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New Year's Greetings

to the Men and Women of the Bell System

A year ends—a new year begins. Each one of us is looking back upon the year that is past and reviewing his individual accomplishment during that year. Whatever the glance backward may reveal, the starting of a new year presents a new opportunity.

We shall all continue to strive for a better, quicker, more accurate and more comprehensive telephone service for the people of our country; a high aim offering opportunity for all and calling for our best efforts.

My heartfelt wish is that the new year may bring for every one health and happiness; and that through our achievements we may merit more and more the confidence and good-will of the nation.

Walter S. Gifford

From Conference to Cable

By FRANK B. LIVINGSTON

"FOR the purpose of discussing"—so read the call—"in an entirely informal manner, the subject of telephone cables." By this conference in 1887 the parent company of the Bell System took an important forward step in its program of development and standardization of telephone cables.

The first result was the coordination of operating experience, upon which to base standard practices in the engineering of telephone cables and standard designs for cable manufacture. A later and even more important result was that development of multi-pair cable which permitted the rapidly growing telephone industry to avoid the limitations on its physical growth which the congestion of open-wire lines in city streets would otherwise have imposed. And a third result of this work, which the staff departments of the American Telephone Company then undertook and have since continued, was that continued reduction in the cost of cable, per mile of telephone circuit, without which there might otherwise have been a serious economic limitation to the expansion of telephone service in thickly settled areas.

The general necessity for a program of development work and of coordination by the parent Bell company had been evident to Alexander Graham Bell and his associates with their first appreciation of the possibility of the telephone. Up to the time of this conference in 1887, however, their developments had been most concerned with the more pressing problems of equipment for transmission, switching, and signalling.

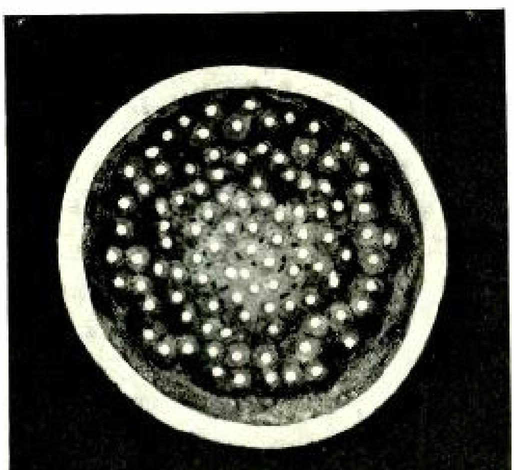
Cables *were* used by the early telephone engineers but in cable engineering they followed quite naturally the practices worked out by the still earlier telegraph companies. As installations grew in number, and as the length of line over which it was desired to talk increased, new problems arose which required for their solution the development of cable for strictly telephonic purposes. One of the earliest instances of the use of cable in the telephone plant seems to have occurred in San Francisco in 1879, where a cable, rubber insulated and containing forty wires, was run for a length of seventy-five feet from the open-wire lines on the roof into the central-office room.

During the next few years very little progress appears to have been made towards the standardization of telephone cables. Of manufacturers there were several; and each had its own ideas about cable design. Since very little was known about transmission through cables it was practically necessary for each telephone company to try in service each of the cables offered to it in order to decide which type was best suited to its needs. In conductor size the cables ranged from 26-gauge to 16-gauge. It appears, however, as if sometimes the size chosen depended more upon the financial condition of the telephone company than upon transmission requirements, although it soon became apparent that the smaller wires were suitable for use only in relatively short lengths. For insulating the cabled conductors there were used rubber, gutta-percha, paraffin, and asphalt compounds. When the softer insulating compounds were employed the wires were mechanically separated by serving each with cotton or sisal.

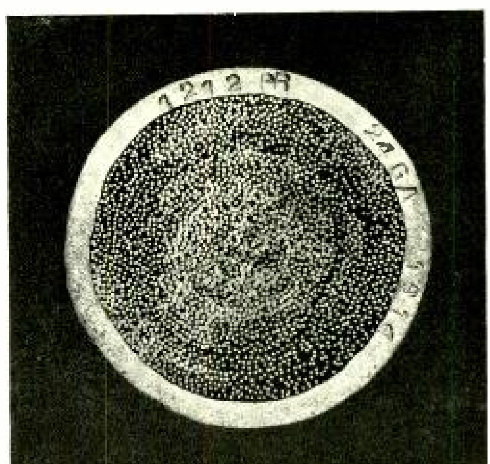
The early circuits worked as single wires with a grounded return; and many were the schemes devised for preventing the consequent induction of crosstalk between circuits. One inventor carried his ideas so far as to encase each insulated conductor in solid lead and he advertised his cable for use "where secrecy is important and distinct articulation a prime requirement." When this cable was used in long lengths, of course, secrecy would have been maintained even between the speaker and listener and in spite of the most distinct articulation on the part of both of them.

The application of the metallic circuit, which was an early contribution of General Carty's, paved the way for a number of advances, including that of improved cable. Several years' experience, however, was necessary to demonstrate conclusively that grounded circuits could not be made to work satisfactorily and that metallic circuits must be used even though the cost was greater. This was recognized in a report which, in the early eighties, recommended the consideration of the "twisted metallic circuit, which annihilates or neutralizes induction entirely." But it is interesting to note that its recommendation was qualified by the addition that "it is not practicable on account of the expense and difficulty of handling such wires for connections."

For one reason or another the state of the art, even as late as 1886, was unsatisfactory. In that year, before a number of telephone executives, the general manager of the Chi-



50-*pair,* 18-*gauge cable standardized as a result of the* 1887 *conference. Approximate size*



1212-*pair,* 24 *gauge cable: largest number of pairs standard at present. Diameter* 2⅝ *inches* cago company reported "the general result of our cable work is unsatisfactory by reason of crosstalk and indistinctness of transmission. . . . I fear that the increasing use of cables is destroying the satisfactory character of telephone transmission. I have serious doubts whether we can, after this year, continue further our underground extensions."

The conference of 1887 was destined to bring to an end this unsatisfactory state of cable engineering. To it the parent company invited representatives of the Western Electric Company and of the larger telephone companies. As a result of this conference the parent company issued during the next year a specification for a standard cable which was recommended to the telephone companies for use under all conditions.

