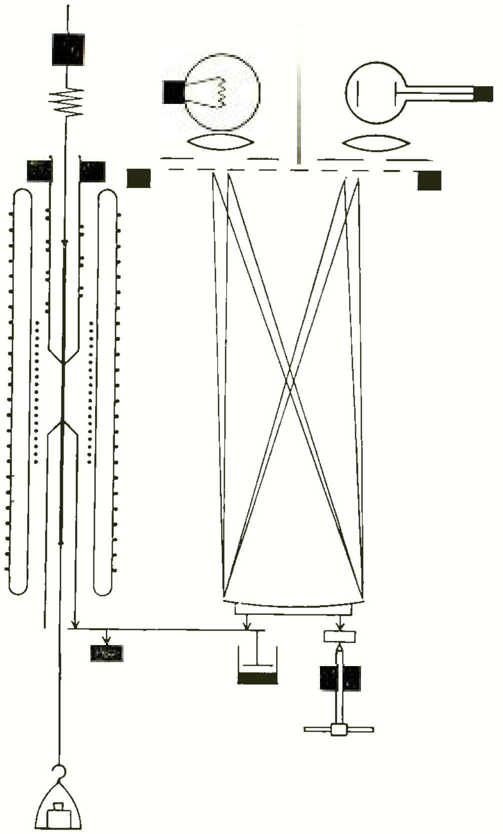


Mr. Cioffi and the apparatus which measures to four parts in a billion

* Bell Laboratories Record, *Dec.*, 1926, *p.* 105.

smaller there is required a method of determining, in a centimeter of length, a change of the order of one-tenth of the diameter of an atom.

As one of the instruments available for such a delicate system of measurements there was the photo-electric cell. This cell connected to a sensitive galvanometer forms an exceedingly accurate and sensitive instrument for measuring changes in light intensity. The method first proposed, therefore, was to direct light by a concave mirror from an illuminated slit onto an unilluminated slit in such a way that the quantity of light transmitted through the latter slit would be proportional to the angle of tilt of the mirror. If the mirror was tilted by a change in length of the specimen under examination then the change could be sensitively measured.



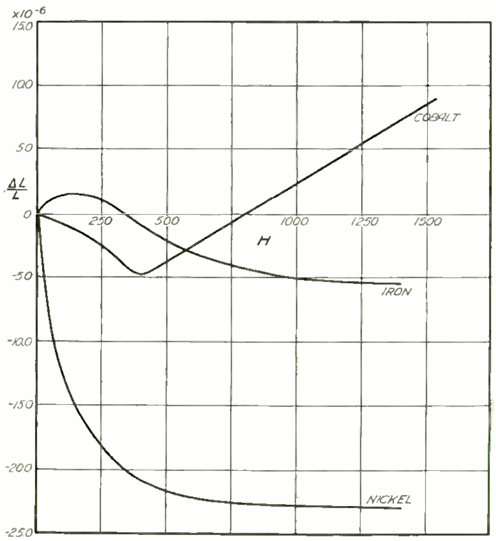
Schematic showing operation of the measuring apparatus; its parts can be identified by comparison with the description in the next column

That the sensitivity could be much increased if the single slits were replaced by screens with parallel stripes of equal width, alternately transparent and opaque, was pointed out by E. C. Wente.

This idea was embodied in the system finally employed. Light from a lamp was directed by a lens onto a concave mirror. Between the light source and the mirror was interposed a glass screen, with opaque and transparent stripes half a millimeter wide. The mirror acted to form an image of the series of slits in the screen. It was set so as to form this image on a continuation of the screen, which projected beyond the original beam of light and received illumination only from the reflected beam. When the bright images of the slits coincided with the opaque stripes of the screen no light was transmitted. As the mirror was tilted, transmission became possible and the amount of light increased to a maximum and then decreased to zero when coincidence with the opaque stripes again occurred. It required but a small tilt of the mirror to pass from full transmission to complete extinction. The transmitted light was collected by another lens onto a photo-electric cell. The changes in photo-electric emission, as affected by the changes in the light intensity, were then read on a galvanometer.

The magnetostriction which was measured was that occurring in the middle portion of the specimen under examination. The specimen was in the form of a wire and the portion measured was that between a rigidly supported upper sleeve and a lower sleeve which rested upon the short arm of a lever. The long arm of this lever actuated another lever which tilted the mirror.

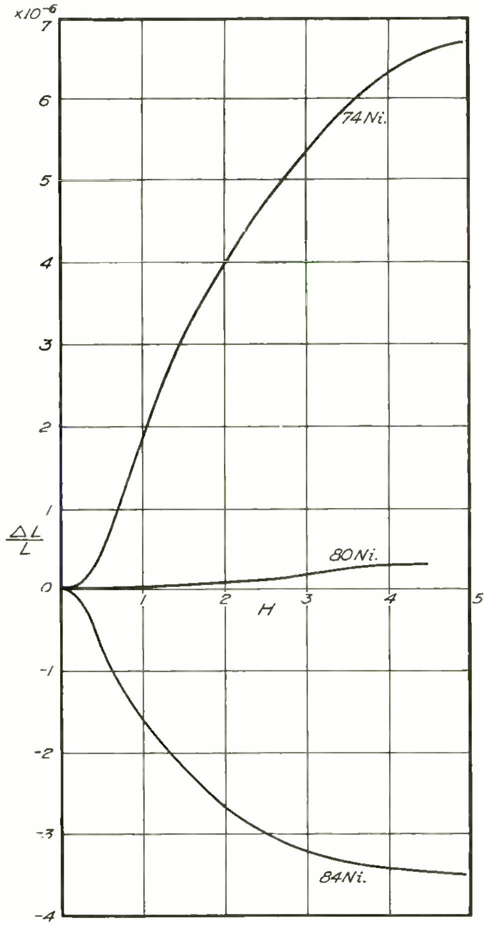
When magnetostriction changes the length of the specimen and the mirror tilts, the galvanometer reading changes. If, for example, at the start there is no current because the image of the slits coincides with the opaque stripes of the screen, then the current and galvanometer reading increase to maximum, and then decrease to zero when such coincidence again occurs. As the length continues to change this cycle repeats; and the observer knows the whole number of spaces on the screen over which the mirror image has been shifted from his count of the number of times the galvanometer has swung back to its zero. The fraction of a space is determined by the galvanometer reading; this could be read to one-tenth of a centimeter on a scale one meter



Magnetostrictive characteristics of cobalt, iron, and nickel

away from its mirror. And that deflection corresponded to a magnetostrictive displacement of about four billionths of a centimeter for each of the ten centimeters of length of specimen between the clamping sleeves.

So sensitive a system necessitated complete protection from building vibrations. The apparatus was accordingly mounted on a heavy plank and the whole was supported upright on a Julius suspension of damped springs. Thermal changes were also to be avoided. These arose from the magnetizing winding surrounding the wire. The effects were considerably reduced



Characteristics of three permalloys

by jacketing the solenoid with a vacuum as shown in the accompanying diagram. This, however, did not result in constant temperature within the solenoid and an additional non-magnetizing winding was imbedded in the upper sleeve. Current was also supplied to this winding so that the heating of the specimen was due to both magnetizing and non-magnetizing windings. This made the wire slightly hotter than it would otherwise have been but its temperature could be maintained by small adjustments of the current through the auxiliary, or heater, winding. The natural drift in equilibrium temperature within the solenoid was thus very closely compensated.

The results of the experiments demonstrated that permalloy, consisting of approximately 80 percent nickel and 20 percent iron, has no magnetostriction for moderate magnetizations and expands only slightly for intense magnetization. Permalloys having less than 80 percent nickel expand with magnetization and those having greater than 80 percent nickel contract with magnetization.

Phonograph Records Illustrating Distortion

By JOSEPH B. KELLY

WHAT happens to speech when certain pitch-ranges are suppressed? To the telephone engineer this question is answered by curves expressing the numerical results of articulation-tests. But to the public, hearing is believing: a demonstration to the ear leaves an impression lasting beyond the memory of curves and tables. And so, in conjunction with technical papers by R. L. Jones and Harvey Fletcher, use was made of speech and music transmitted through a public address system into which distortion could be introduced at will. So effective were those initial demonstrations that many requests were made that they be given before other audiences. On account of the expense and effort involved in setting up bulky apparatus which was required, only a few of these invitations could be accepted.

To simplify the apparatus problem through the use of phonograph records was a logical step. Cooperation of the Research group engaged in development of electrical recording and reproducing was enlisted, and a series of records was made in May, 1925. With these records a demonstration required only a phonograph turntable and reproducer, a suitable amplifier and a loud speaker; the whole being readily transported, and set up in a few minutes. Such an outfit was used on a number of occasions, among them a series of talks to non-technical audiences in Pittsburgh, Cincinnati, St. Louis, Chicago and Cleveland by Paul B. Findley of the Bureau of Publication.

During these talks it was realized that certain improvements could be made in the sound-quality of the records and in the selection of material.

Accordingly a new set of records was cut in the autumn of 1926 which has been favorably received by technical and general audiences alike. Its presentation is accompanied by an explanation, couched in terms to suit the previous experience of the audience. A brief recapitulation of this material will serve here to introduce a description of the records themselves.

Research efforts in our laboratories have been devoted for a number of years to investigations into the character of speech—a fundamental study carried on for the American Telephone and Telegraph Company as basic to its program of improving the telephone art. To proceed with this improvement on a systematic basis it was necessary to know the importance in speech of its various pitches, and this is most easily found by determining the relative degrading effects on the intelligibility of speech resulting from the suppression of certain pitch-ranges. Since electrical filters may be designed to pass, unhindered, electric currents corresponding to the sound vibrations of certain pitches while entirely suppressing those of other pitches, suitable filters were constructed to suppress any desired range of pitches. Statistical studies were then made of the transmission of each of the characteristic speech sounds through a telephone system containing these filters. Since speech is composed of vibrations varying in frequency from 100 to about 8000 cycles per second, the filters were constructed so that the upper and lower limits of transmission could be imposed at will on the various pitches of the voice range. The transmitted band, for example, could be set to include from 60 to 3000 or 60 to 2000 cycles per second; or some of the lower tones might be suppressed by adjusting the filter to pass only the region above, say, 375 cycles per second. The results of the studies have been extremely valuable in engineering improvements in the telephonic apparatus both for wire and for radio communication.

Listening to a demonstration of one of these records, concerned with speech, we hear part of an essay by Poe, the speaker's voice sounding very natural with the fundamental tones well rounded out and the higher pitched endings of the consonants being in proper proportion. As the record progresses the lower tones suddenly disappear from the speaker's voice and it loses its character although the intelligibility is perfect. Since no vibrations below 375 cycles per second were passed through the filter inserted at this point in the process of recording, they do not appear in the sounds of the loud speaker. Continuing, the record reaches a point at which the filter was adjusted so that no sound below 750 cycles per second was recorded. The voice is then without character and most unnatural. The higher tones are, however, unhindered and without difficulty we interpret the speech by the consonants although the vowels are badly distorted. The importance of the consonants for interpretation is thus emphasized.

The record continues and the lower tones are restored, but all the vibrations above 2500 cycles per second are suppressed. The voice sounds natural but the interpretation is not so good as before. The consonant endings are missing and one gets the impression that the speaker's mouth is full of mush. When the record progresses to the point where nothing above 1000 cycles per second is transmitted the speaker's voice has a guttural character, and in the absence of the consonants it is extremely difficult to interpret the speech. At times whole phrases are missed. This record illustrates well the contribution of the various regions to the intelligibility of speech.

A second record shows the effects of the same type of transmission on piano music. The prelude to the Waltz from the Ballet "Naila" is heard, first with extremely natural reproduction. We note that the selection is one which encompasses almost the entire range of the piano. As the record reaches the first point at which the filter was introduced in the process of recording, the bass notes are suddenly stilled. The filter passes only the vibrations above 375 cycles per second. This corresponds to F-sharp above middle C and all the lower tones are therefore suppressed. The melody is present but the tonal character is missing. When the record progresses to the point at which the 750-cycle filter was introduced, corresponding to a pitch an octave still higher, the music begins to assume a tinkling character.

The lower tones are then restored and those above 2500 cycles per second are eliminated. The selection assumes a rather dull character; the brilliance of tone is gone and the music becomes almost a thumping noise as the 1250-cycle point is reached, the preponderance of the bass and the absence of the treble causing the reproduction to lack musical character.

A third record shows the effects of forcing a vacuum tube to carry more than its rated load. We have often heard the effects of such over-loading in radio receiving sets perhaps without knowing its cause. By contrast with a condition of normal load, we notice in the over-loaded condition many harsh extraneous sounds in the music or the speech, sometimes described as "buzzing" or "rattling." When the reproduction is further limited by the transmission of only the band of frequencies from 375 to 2000 cycles per second we are reminded of radio sets in the days before much attention was paid to the quality of the reproduction, when the receiving set reproduced only a limited part of the speech band and the vacuum tubes were over-loaded in the process.

Due to the simplicity and reliability of such records for demonstrating the fundamental ideas as to the transmission of speech and music, it is probable that the new records will find many uses. They can serve for demonstrations to almost any group which is interested in speech and music and their transmission. This month they are being used for this purpose in a series of talks which L. S. O'Roark is giving before A. I. E. E. sections on the Pacific coast.