Factory joint in 1887 cable. Present cables are covered by a continuous sheath

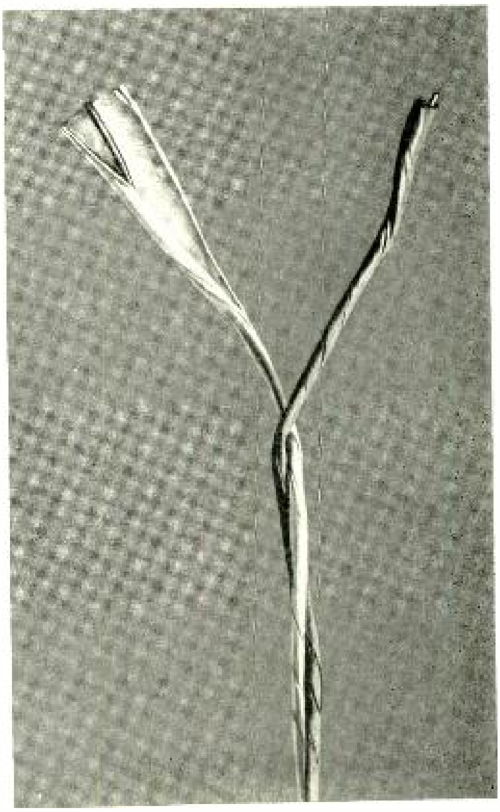
This first standard cable of the Bell System was arranged for metallic circuits. A single gauge of conductor was recommended—No. 18 B and S. The possible standardization of smaller wires was considered; but at the time it was felt that it would not prove economical to try to adjust the gauge of conductor to the actual length of line. The largest size of standard cable contained fifty pairs of 18-gauge wire. The conductors were each wrapped with cotton to a diameter of about one-eighth of an inch and twisted in pairs. They were then cabled together in reverse layers and pulled into a lead pipe of two inches outside diameter. The composition of this sheath was 97 percent lead and 3 percent tin. The cable thus formed was also impregnated with an insulating compound.

This particular type of cable was standard during the next three years—until 1891—when dry-paper insulation was adopted after having been tried out successfully over a period of about two years. The transition, from impregnated cables with cotton-insulated wires to an unimpregnated cable with wires insulated by dry paper, seems to have occurred without being due to any particular invention. It was rather a matter of gradual evolution and accumulated experience. The omission of the filling, or sealing, compound apparently came about quite naturally when experiments had shown that the lead sheath could be applied so as to be trustworthy in excluding water. Other experiments showed that the electrical characteristics of paper were better than those of cotton and that paper tape could be applied satisfactorily to the wires. During this time the gauge size of the conductors was also reduced from 18 to 19. The requirement of a definite capacitance had entered cable engineering sometime earlier; and at this time there was specified an average capacitance of 0.080 microfarad per mile as measured between one conductor and all the other conductors, connected together and grounded to the sheath. This is approximately equivalent to a mutual capacitance of 0.054 per mile as measured between the two wires in any pair.

Cable of these characteristics came to be known very definitely as "standard cable." And to this standard there was referred, as a basis of comparison, the efficiency of all the later cables, until the recent adoption of the transmission unit.

The maximum size of this cable in 1892 was two and one-half inches outside diameter and it contained one hundred pairs of wire. By 1895 the same size of lead sheath was being used with one hundred and fifty pairs, and by 1896, one hundred and eighty pair cable was standard. In 1901 cables of three hundred pairs of 19-gauge wire were available.

Cables containing such large numbers of wires found their first application in lower Manhattan, and in similar centers throughout the country, where the unprecedented growth of exchanges was beginning to tax the capacity of the existing systems of underground conduit. The great cost of laying more conduits to provide room for more cables was a direct stimulus towards the development of cables with a greater number of pairs. By 1899 it had been realized that the increasing number of subscribers, who would be near any central office, would permit the economical use of conductors of smaller than 19-gauge. Also there was a rapidly approaching need for cables which would contain more pairs of wires than could possibly be obtained with 19-gauge conductors. Work had therefore been started on the design of 22-gauge cables; and by 1902 there were in successful use cables containing as



Twisted pair, showing twist and method of applying paper

many as 606 pairs of 22-gauge wire.

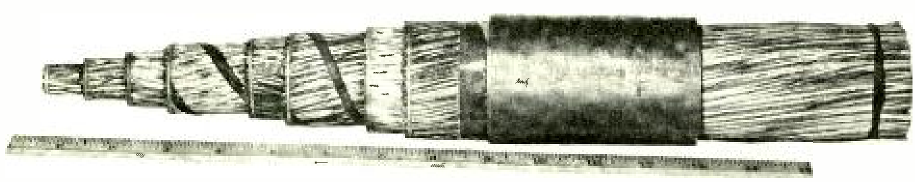
For some years this 600-pair cable satisfied the needs of the telephone companies for larger cables but the steady growth of the System and the consequently increasing number of cables, filling the underground conduit to capacity, required a further extension. By 1910 the desirability of cables containing still larger numbers of conductors was apparent. To obtain such cables it was necessary to develop manufacturing methods suitable for applying thin and narrow insulating papers to 22-gauge wires, or even to finer wires; and then it was necessary to determine also the size of insulating paper which would form a cable satisfactory for handling in installation and possessing the desired electrical characteristics. The external diameter of the cable was already definitely limited by the ease of handling, to say nothing of the duct size of the existing underground conduit.

For experimental purposes and field trials, lengths were then made of cable containing 700 and 800 pairs of 22-gauge wire and 900 and 1000 pairs of 25-gauge wire. The studies of these resulted in the standardization of the 900-pair 22-gauge cable which became commercially available in 1913. The continuation of the studies, however, quickly resulted in further developments and in 1915 there became available a 1200-pair 24-gauge cable. This is at present the largest number of pairs in any of our commercial cables. Before this type could be standardized extensive changes were required in the manufacturing equipment in order to handle economically the thinner and narrower strips of insulating paper and the finer wire which had to be used.

Had such improvements not resulted from the continuing program of development work initiated by the 1887 conference, it is difficult to conceive how telephone service of the range and magnitude of the present could have been possible. Even if physically it might have been possible there would have been economic limitations, for during these years the Bell system has expended hundreds of millions of dollars for underground conduit and cables; and if the additional circuits thus provided had had to be obtained by other physical means this enormous investment would have been greatly increased.

How the lead-covered cables of subscriber and local circuits have grown in character and importance is indicated in the accompanying table. This shows the output each year in billions of conductor feet and the percentage of the different sizes of wire which formed the cables. The increasing popularity and engineering importance of 24-gauge wire is shown very markedly by this table.

Accompanying the development of cable, improved in size and efficiency, there has been an increasing reduction in the first cost of cable. The rapid and continuous development of economies, which has resulted under the direction of the staff departments

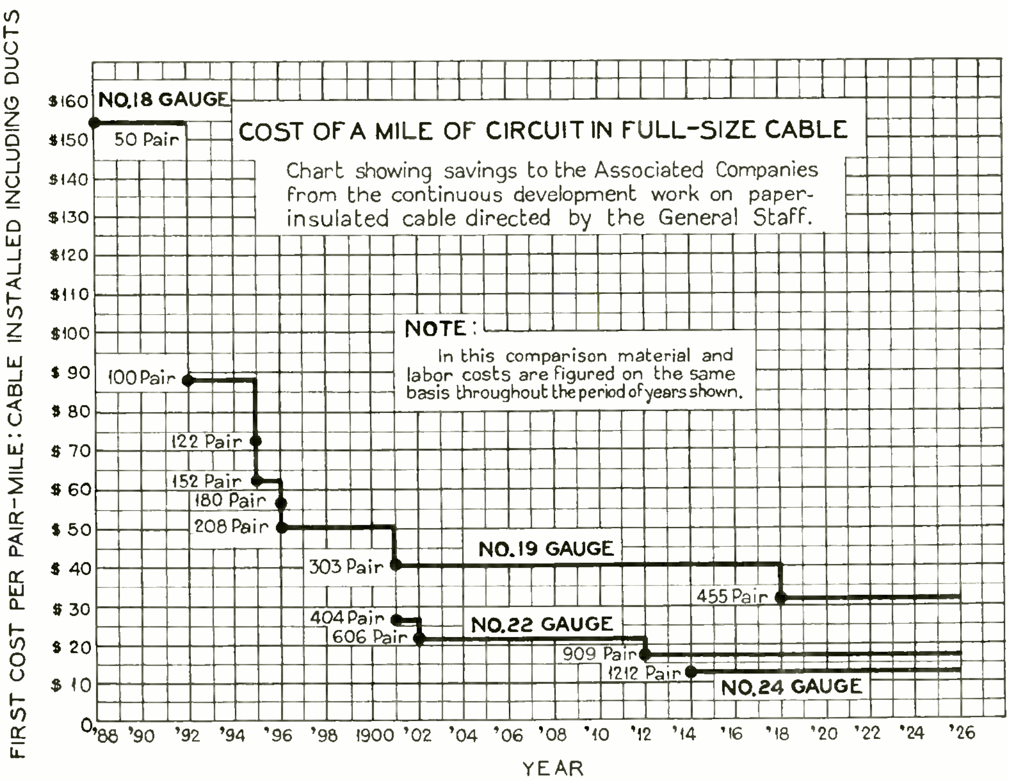


1212-*pair, 24 gauge cable, showing manner in which pairs are cabled together* of the American Telephone and Telegraph Company during the years since it undertook the coordination of this work, are illustrated in the accompanying chart. There is shown the cost per pair of conductors per mile of cable, including conduit costs, for the various cables which have been standard.

During these years a great deal of development work has been done on the fundamentals of cable design. This has included studies of the relations between the dimensions of insulating paper, the methods of its application to the conductor, the effect of the amount of paper in a cable on its characteristics for handling during installation, the lengths of twists of the pairs, and their effect on mutual capacitance between circuits, and the effects of all these factors and the space occupied by a circuit in a cable upon the mutual capacitance of the circuit itself. These studies* have included also the performance of cables in actual service conditions.

In contrast with the earlier work on cables there is now, and has been for some years, a growing amount of information, sufficiently large and complete to permit a very direct attack on the problems of new designs. Because of the large amounts of money involved in the telephone

** The studies mentioned are those of cable design and do not include a wide range of studies on transmission relations or on the chemistry and mechanics of cable sheath, insulating paper or copper conductors.*



Cost of a mile of circuit in full-size cable. Data furnished by F. L. Rhodes, Outside Plant Engineer, American Telephone and Telegraph Company cable-plant much of the current development work is directed, of course, towards production not only of better cables but of better cables at reduced cost. New problems in design and construction are continually arising, or are anticipated; and these furnish a constant incentive to the various groups—laboratory, staff, and manufacturing—which are most directly concerned with the important problem of cable development.

	Percent of Total Output			*Total output Billions of Conductor feet*
Year	19 *gauge*	22 *gauge*	24 *gauge*	
1915	14	85	1	6.5
16	15	81	4	9.3
17	14	80	6	8.7
18	13	81	6	4.9
19	10	84	6	5.2
20	12	80	8	6.5
21	11	43	46	10.8
22	10	35	55	16.8
23	9	38	53	22.0
24	12	33	55	29.3
25	10	34	56	30.2

This table gives the output of cable each year since 1915, *and shows the percentage of the totals formed by the various types*

Understanding Women

By JOHN C. STEINBERG

MAN'S traditional inability to understand women may have a basis of fact if one so wishes to interpret certain recent experiments in our Laboratories. By the same experiments, however, another popular judgment as to women is shown to be incorrect. Contrary to the usually accepted idea her soft voice speaks as loudly as a man's; and—even more unexpected—her enunciation of the fundamental sounds of speech is not clearer but is more difficult to understand.

The experiments which revealed this information were designed to measure the relative difficulty with which the fundamental sounds were perceived when uttered by male and female speakers. Each speaker uttered a hundred simple English words; and observers recorded the words in the usual manner of an articulation test. Half of the words involved differences of vowel, e.g., "bat, bait, but, bout" and the other half differences of consonant, e.g., "by, my, thy." The percentage of the various vowel and consonant sounds which were correctly perceived was thus ascertained for each of forty speakers.

At the same time the loudness with which the various sounds were spoken was automatically recorded. Each speaker addressed a transmitter; and the deflections of a sensitive galvanometer measured the several speech currents. These measurements for twenty men and twenty women showed that on the average a woman's voice is as loud as that of a man although individuals differ widely in the loudness with which they speak. In the case of the women the enunciation, or articulation, of the vowels was on the average a few per cent less than for the men, and the consonant articulation was about ten per cent less. The decrease is brought about largely by the stop and fricative consonants. In the case of the women the most difficult consonants to perceive were the fricatives *s* and *z*, which, strange as it may seem, in the case of the men were among the easiest. The *f* and *th* sounds (unvoiced as in thin) were the next most difficult in woman's speech and the most difficult in man's speech. These were followed by the *v* and *th* (voiced as in then) and the stop consonants *p, k, t, b, d* and *g* in approximate order of difficulty.

Just why it is more difficult to interpret woman's speech than man's is not entirely clear. One difference which contributes to this state of affairs is that the chord tone, or fundamental, of a woman's voice is 250 cycles, whereas that of a man's voice is 125 cycles. Since the component frequencies in the sound waves are multiples of the fundamental there are only one-half as many components in a woman's voice to supply data for perception to the brain of a listener.

Contributing to the difference in voice of men and women is the fact that the frequency ranges which characterize the consonant sounds are appreciably higher in the speech of women. Elimination of all frequencies above 5000 cycles affects only slightly the interpretation of masculine speech. For women's voices such elimination would produce considerable degradation in interpretation; and it is estimated that frequencies as high as 7000 must be transmitted to give possibilities of interpretation corresponding to a man's voice with frequencies only up to 5000 cycles. These higher frequencies are more difficult to hear; when the speech is loud "auditory masking" occurs and these high frequencies are thus obliterated in the ear itself. It thus appears that nature has so designed woman's speech that it is always most effective when it is of soft and well modulated tone.

From Good to Worse

As it progresses from one newspaper to another, the truth assumes successive forms of which the last may be quite unlike the first. Of this, a story about the photoelectric cell is an amusing example. Originally written by Herbert E. Ives of our laboratories at the request of an organization which distributes scientific information to the popular press, it sketched the history of photo-electricity, and mentioned that the discoverer, Hertz, also laid the foundation of modern radio. After describing present-day applications, Dr. Ives said: "We may, by advancement in knowledge of photo-electricity master ultimately the utilization of solar radiation, although we may have to resort to the indirect method of nature."