News Notes

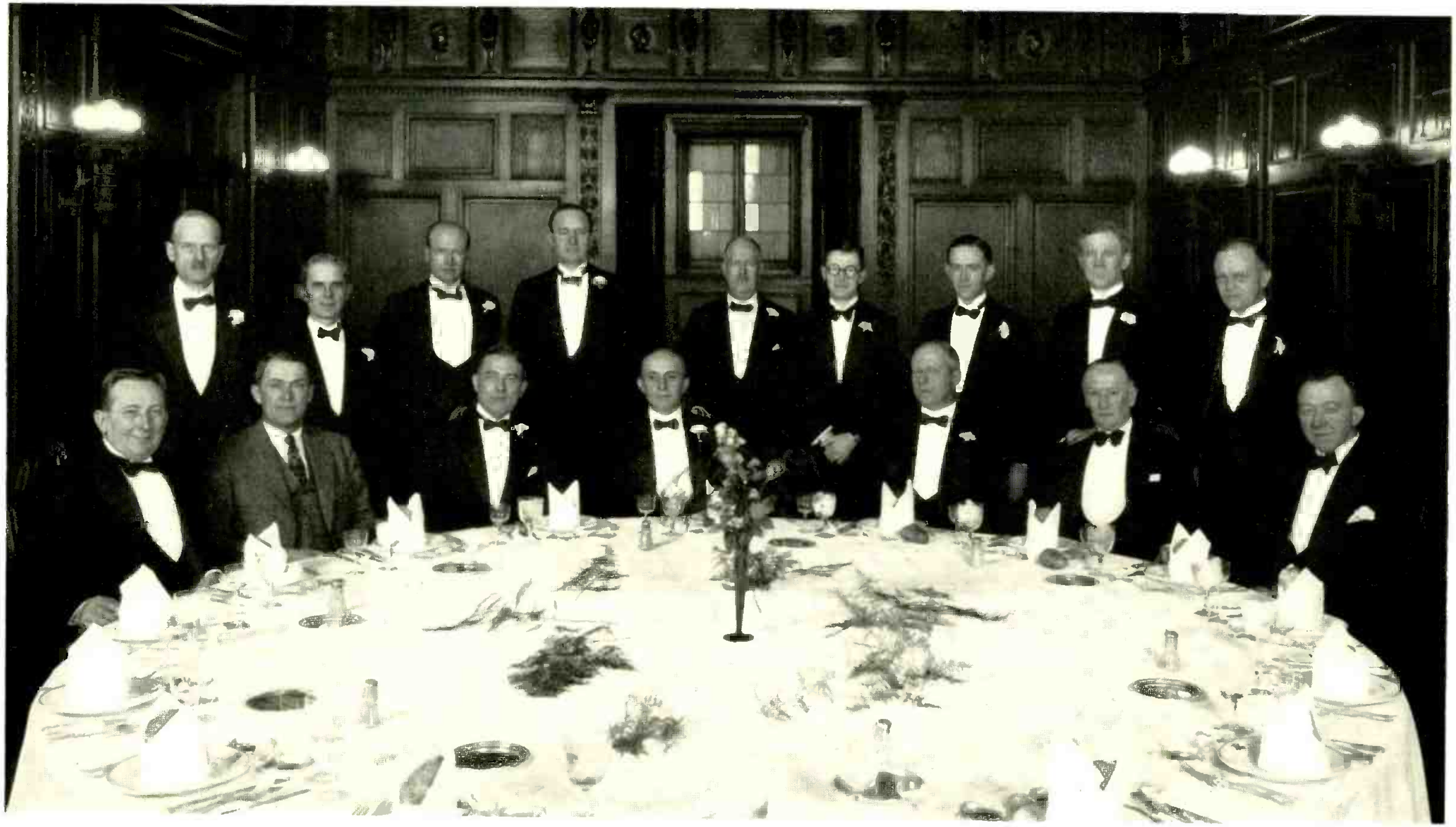
During the month of February there will be delivered to members of the Laboratories on completed subscriptions, 4,448 shares of American Telephone and Telegraph Company stock. This is the largest number delivered to our staff in any one month and represents total savings through salary deductions and interest of $511,520.

W. A. Shewhart has been appointed to represent the American Physical Society on the Sectional Committee of the American Society of Mechanical Engineers, organized for the standardization of graphic presentation. The scope of the committee's work includes standard methods for the graphic presentation of business and other data.

R. D. Gibson and K. O. Thorp are in Birmingham, Alabama, making an investigation of the power-line carrier-telephone system of the Alabama Light and Power Company.

L. B. Cooke is installing for the Penn Public Service Corporation a power-line carrier-telephone system which employs a repeater of recent design. This system will provide

At the inauguration by the American Telephone and Telegraph Company of commercial telephone service between New York and London. In the foreground, left to right: President Gifford, B. Gherardi, E. B. Craft, N. T. Guernsey



A dinner tendered by President Jewett to E. B. Craft, Executive Vice-President of Bell Telephone Laboratories, at the University Club, to celebrate his completion of twenty-five years' service in the Bell System. Those seated are J. J. Lyng, C. G. Stoll, Mr. Craft, Mr. Jewett, Bancroft Gherardi, E. P. Clifford, and E. H. Colpitts; standing, John Mills, J. G. Roberts, O. E. Buckley, O. B. Blackwell, F. L. Rhodes, A. F. Dixon, R. L. Jones, L. F. Morehouse, and P. Norton communication between the following cities: Erie, Piney Dam, Seward, Glory, Johnston and Deep Creek.

R. M. PEASE has joined Henry B. Arnold in Atlanta, where they are investigating the power-line carrier-telephone system of the Georgia Railway and Power Company.

SHEET BRASS for Bell System use will now conform to specifications agreed upon at a conference held in Montreal on December 2 and 3 between representatives of the Hawthorne Works of Western Electric, American Brass Company, and Messrs. Fondiller, Van Deusen, Townsend, and Hayford of the Laboratories. Several months' work were involved in developing the specifications; similar work on other nonferrous metals is now in progress.

L. J. SIVIAN of the Laboratories and H. S. Osborne of A. T. & T. recently returned from five weeks in London and Paris. While in Paris they represented the Bell System at the plenary meeting of the Comité Consultatif International des Communications Téléphoniques, which adopted for its Transmission Reference Standard a replica of the one developed in the Laboratories. This will be built here and installed at the Conservatoire des Arts et Métiers in Paris. At this meeting it was also decided to recognize as the admissible units both the "napier" and the "decimal unit", which equals ten TU.

ON THE EVENING of December 9, 1926, Mr. Craft spoke on the general subject of "Research" at the annual dinner of the Alumni of Worcester Polytechnic Institute, of which he is an honorary alumnus. In emphasizing the need for research, Mr. Craft said, "We cannot make the engineering applications unless we encourage research, and research developments cannot reach their fullest utilization for public welfare unless the engineer is interested, sympathetic, and appreciative of their importance."

EARLY IN JANUARY W. L. Tierney completed the installation of a one-

Edward Buttner of the Engineering Shop Department has been forty years with the Bell System

kilowatt broadcasting equipment for the Fisher Blend Station of the B. F. Fisher Flouring Mill in Seattle. Before leaving the coast he made a survey for a similar installation at Santa Barbara, California.

ON JANUARY 8, D. H. Newman left New York for Montevideo, Uruguay, where he is supervising the installation of a one-kilowatt broadcasting equipment for the Republic of Uruguay.

UNDER THE SUPERVSION OF H. S. PRICE the National Life and Accident Insurance Company of Nashville has replaced its one-kilowatt broadcasting equipment with a five-kilowatt outfit.

P. A. ANDERSON has completed the installation of a one-kilowatt broadcasting equipment which replaces the 500-watt set at WBBR, the Staten Island Station of the People's Pulpit Association. In addition this customer operates a one-kilowatt equipment at Cleveland, and a five kilowatt one at Batavia, Illinois.