Here enters the re-write man. Grasping for the spectacular, the news agency introduced the article thus: "Scientists may harness the sun when they know more about photoelectricity, the principle underlying radio." A head-line writer on Newspaper No. 1 captioned the item, naturally enough, "Sun may be Harnessed by Photo-Electricity." *Newspaper No. 2 had it,* "Radio Principle may Aid in Harnessing Sun." *The climax was reached by Newspaper No. 3, which challenged the attention of its thoughtful readers by the line,* "Radio may Say 'Giddap! Sun.' "

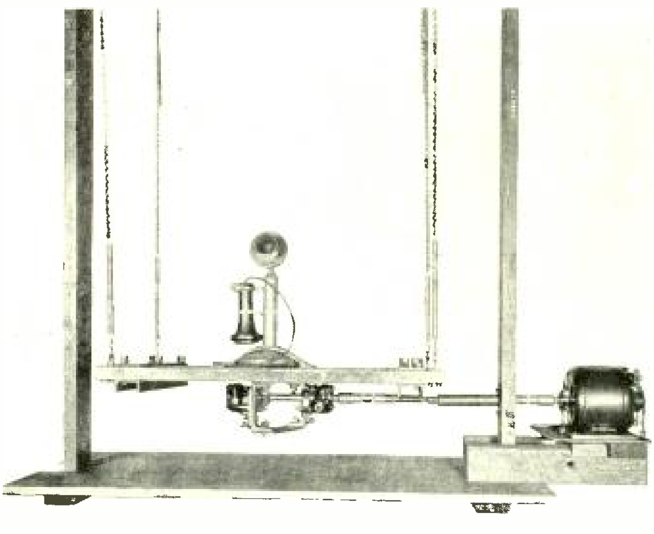
Accelerated Laboratory Tests

By E. MONTCHYK

PRIOR to the field trials which place the final hallmark on telephone apparatus of new design, laboratory investigations of important characteristics of the completed apparatus are undertaken. A thorough investigation is made of its physical characteristics, which in the majority of cases covers the dimensional correlation of the individual parts engaging with each other, and of the proper choice of materials. The latter study involves the consideration of such properties as strength, hardness, springiness, wear, resistance to atmospheric influences and insulating properties. Into this section of the testing pattern fit the accelerated laboratory tests, which aid in arriving at prompt decisions. Also, by bringing to light defects, these tests obviate the necessity of making field trials which are predestined to prove the apparatus faulty.

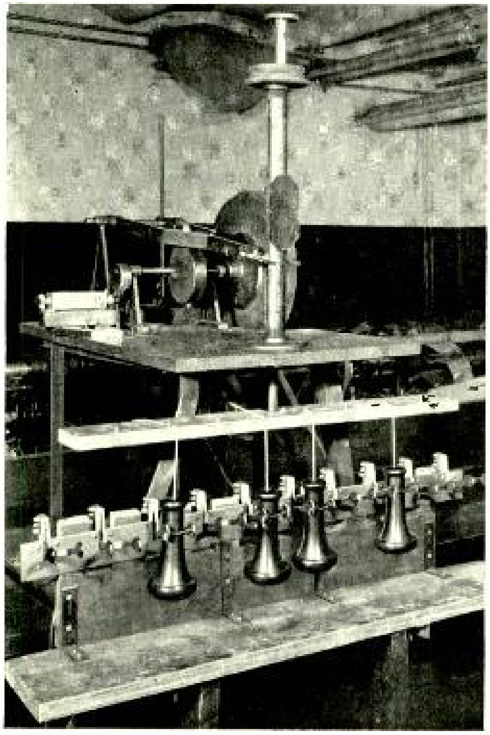
These rapid tests are somewhat exaggerated, but stimulate service conditions nearly enough to give quite accurate data provided the proper interpretation is given to the results. In this way certain engineers of the General Development Laboratory cooperate to the greatest extent with the engineers who design apparatus. With the results of these tests in mind, the designers can eliminate troublesome features which would not be discovered in a theoretical consideration. Almost indispensable in this work are several ingenious machines which add greatly to the rapidity and accuracy of the tests.

Vibration is the bane of many things besides slumber on a railroad train. When excessive vibration is applied to apparatus things begin to happen. Screws holding together individual parts tend to loosen; the welding in a vacuum tube may crack and render the tube inoperative; and even carbon grains have been shaken out of transmitter-buttons. For a



Testing a deskstand in the vibrating machine rapid study of this condition a simple machine to force vibration was developed.

In this device the test pieces are placed on a wooden platform which is suspended on long helical springs. On the under side of this platform are two revolving weights in the form of cams which are driven at about 1800 revolutions per minute. The centrifugal force exerted by these weights tends to pull the platform back and forth, thus setting up vibrations. The cams can be set on the shaft at different angles, and thus the amplitude of vibration can be altered.



How receivers are tested in the dropping machine

When the machine was first built the cam shaft was directly connected to the motor, with dire results—to the motor. The design was so efficient and the telephone apparatus was so comparatively strong that several motors broke down before any apparatus was damaged. A flexible shaft was then substituted, and the bearings, which had also proved unreliable, were changed. As it now stands, the mechanism wreaks damage upon the test pieces and not upon itself.

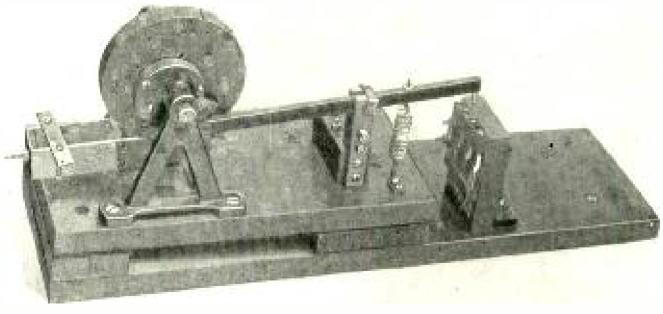
With all the care that, in general, is exercised in the use of telephone apparatus, desk-stands are often handled roughly, and receivers are slammed onto their hooks. Apparatus must also be shipped, and freight handlers are not receiving any palms for considerate treatment. These factors must be considered in design. To test the robustness of the product, a dropping machine was developed.

The driving elements in this device are a motor and a cam-driven lever. A top view of this lever reveals its working end as a fork whose two prongs engage fingers projecting from a vertical rod which supports the objects under test. In operation, the lever lifts the rod until the prongs come into contact with a stationary plate and are forced apart. When the prongs no longer hold the fingers, the rod falls freely and the objects under test strike a platform of steel, wood, or stone, as the test may require. Some apparatus is handled differently; for instance receivers are dropped upon their switchhooks as they are in service. The violence of impact in any case depends upon the height adjustment of the release plate.

This same set-up is used to determine the resistance of stationary objects to abrasion. Suitable bundles of chain, or a metal ball, are attached to the moving rod and then allowed to fall upon the test piece. By comparing the result with the effect on standard articles are determined the relative abilities of substances to withstand abrasion and impact.

Number plates, which are associated with the jacks on a switchboard, are subject to blows from the plugs as the operators set up connections. Inferior finish on these plates soon deteriorates, with poor appearance and illegibility the results.

To ascertain the resisting qualities of various finishes, a "woodpecker" machine is employed. This resembles that industrious bird in action except that the man-made "woodpecker" works in a horizontal position. A pivoted metal arm carries at one end a portion of an ordinary plug. Operating this lever is a fairly high-speed cam. The force of impact is governed by a spiral spring which acts at a point between the pivot and the plug.

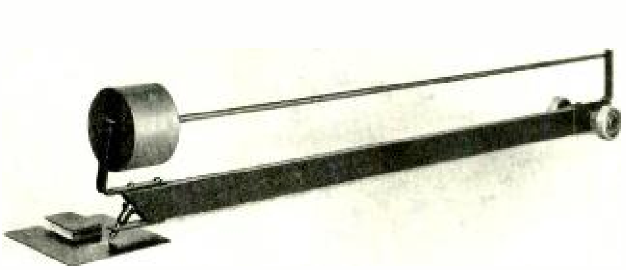


The "woodpecker" machine

Usually these tests are comparative. A new finish is tested side by side with a standard. Thus direct evidence is obtained with a minimum of time expended. Special attention must be paid to the support of the test piece. Too rigid a support means fast wear; a resilient support—wood, for example—results in slower wear.

Finishes are also tested by a simple process for resistance to scratching. A sharp point is suspended in a frame which can be wheeled by hand along a table. The pressure exerted by the cutting edge is regulated by a weight which slides on the upper portion of the frame.

Another specially designed machine replaces the operator's finger as it tests the durability of push-button keys which must survive an extremely large number of operations. Associated with each key under test is a lever tipped with a soft rubber finger. An electromagnet operates the lever and forces the finger against the push button. Controlling the magnet is a sequence switch whose motor drive determines the speed of operation. An automatic register records the total number of pushes. Day and night the keys are kept in motion until the required number of operations is completed, or the keys fail. Fifteen years' service in the field is duplicated by the machine

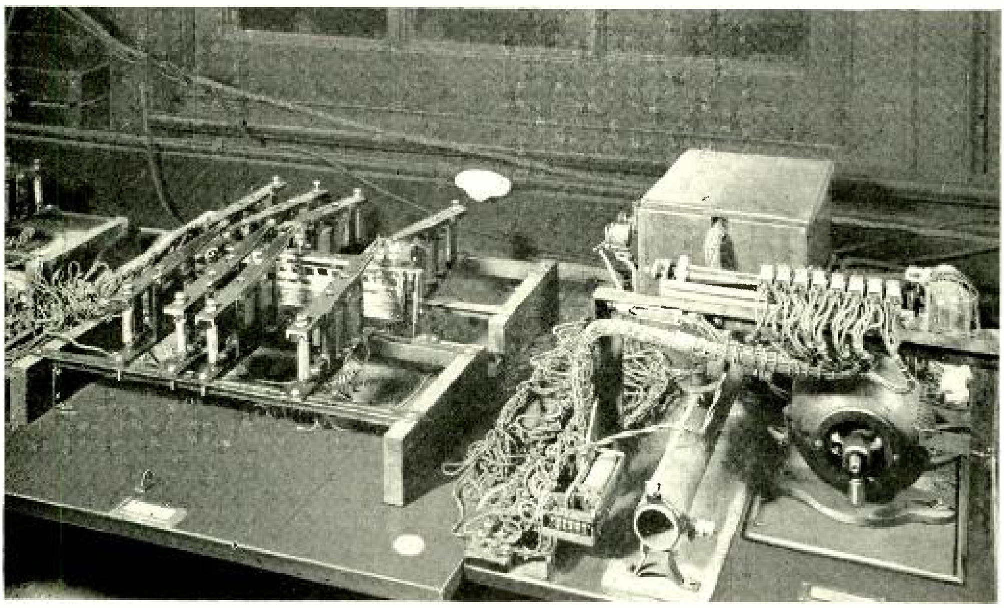


Testing a finish by moving the scratching point back and forth. The cylinder on the left is an adjustable weight in the space of two months. If the machine fails while the attendant is absent a circuit breaker shuts down the system.

Frequently an investigation of an entirely special nature is undertaken. In such cases existing facilities often do not suffice, and a new testing technique must be established. Such a situation arose in the investigation into the failure of the salt-water cooling tubes in radio transmitters similar to the installation on the S. S. *Leviathan*. To determine what material was least corrodible under the circumstances, several samples were made into coils of the form actually used. Since the materials did not react with one another they were connected by a rubber tubing. Hot salt water from an earthenware tank was circulated through the coils, and the reaction in each was observed.

To state that the faster a test, the sooner will apparatus deteriorate, seems a truism. Sometimes, however, the obvious concepts are false. It might seem reasonable to believe that a bearing which at low speed becomes unserviceable, will fail much faster at one hundred times that speed. Yet, some composition bearings operate satisfactorily at the high speeds for which they were designed, but at low speeds the opposite is true. The explanation is simple. At high speeds the lubricant becomes warm and acts very efficiently. At the low speed little heat is developed, the lubricant forms a thick paste with the powder produced by the wear of the bearing, and the shaft is seized. Thus, between test and service speeds a balance must always be struck, and an accurate determination of this relation is vital before a method of test is adopted.

As sentries guarding the far-flung lines of telephone design and developments stand the group concerned with "apparatus analysis." The machines, a few of which were described, form



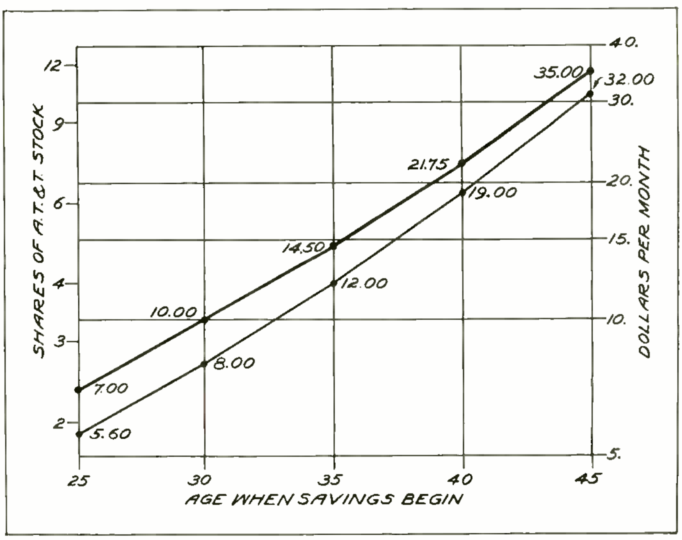
To the left is the key testing machine; on the right are the drive motor and the sequence switch, which controls the operation of the electromagnets in the tester their first line of defense and assure telephone apparatus of highest quality—apparatus that will not falter in service; that reasonable abuse will not affect. It is true that only with large interests at stake can extensive tests be made. Yet it is easy to see the economy of such action when one stops to think that telephones are manufactured by the hundreds of thousands; and each little saving is magnified far beyond its face value.

The Price of Money

How much will each ten thousand dollars cost me?

An approximate answer is given in the two curves shown below, which indicate how much must be invested each month, at two different rates of interest, to give the investor ten thousand dollars when he is sixty years old. The upper and heavier curve is figured on an interest rate of six percent compounded semiannually; the lower and lighter, on a rate of seven percent compounded quarterly.

American Telephone and Telegraph stock is now being sold by the Employees' Purchase Plan at 130, which yields very close to seven percent in dividends. As payments deducted from salary are allowed interest at seven percent compounded quarterly, money systematically saved in accordance with this Plan will bring returns somewhat similar to those indicated by the lighter curve. Unfortunately, after each block of stock is paid for, it is extremely difficult safely to reinvest the dividends at this high rate of interest—presuming that the investor is already buying A. T. & T. stock up to the limit allowed for his salary. Six percent compounded semiannually is, however, possible to one who reinvests his dividends in A. T. & T. stock at its market price, through the Bell Telephone Securities Company.