A. HADDOCK visited the New York Central Freight Classification Yards

Philip C. Rossi of the Patent Drafting Group has had thirty-five years' service

at Gibson, Indiana, on January 6 and 7, to observe the operation of the system recently installed there for transmitting orders to the engineers of switching locomotives by radio telephone.

THE LABORATORIES signified their advent at Whippany by taking active part in the Community Christmas Celebration on December 26. A brief address was given by L. S. O'Roark and music for the occasion was supplied by engineers, attached to the station, who used a Public-Address System in combination with an electric phonograph.

R. H. MILLER AND G. H. DUHNKRACK spent several days in Wash-

John Groeling of the Building Shop, a thirty-five year veteran

ington and Baltimore when the Baltimore toll board was changed over to the C. L. R. method of operation.

THE COMMERCIAL DESIGN of generators for charging central-office batteries was successfully tested recently at Reading. Use of this generator is made possible by the electrolytic condenser. The tests were observed by members of the engineering staffs of the Telephone Company and the American Telephone and Telegraph Company, and by A. E. Petrie, R. L. Lunsford, and M. A. Froberg of the Laboratories.

F. F. SIEBERT has been at East Pittsburgh, in connection with tests on small unit gasoline engines.

TESTS OF THE TRIAL INSTALLA-

TION of the new single-channel carrier system are in active progress. During December K. M. Fetzer, A. Chaiclin, H. S. Black and A. C. Dickieson visited Watertown and Syracuse in connection with these tests.

E. W. HANCOCK AND W. J. LACERTE visited Hartford in connection with a trial installation of new multilevel hunting connectors.

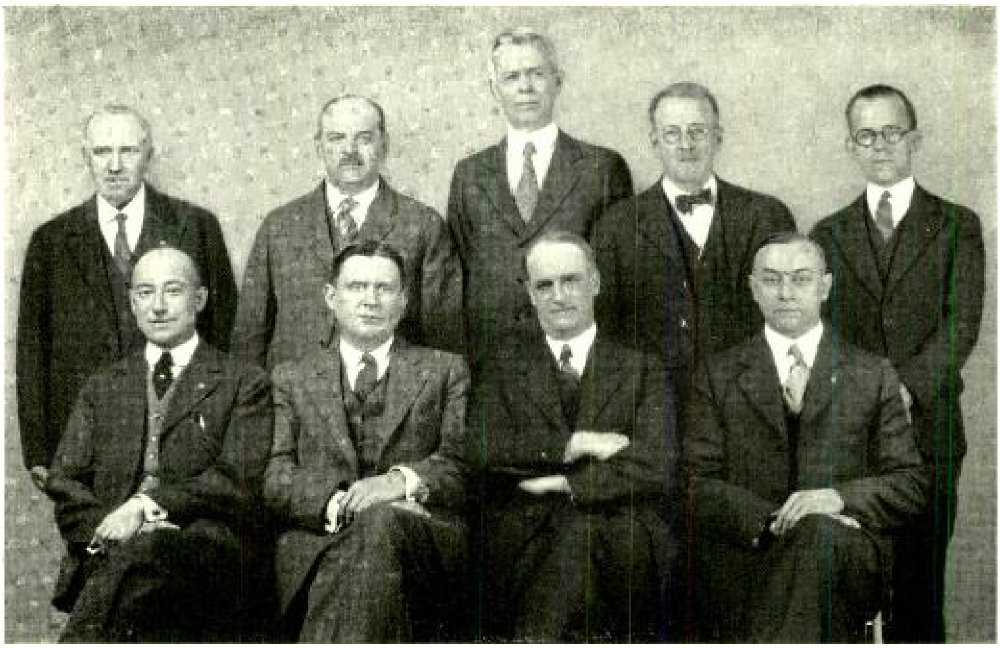
W. BENNETT has been at Springfield, making tests on the step-by-step switches which were made in Hawthorne.

R. B. BUCHANAN visited Lehigh Office, Pittsburgh, in connection with the introduction of straightforward trunking equipment.

DURING DECEMBER, W. A. Boyd and H. G. Eddy were in Hawthorne on regular Survey Conference work.

AT THE ANNUAL MEETING of Edward J. Hall Chapter, Telephone Pioneers of America, held on December 16, 1926, the following members of the Laboratories were elected to office and as delegates to the next annual convention: J. E. Moravec, member of Executive Committee; W. B. Sanford and W. C. F. Farnell, delegates; G. F. Atwood and G. F. Morrison, alternates.

"RECENT DEVELOPMENTS IN COMMUNICATION" was the subject of a talk given by M. B. Long, Educational Director, on the evenings of January 10, 11 and 13, before the Indianapolis, Purdue University and Armour Institute Sections, A. I. E. E. Also, Mr. Long informally addressed the Telephone Luncheon Club at Indianapolis on January tenth.

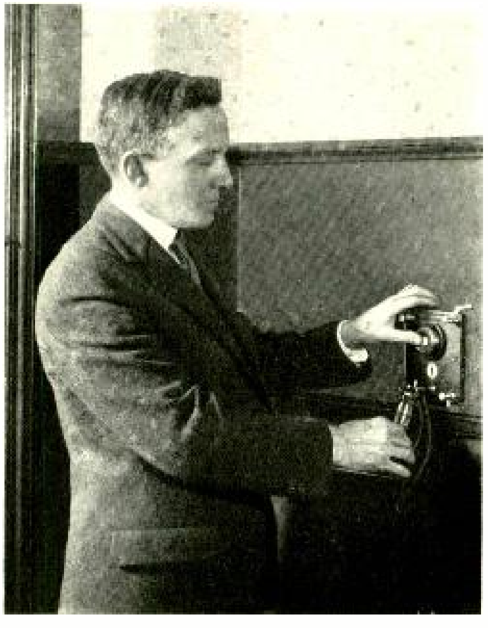


A group of twenty-five year men: standing—J. Lawless, Building Service; J. W. Upton, Engineering Shop; T. H. Roberts, Systems Development; W. M. Post, Shipping; E. F. Hill, Apparatus Development. Seated—C. W. Widmaier, Research; J. F. Newcomb, Assistant Treasurer; H. G. Eddy, Inspection; C. Westerburg, Engineering Shop

Reconstructing the Past

By W. C. F. FARNELL

RECONSTRUCTING the past from such traces as may remain is one of the tasks of the historian. From finds like the tomb of Tut-ankh-Amen there are pictured for us the lives and customs of ancient civilizations. Of times more remote, the geologist and palaeontologist draw inferences from the occasional finds of fossils. Their tasks are frequently most difficult. Is some particular fossil, for example, the



Mr. Farnell makes a call on Station One

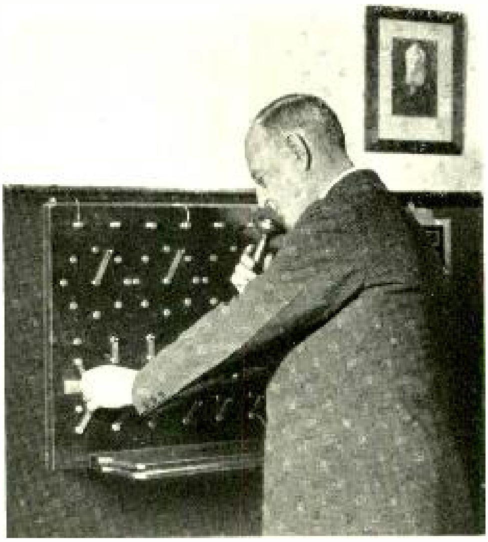
skull of a primeval man, or the knee-cap of an elephantine animal? Sometimes sufficient material is found to permit a rather complete reconstruction, and in museums of natural history there may be seen models of the skeletons of prehistoric animals.