How to have ten thousand dollars at sixty years of age

Closing the Books

By A. J. DALY

A Simple Account of a Complicated Accounting Procedure

NEW YEAR'S Day has come and passed. Another meter reading has been taken on the dial of time. With it we have all closed in usual festivity the metaphorical books of our last year's lives and opened expectantly those for the year ahead. In shelving the former we have mentally listed the good things that have accrued, while weighing with care any reverses or disappointments. In the light of present and potential values we have made proper allowance for charges to experience. Looking back, we have at the same time peered forward.

Our Laboratories as a business organization has likewise come to the annual closing of its books—its literal ledgers and journals. Instead of attendant festivity, there is extensive and intensive checking of figures, and more figures. The retrospection is formal and even compulsory. For the operation of our Laboratories and the investment which it entails is essentially a stewardship placed in the hands of the management which must render an accounting thereof to our directors, as representing our stockholders. How has this investment been handled? What is its status at the end of the year compared with what it was at the beginning? Have the standards of performance as anticipated been met? These and many other similar questions must be answered. And finally, from the standpoint of taxable income, there is the Government with its interest in us as a corporation. As sure as taxes is the perennial simile.

It is not the intent herein to explain the array of detail involved in closing. It is under the most favorable conditions a complicated procedure. For an organization such as the Laboratories with its cost of operation approximating several millions of dollars and its large investment in plant and merchandise, closing is an operation of appreciable magnitude. It might be made the subject of an elaborate and highly technical report, such as one would expect in an accounting journal. The aim here is rather to convey to the layman to whom such terms as "surplus loadings," "reversing entries" and "revaluations to market" may be regarded as catch-phrases of auditors and accountants, a general picture of the purpose and involvements of closing.

Closing the books is undertaken to determine the true financial condition of the Laboratories as of December 31st by ascertaining what we own and have owing to us—assets; and what we owe others—liabilities. Some of these have been carried throughout the year on an approximate basis. Closing transforms such approximations into actualities. In the process care must be taken to insure that all items of expense that properly pertain to our operating cost for the closing year and all items of income are recorded. There is thus evolved the basis on which the Government levies its income tax and on which we accordingly render unto Cæsar the things that are his. Closing also enables the management to measure actual performance as reflected by expense at the end of the year against the standard of performance which was set up in the annual budget of expense at the year's beginning.

While consummated under the date of December 31st closing is a matter of three months in process and is carried on under the direction of the General Auditor. It enters on its preliminary stage at the end of October when an actual count is made of all items of machinery and furniture in the building. Many no doubt have noted the numbers punched on their desks and chairs, typewriters and machines. These markings are the identification discs whereby the complete history of any item may be known through a card record maintained in the Costs and Accounts Department. The annual inventory is caried out on carefully planned lines so that the whole building is covered outside of working hours. As the squads of inventory takers deploy from floor to floor, listings (for subsequent verification with the card record) are made of all of these items. This checking is to reflect on our books our actual outlay for plant. It is limited to furniture and machinery, since these generally represent our floating plant. In the case of grounds, buildings and permanent fixtures, the book records are in the order of things accepted in place of an actual check. Thus we bring our book value of plant in line with our physical inventory thereof and so determine how much depreciation for wear and tear and obsolescence is properly chargeable to expense.

Following closely on plant inventory comes the determination, through actual count, of our merchandise inventory. This constitutes all items carried as stock materials in our Laboratories storerooms, and all work performed but uncompleted on customers' orders. This inventory is recorded, item by item as counted, and is valued at cost or revalued to current market price. Any losses sustained through revaluation are properly charged to operating expense. In connection with computing this inventory, all transactions in stock materials and expense supplies for the year are summarized and profits and losses therein are determined and disposed of.

Closing operations as so far described are carried on previous to the actual expiration of the old year and extend well into the new. There is, however, one class of transactions that are closed finally at five o'clock on the evening of December 31st; namely, cash transactions. This practice merely adheres to that followed on any other working day of the year. Cash on hand is counted and the cash book balanced, subsequent reconcilement being made with the cash balance rendered by our bank. Thus, while others were festively bound on this eve of eves, our auditors and cashiers had first to observe a little watch hour of their own.

In the early part of the new year the Laboratories, as each of us, is engaged in receiving "billets due" from its suppliers. In the one case it is the normal occurrence, whereas with us it is the Christmas aftermath. The Company is thus relieved of those pangs that are our common lot and is concerned only that bills pertaining to the expense of the old year shall be kept apart from those applying to the new. Items such as subscriptions to magazines and periodicals and license plates for company automobiles are payable in advance in the old year but are a proper charge to the ensuing year's cost of operation. In like manner living allowances to employees located abroad which apply to 1926 expense but cannot be vouchered until after the books are closed must not be carried as a charge to the expense of the new year. Proper reserves must therefore be set up for all such items whereby through a process of reversal they may be finally allocated on our books in the period to which they apply.

After all of the old year's expense has been segregated, the adjustment necessary to bring the cost of operation from standard to actual follows. Loading or overhead rates which were set at the beginning of the year on the basis of estimated performance have been too high or too low in the light of actual performance. Surplus or deficit loadings have thus been created and must be disposed of. This distribution is prorated on the basis of work performed for our customers during the year. Thereby we come to our final billing out.

At this point we are ready to determine what we owe to the Government. We turn to our expense account, familiarly known as "50" from its numerical accounting designation. The debit side of "50" in total reflects the actual cost of operation for the year; the credit side reflects the total of payments by our customers for bills rendered them during the year for work performed. We note that the total credits exceeds the total debits. Our customers have paid us more than we have charged into our cost of operation. On analysis this credit balance turns out to be in part the reserve set aside for our Benefit Fund in accordance with the terms of our Benefit Plan. The remainder is the amount equal to the Government's tax on that reserve.

The mechanics of closing are completed. Plant, merchandise, cash—in fact all assets and liabilities have been set up on the books at actual value and the true financial status, cost of operation and taxable income have thereby been established. New Year's Day has come and passed. Only with the arrival of February 1st, however, can the Laboratories accountants say: "The old year is closed."

News Notes

Edward J. Hall Chapter, Telephone Pioneers of America, met in the auditorium of Bell Telephone Laboratories on November twenty-ninth. At this time there was recreated for the Chapter and its guests, members of the other metropolitan chapters, the program which they had courteously foregone last August in favor of the out-of-town members of the Pioneers. As on the former occasion, John Mills, Director of Publication, described the organization and work of the Laboratories, particularly as to investigations of speech and hearing, and the development of high-quality transmission, recording and reproduction of sound. He then introduced Paul B. Findley, Editor of the Record, who explained the importance of retaining a wide range of tones if lifelike reproduction is to be secured. This point was demonstrated by means of phonograph records, cut by a high-quality system. Vitaphone reproduced the Tannhauser Overture, by the Philharmonic Orchestra; Roy Smeck, Martinelli and Elman entertained and thrilled the audience through the same medium. How Vitaphone works was explained by Mr. Mills. During the program a new motion-picture film, "The Magic of Communication," was shown.