The processes of evolution with which these historians deal were not only slow but lie obscured in times of unwritten history. Another type of evolution occurring in these present days, when records are easily made and preserved, is that of science and its associated arts. The marvelous evolution of the telephone has all occurred within the brief span of fifty years.

A historian of the art of telephony does not lack written material from which accurately to reconstruct the past. In our Bell Telephone Historical Museum there are also many and interesting exhibits of early apparatus or of models of such apparatus reconstructed on the basis of pictures

Mr. Richards restores the calling annunciator drop at the switchboard and written descriptions. We can build, for example, actual reproductions of the instruments with which Alexander Graham Bell carried on the first telephone conversation; one such model was used by him at the opening ceremonial of the transcontinental line in 1915 when he spoke from New York to Thomas A. Watson in San Francisco.

Another model, also of the first apparatus of its kind, has recently been built in our engineering shops under the advice of W. L. Richards, Consulting Historian. There was reconstructed the equipment of the first commercial telephone-exchange system in the world, that inaugurated in New Haven, Connecticut, on January 28, 1878. To this system there were at that time twenty-one subscribers; but the list had grown to fifty by the time the first telephone directory was published on the twenty-first of the succeeding month. The model was built for the Southern New England Telephone Company, which will exhibit it at the New Haven Progress Exposition from January twenty-sixth to February fifth.



Mr. Richards answers the call from Station One

The original switchboard was made by George W. Coy. It had a capacity of eight lines, but each of the lines was a party line accommodating several subscribers. Just how the exchange operated may be seen from an inspection of the accompanying pictures. These were taken while Mr. Richards, with the assistance of the writer, was demonstrating this first central-office system to A. F. Dixon, Systems Development Engineer.

Mr. Dixon receives the call, on Station Four

The eight lines terminated in eight binding posts at the top of the board. There were also available, what were in effect, two cord circuits, each consisting of two rotary levers electrically connected. On a circle, about the pivot of each lever as a center, are eight discs or studs. Discs corresponding in position with reference to the two levers are connected in multiple to the eight lines. Below the levers of each cord circuit are the line switches for the annunciator circuits, one for each line. And below these, is a strip to which is connected one terminal of the operator's telephone. The system, of course, as was common in those days, used only a single wire and had a ground-return circuit. At the bottom is a row of switches and studs for connecting the ringer or buzzing mechanism to the line of the subscriber who is to be called.

On the upper right corner is an annunciator box where the signal appears when a subscriber initiates a call. At the lower right-hand corner is the calling buzzer designed by Thomas A. Watson, and later known as "Coy's Chicken". It consists of a large induction coil and a flat steel-spring which is caused to vibrate by the hand operation of a lever making and breaking a local circuit. The current from this buzzer causes the diaphragm in the subscriber's telephone to howl violently. This signal can be heard for a considerable distance. At the time these subscriber sets were in use there were no ringers at the substations and the hand telephones had to function interchangeably as a transmitter, as a receiver, and as a ringer.

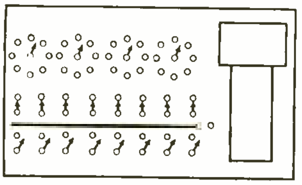


Figure (1)

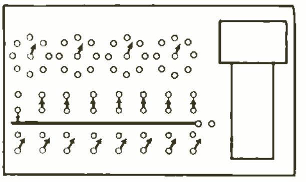


Figure (2)

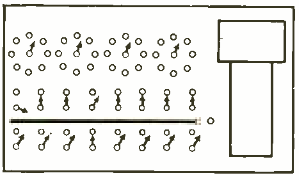


Figure (3)

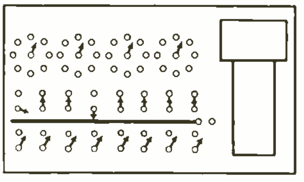


Figure (4)

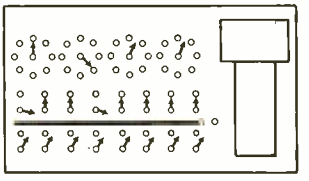


Figure (5)

Establishing a connection through the Coy board: (1) *Awaiting subscriber's signal*, (2) *"Number, please,"* (3) *ringing the station called*, (4) *awaiting an answer to the ring*, (5) *during the conversation*

The subscriber's set consists of a "butter stamp" hand telephone for talking and listening, a push button for operating an annunciator at the switchboard, and a lightning arrester.

D & R News Notes

Contributed through H. S. Sheppard, *Executive Assistant*

At the annual convention of the Institute of Radio Engineers, Dr. Ralph Bown, newly elected president of the Institute, was presented with the Liebmann Memorial Prize awarded him by the Board of Directors of that body "for his researches in 'Wave Transmission Phenomena.'"

Dr. Bown received his Ph.D. from Cornell in 1917. He entered the army in 1917, where he was commissioned as Captain in the Signal Corps. He was in charge of development of radio apparatus for the Army at the Signal Corps Radio Laboratory, Camp Alfred Vail, until June, 1919. In August, 1919, Dr. Bown took up his present work in the American Telephone and Telegraph Company.

The Morris Liebmann Memorial Prize, consisting of the sum of five hundred dollars in cash, is awarded annually by the Board of Directors of the Institute in recognition of noteworthy inventions or other developments in radio technique.

Dr. Bown well merits this recognition, as he has been an outstanding exponent of the development of methods and equipment to place radio transmission studies on a quantitative basis. His outstanding researches relate particularly to transatlantic radio telephony and radio broadcast transmission. Dr. Bown has presented many of the important results of the work of this organization in technical papers before the Institute.

At the same convention, a paper was presented by DeLoss K. Martin, Glenn D. Gillett and Isabel S. Bemis on the subject, "Some Possibilities and Limitations in Common-Frequency Broadcasting," reviewing experimental work done by these engineers and their associates.

Early in 1926, the Bell Telephone Laboratories devised and built for the Information Department of the American Telephone and Telegraph Company three portable talking moving picture outfits for use in connec-

Ralph Bown

tion with celebrations throughout the United States commemorating the fiftieth anniversary of the birth of the telephone. The portable equipments were placed at the disposal of the Associated Companies with engineers from this company and the Laboratories, to supervise the installation and operation of the pictures in the field.