A bust of Alexander Graham Bell was presented by the American Telephone and Telegraph Company to the Smithsonian Institute in Washington, D. C. In the course of his presentation speech, President Gifford quoted a letter written in March, 1875, in which Bell told of his meeting with Joseph Henry, the great scientist and first Secretary of the Smithsonian. Discussing Bell's nascent ideas of speech transmission, Professor Henry characterized them as "the germ of a great invention"; and his answer to Bell's misgivings as to lack of knowledge was "Get It." This encouragement spurred Bell on and a year later the telephone was born.

L. W. McKeehan and K. K. Darrow attended on November 26 and 27 a meeting of the American Physical Society in Chicago.

D. G. Blattner was in Chicago the week-end of December 11th supervising the installation of Vitaphone equipment for a demonstration given before the Western Society of Engineers through the courtesy of the Vitaphone Corporation.

Several engineers of the Research Department were in Hawthorne the last week of November in connection with questions of transmitter development and manufacture; they were H. A. Larlee, A. F. Bennett, W. G. Breivogel, L. J. Cobb, C. H. G. Gray, E. Hartman and W. G. Knox.

New Year's Greetings

From F. B. Jewett, Vice-President, American Telephone and Telegraph Company, and President, Bell Telephone Laboratories

FOR UNTOLD AGES AND UNDER EVERY FORM OF CIVILIZED communal life the day which men set apart to mark the beginning of a new year has been a day on which, metaphorically, they take account of stock. It is a day hallowed by custom for universal mutual felicitations among friends and for visioning the future by a review of the past.

Under the sanction of this custom, which is much more than a pretty gesture, I avail myself of the occasion to speak for those of us in the Bell System who are concerned primarily with the enlargement of communication through research and development. To Mr. Craft and Mr. Colpitts, and to all the individuals of the very able groups whose activities they direct, I would first of all express my heartfelt wish for a Happy New Year. Nearly a quarter of a century of intimate association with the men and women of these groups has developed in me feelings of admiration, esteem and love such as are ordinarily associated with the ties of family relationship.

In wishing you all a Happy New Year I know that in so far as happiness depends upon the joy of creative work, upon the broad social importance and individual responsibility of our tasks, upon the recognition of personal accomplishment and upon pleasant companionship in well coordinated enterprise, my wish will not be a vain one. I would go farther than this, however, and into matters over which I have no control. I would wish for all of the members of the Department of Development & Research and of Bell Telephone Laboratories the fullest measure of happiness in their most intimate concerns.

While New Year's Day is a fitting occasion for the expression of such wishes, the wishes themselves will outlive the occasion of their formal expression by more than the year. New Year's greetings are but a concrete vivid illustration of that daily process by which we one and all turn the experiences of the past into hopes for a better future in our mutual relations. So also the transformation of retrospect into prospect is a daily operation in the field of our scientific work. Visions of the future we must have, and framing these visions are the facts of the past. Each day we peer into the unknown ahead and as the day passes its accumulation of knowledge and experience slips from the vision to merge *with the frame and give us clearer vision of a yet more distant tomorrow. For this, our mutual quest for useful knowledge, as well as for our mutual quest for happier human relations, I express also our common wishes by saying again Happy New Year.*

Frank B. Jewett

New Year's Greetings

From E. B. Craft, Executive Vice-President, Bell Telephone Laboratories

IN ENTERING UPON THE YEAR 1927 AND PASSING IN review the events of the year just closed we find much of which to be proud. The various technical achievements of the Laboratories come first to mind for it is through them that we have played our part in the program of continuing improvement and expansion of service by the American Telephone and Telegraph Company and its Associated Companies.

But beyond and deeper than our visible achievements there has been a steady development in our own mutual relations. We are closer knit than ever before; we recognize more of the dignity and importance of each other's work and departments; we have increased our mutual trust and confidence; and we have grown more instinctive and less conscious in our cooperation.

So we face the problems and opportunities of the New Year with what is, I believe, the most harmonious and efficient personnel of our history.

May I take this opportunity of expressing the wish for a Happy New Year to each and every member of the organization? I have enjoyed our association of the past year and sincerely appreciate your cooperation which has produced so satisfactory a result.

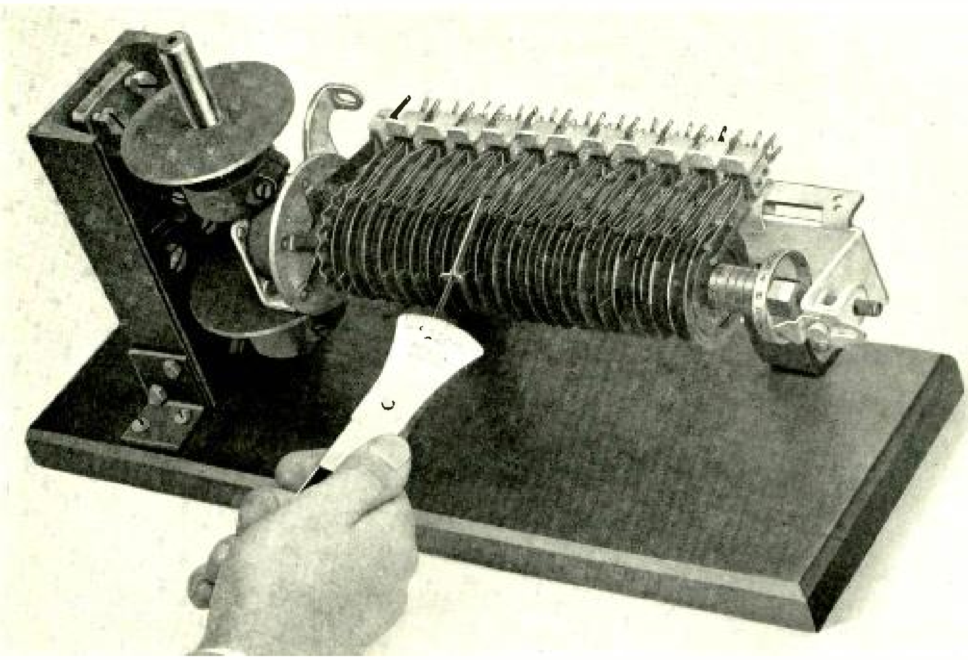
E B Craft

Gauges for Machine-Switching Equipment

By G. W. FOLKNER

ALL of us can estimate the size of an object accurately enough for many purposes. After some training, an adjuster can adjust the pressure of contact-springs accurately enough by his sense of touch. But the accuracy of our senses changes from day to day; and so, as somewhat less variable standards, we use physical measures: yardsticks, weights, springs. Commonly these devices serve to measure anything within their capacity. Their usefulness may be greatly enhanced in one sense and limited in another by specializing them so that they will measure only one or two values. Under the name of gauges, then, such measuring devices are widely used to determine how well some object conforms to specified dimensions.