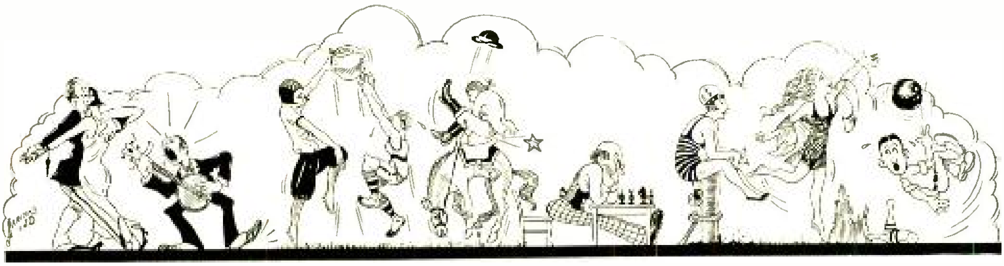
Two talking pictures were exhibited—one of Thomas A. Watson, assistant to Professor Alexander Graham Bell at the time of the invention of the telephone, and the other a picture illustrating the development of the telephone switchboard from the days of its infancy up to the present time.

During the year which has just passed, the two pictures were shown in twenty-six different cities and towns over nine hundred times to audiences totaling over 206,000. This includes the installation which was made at the Bell System exhibit at the Sesquicentennial, where the pictures were shown over a period of twenty-three weeks.

Naturally, the "one-night stand" installations throughout the country introduced many difficult and varying conditions. In view of this, credit is due W. W. Sturdy of A. T. & T., and to R. E. Kuebler and J. B. Irwin of the Laboratories for meeting all the dates assigned to them, and showing the pictures on schedule time.

During the first eleven months of 1926 one hundred and thirty-four patents were issued to the following members of the Department of Development and Research:

E. H. Colpitts, L. F. Morehouse, O. B. Blackwell, H. A. Affel, R. S. Bailey, F. H. Best, W. G. Blauvelt, R. K. Bonell, L. L. Bouton, R. Brown, A. Carpe, A. B. Clark, S. I. Cory, G. Crisson, C. S. Demarest, E. Dietze, W. H. Edwards, L. Espenschied, H. A. Etheridge, J. M. Fell, C. H. Fetter, D. K. Gannett, L. L. Glezen, C. S. Gordon, E. I. Green, I. W. Green, R. A. Haislip, H. S. Hamilton, J. Herman, W. H. T. Holden, R. K. Honoman, R. S. Hoyt, A. E. Hunt, L. M. Ilgenfritz, A. H. Inglis, E. Jacobsen, O. H. Loynes, D. K. Martin, W. H. Martin, A. L. Matte, R. G. McCurdy, N. D. Newby, H. Nyquist, R. S. Ohl, J. T. O'Leary, G. H. Peterson, K. W. Pfleger, H. E. Phelps, R. K. Potter, F. W. Reynolds, W. A. Rhodes, F. W. Schramm, J. T. Schott, S. P. Shackleton, R. B. Shanck, H. F. Shoffstall, E. St. John, M. E. Strieby, C. V. Taplin, H. M. Trueblood, G. S. Vernam, E. Von Nostitz, J. N. Walters, E. F. Watson, A. Weaver, S. B. Wright, M. K. Zinn, O. J. Zobel.



Club Notes

The 1927 social season will open on Thursday evening, February 17, 1927, with the midwinter dance to be held on the Roof of the Hotel McAlpin. The music will be furnished by the Tennesseeans, who are well known to all WEAF fans.

This will be the ninth dance given by the Club since February, 1924, and we are sure that all of the Club members and their friends who have attended these parties have spent very enjoyable evenings. It has been the policy of the Club to hold all dances in New York hotels, and to have the best music obtainable. The Committee wishes to announce that this policy will be followed throughout 1927.

The sale of tickets for the February dance has been limited to five hundred by the management of the Hotel McAlpin and, as only this number has been printed, we advise you to purchase your tickets at once to insure having them. Admission will be $1.10 each, including tax. No tickets will be sold at the door. D. R. McCormack will manage all of our dances and entertainments for 1927.

Men's Bridge Club

On Monday evening, January 17, 1927, the winter session of the Men's Bridge Club started in room 269. These meetings will be held every Monday at 6:30 P.M.—all men bridge players are welcome. Prizes will be given each evening for the best scores, and also at the end of the season for the best three all-season scores. Players must attend seven nights to be eligible for season prizes. A weekly fee of fifty cents is charged.

Results of the Mixed Bridge Tournament, January 3, 1927

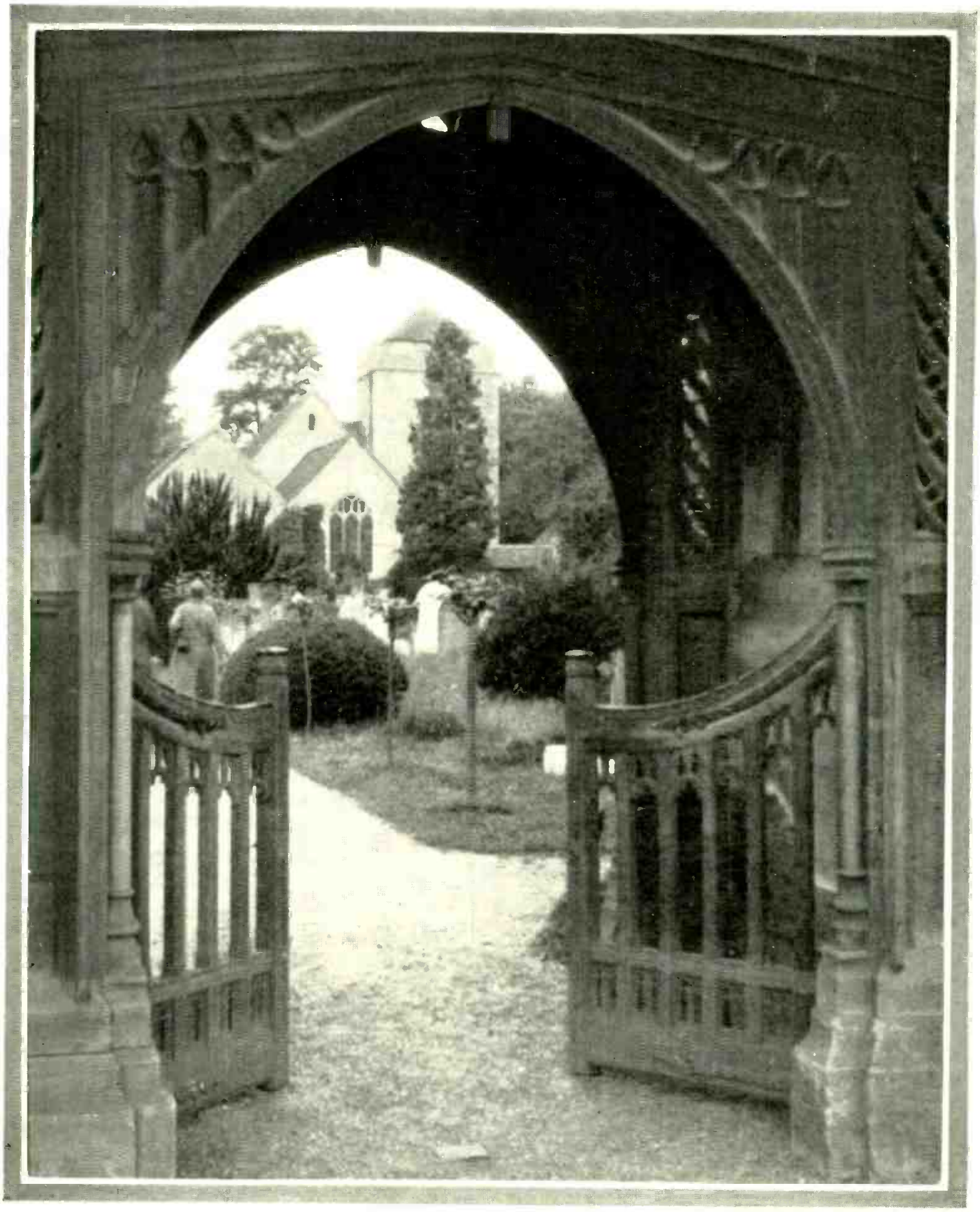
1. A. L. Thuras
2. Miss Coakley
3. F. W. Treptow
4. E. M. Smith
5. Miss Munn
6. Miss Brisbane
7. Miss J. Johnson
8. H. W. Bode
9. Miss Lynch
10. T. V. Borlund
11. J. Dusheck
12. Miss Kilpatrick
13. D. Wetherell
14. Miss Bagdon
15. Miss Wilson

Results of the Men's Ten-Night Tournament Ending December 27, 1926

1. H. M. Hagland
2. A. L. Thuras
3. D. Wetherell
4. E. Rahn
5. D. S. Myers
6. H. B. Barber
7. T. C. Rice
8. M. N. Smalley
9. J. E. Cassidy
10. A. Zitzman

Photographic Contest

Pictures from everywhere and of all sorts of subjects came to us in the



The church at Stoke Poges—where Thomas Gray wrote his "Elegy in a Country Churchyard." First prize, Landscape Class; W. Orvis picture contest. The Club surely is proud of its first picture exhibition and is already looking forward to making it a yearly event.

The judges, H. E. Ives and I. B. Crandall, found before them a rather difficult task when it came to choosing the best picture, but we feel that they have succeeded very well in awarding the prizes to these contestants:

Landscape Class:
First prize, W. Orvis
Second prize, W. Orvis
Third prize, J. Popina
Honorable mention. J. Popina and H. Maude.

Portrait Class:
First prize, J. Popina
Second prize, H. Maude
Third prize, P. D. Hance
Honorable mention, J. Popina, H. Maude and K. B. Lambert.

Christmas Card Class:
First prize, H. Maude
Second prize, E. Alenius
Third prize, E. Alenius
Honorable mention, E. Alenius, C. R. Keith and K. B. Lambert.

The prize for the picture showing the greatest amount of thought when photographing was most difficult to judge. These were awarded in this order:

Landscape Group, O. O. Ceccarini
Portrait Group, O. O. Ceccarini
Christmas Cards, K. B. Lambert

The prize for the best group of pictures was awarded to H. Maude, with J. Popina a very close second.

The Department prizes were awarded to M. G. Allison in the Inspection, A. S. Curtis in the Research, R. H. Mills for the Apparatus Development, J. Popina for the Commercial and E. Alenius in the Systems Development Department.

The color plates submitted were especially fine. The prize in this group was given to A. S. Curtis, while R. H. Mills received honorable mention. Among the color plates were some very interesting technical studies made under the microscope.

The Club is very well pleased with the response it received and wants to extend to all the contestants a word of praise for the good work that was represented by the pictures submitted.

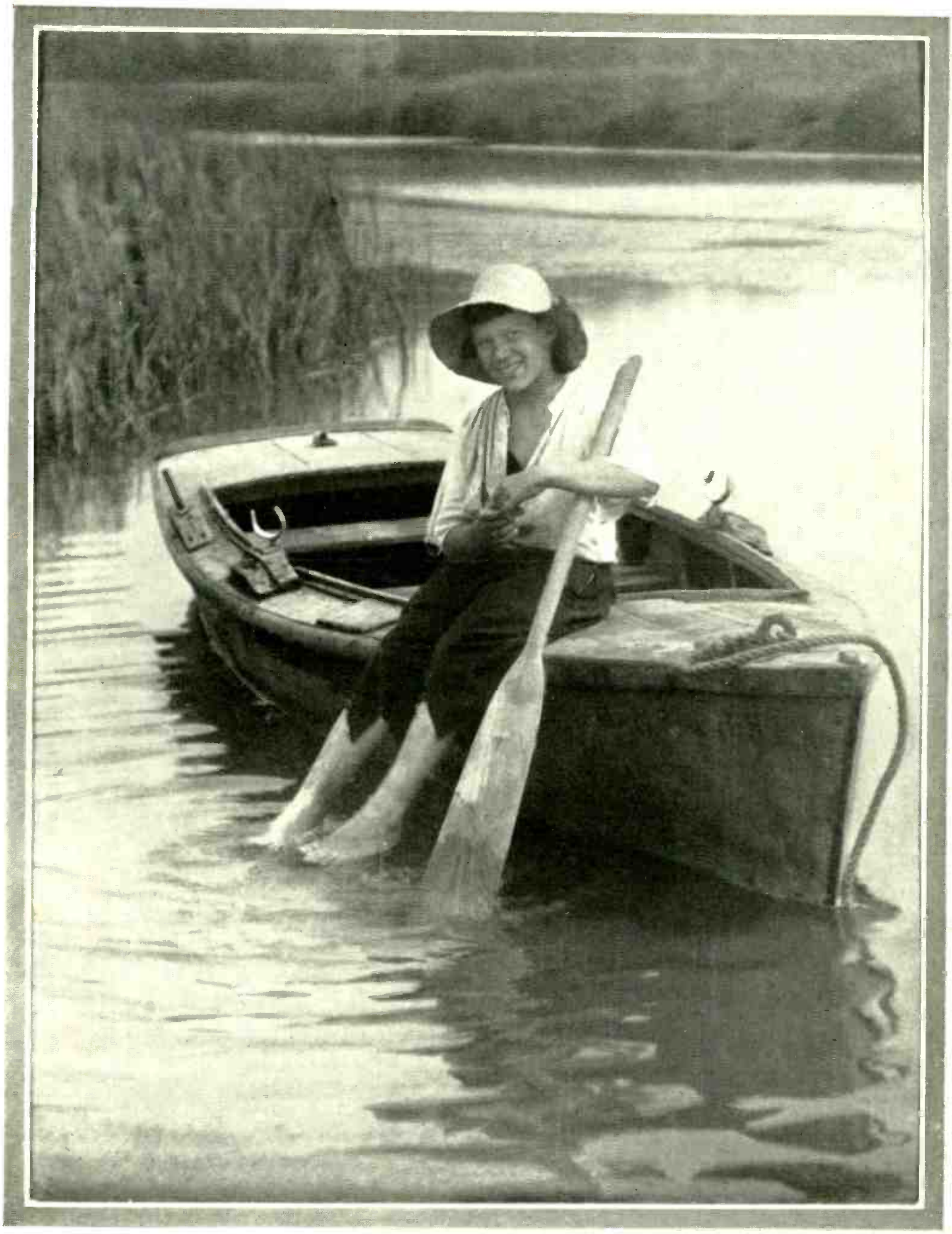
Basketball

In one of the hottest basketball games ever seen by our friends across the River, the Bell Laboratories Club defeated by a score of 34-23 an all-star team from the Kearny Works of the Western Electric Company. This game took place on Wednesday evening, January 12, in the 4th Regiment Armory in Jersey City.

The Wekearnians fought our men during every second of play but when it was all over West Street had scored its third straight victory over Kearny in as many years.

At no time during the game was there a difference of more than two points, and with two minutes to play Kearny was leading 23 to 21. A daring shot by Maurer for a clean basket brought the score to 23-23, and with only seconds to play Gittenberger dropped a foul almost as the whistle blew, ending what the Jersey daily papers referred to as the best game ever staged on the floor of the Old 4th Regiment.

While Maurer starred for West Street our victory was due to very fine all-around team work. The entire team worked as one man with



This portrait of a young seaman took first prize in the Portrait Class; J. Popina no thought of individual honors. The details and line-up of this game are given below.

Not to be outdone by our star team, our Juniors met and defeated the Junior team from the Western Electric Company, 195 Broadway, on Friday evening, January 14, in the gymnasium of the Labor Temple, 14th Street and 2nd Avenue. The West Street boys finished on the right side of a 26-14 score and in doing so beat the team which recently won the Junior Championship of 195 Broadway.

This organization of Juniors is playing in the Club Tournament and at present is tied for second place.

WESTERN ELECTRIC, KEARNY

		Goals	Fouls	Total
Johnson	F	1	0	2
De Force....	F	2	1	5
Russ	F	3	1	7
Ortleib	C	1	1	3
Fudell	G	1	1	3
Dorr	G	0	3	3
		8	7	23

BELL LABORATORIES

		Goals	Fouls	Total
O'Neil	F	0	0	0
Curley	F	1	2	4
Gittenberger...	C	1	3	5
Hanson	G	0	0	0
Cahill	G	1	1	3
Maurer	G	5	2	12
		8	8	24

What Luxuries Cost

"What does it cost me in days of labor to satisfy my desires for the unnecessary things of life?" You will probably be surprised when you figure out just how hard you are making yourself work for some of the casual bits of expenses you incur regularly without giving them a thought.

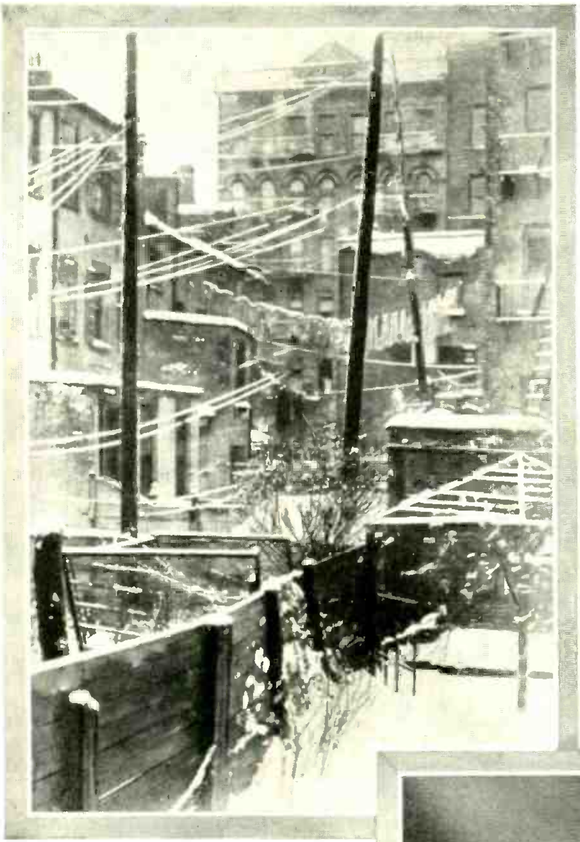
Let us say that your income is $2000 per year, and that your food, shelter, clothing and other actual necessities cost $1600. Your net income which you can spend for other than necessities is $400; you have no choice as to how you will spend the $1600, because this must go to the butcher, grocer, landlord, public service company and others who are on your payroll.

The $400 is what you have earned for yourself, and this is equivalent to $1.30 per day.

Therefore, if you feel like spending $10 for something you could do just as well without—some luxury which must be paid for out of your net income—you can calculate that this $10 net income is equivalent to eight days' work.

Second prize, Portrait Class; H. Maude

Third prize, Portrait Class; P. D. Hance, Jr.



Third prize, Landscape Class; J. Popino

Second prize, Landscape Class; W. Orvis

In the Month's News

THE LABORATORIES were well represented at the Christmas meeting of the American Association for the Advancement of Science held in Philadelphia on December 28 and 29. The following papers were presented:

"Photoelectric Emission as a Function of Composition in Sodium Potassium Alloys," by H. E. Ives and C. R. Stillwell, presented by H. E. Ives; "Thermal Agitation of Electricity in Conductors," by J. B. Johnson; "The Life History of an Adsorbed Atom," by J. A. Becker; "The Direct Comparison of Loudness of Pure Tones," by B. A. Kingsbury.

ARTHUR W. PAGE assumed on January first his duties as Vice-President of the American Telephone and Telegraph Company. Upon graduation from Harvard in 1905 Mr. Page entered Doubleday, Page and Company, of which he later became Vice-President. Since 1913 he has been editor of "The World's Work".

T. C. FRY is planning to give a series of lectures at the Massachusetts Institute of Technology on the engineering application of the theory of probability, beginning the early part of February and continuing until the end of the school term in June.

JOHN C. LATHAM, until January first in charge of technical information in the Bureau of Publication, was on that date transferred to A. T. & T. He recently sailed for London to become assistant to H. E. Shreeve, the technical representative of the Bell System in Europe.

A CONFERENCE in regard to the Field Engineering work of the Inspection Engineering Department in the Up-State Territory of the New York Telephone Company, was held in Albany on December 8. On December 16 a conference on similar work in the territory of the New England Telephone and Telegraph Company was held in Boston. In addition to Telephone Company engineers and representatives of Western Electric Distributing Houses, R. L. Jones, G. D. Edwards and R. J. Nossaman were present at the Albany conference, and G. D. Edwards and R. J. Nossaman were present at the Boston conference.

R. B. MILLER spent the 9th and 10th of December in Toledo observing a trial which the Installation Department of Western Electric Company was making of a sampling inspection plan.

D. A. QUARLES and E. G. D. PATERSON were in West Lynn, Massachusetts, in connection with a Survey Conference on telephone power equipment manufactured by the General Electric Company.

AN ELECTRIC STETHOSCOPE operated by H. F. Hopkins figured in the detection of a "crime" as part of a demonstration before the New York Electrical Society on December 15. As each of three volunteer "suspects" was examined about the affair, the stethoscope and a loud speaker made the thumping of his heart plainly audible to a large audience. The quickened beat of the guilty person's heart was instantly evident.