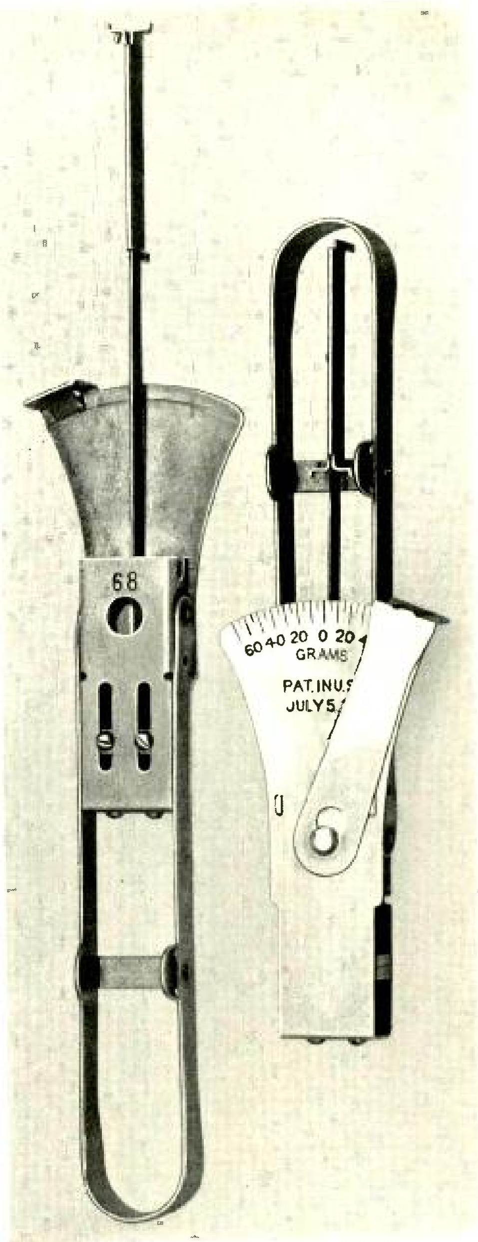
To measure, for example, just those dimensions of a switchboard plug which would indicate wear and approaching unserviceability, the No. 27 gauge was developed. It does the work of three micrometers, each set at a fixed value, saving the initial cost of these instruments as well as the expense and uncertainty of setting them from time to time. Among gauges of this general class are flat strips of hardened steel, ground to certain thicknesses, and representing



Using a reed gauge to test the tension of the brushes of a sequence switch the operating limits of some critical dimension in the telephone plant. Usually one end, marked "NO GO," is a little thicker than the other, marked "GO." The maintenance man then adjusts the apparatus so that it falls within these limits.

Measures of pressure also find a place in the tool-cabinet of a machine-switching room. Wiping contacts are made by brushes on multiple banks, sequence switches, and commutator strips. Under too heavy pressure, wear will be excessive; if too light, the electrical contact will be uncertain. Such pressures are measured by engaging one end of a steel reed under the spring and flexing the reed until it pulls the spring out of contact. Graduations on a circular segment indicate the force applied at the tip of the reed. When a large number of springs are to be adjusted within the same limits, a stop is placed to hold the reed at a deflection corresponding to the lower limiting pressure. If the spring breaks contact before the reed is lifted off the stop, the spring-pressure is too light. This stop can also be placed at the upper limit for testing the maximum pressure.

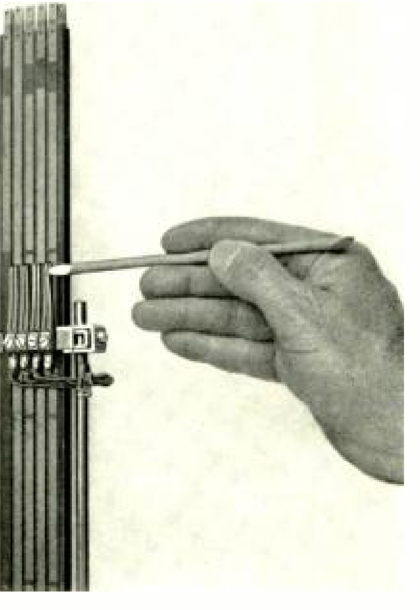
How human perceptions have partially replaced the gauge is interestingly illustrated in the adjustment of contact springs. The adjuster begins by setting a number of springs to tensions just inside the upper and lower limits. With an orange-wood or fibre pick he then gets the "feel" of these springs and proceeds to adjust others until his sense of touch tells him that they lie within the limits indicated by the springs first tested. This is much quicker than when he has to watch the reed-gauge. Working in this way, the adjuster saves time because



Pressure exerted by brushes in machine-switching devices is measured by this gauge. At the left it appears ready for use; at the right, with its handle folded to protect the reed when not in use. In the right-hand view is also seen the stop which facilitates repeated measurements his attention is concentrated on the spring instead of being divided between the spring and the reed-gauge. Surprisingly, his slight uncertainty as to the settings actually results in a better job. When a gauge is used continuously the adjuster tends to pass, as satisfactory, tensions near the limiting values provided they are inside the limits. When working to "feel," however, he keeps farther away from the danger points. That he does so and that in his output the actual tensions are grouped more closely in the center of the range appears from the final inspection.

Back of the use and design of gauges is the fact that inherently, no two manufactured products are ever absolutely alike. The more nearly identical one tries to make them, the more the costs for manufacture and inspection. In their significant dimensions, therefore, certain tolerances have to be admitted. These tolerances depend on the other apparatus with which the particular piece must work. By consideration of this fact during the design of a piece of apparatus, it is often possible to allow for increased tolerance in another piece and so to effect a considerable saving in the cost not only of the second piece but in the gauges for measuring it. For the cost of making and using a gauge increases very fast after a certain degree of accuracy is passed. It is also important to allow in design for the easy insertion of the necessary gauges. When tension is important, for example, the design may include a lug for the ready attachment of a gauge, to the great convenience of the tester.

The art of gauge design involves a wide variety of knowledge and often a good deal of ingenuity in planning a gauge which will pass through available openings in the apparatus. In many cases, the total number of any one gauge required in a year is small. To keep down the production cost, the demand can sometimes be increased by making the gauge suitable for installers' use. This usually means a sturdier and more expensive gauge, and a nice cost-balance must be struck. All gauges are subject to wear, and provision must be made for their calibration from time to time.



An adjuster testing brush tension by means of an orange-wood pick

Flat type gauges are quickly checked by a micrometer; and tension gauges by applying standard weights. These primary standards are part of the equipment of every Associated Company; they are used frequently enough to make sure of the accuracy of the gauges and so in turn keep the operating equipment adjusted within those limits which have been found necessary for satisfactory operation.

D & R News Notes

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

THE Telephone Theatre at the Sesquicentennial closed its doors on November 30, after operating for a period of twenty-three weeks. The Theatre was located within the Liberal Arts Building and had a seating capacity of two hundred and ten. Talking motion pictures and regular motion pictures were shown illustrating the development of the telephone art for the last fifty years. A demonstration switchboard was also exhibited with two operators in attendance, showing how a telephone call is made from one station to another. An interesting feature exhibited was a duplicate of the Alexander Graham Bell exhibit which was made by him at the centennial in 1876.* Practically continuous exhibitions were given every week day during the above period with a total attendance of over 165,000 persons. The exhibit was planned and installed under the direction of G. K. Thompson and was in charge of G. W. Peck, of the Long Lines Department, who was temporarily transferred to the General Staff for the period of the exposition.

A. Weaver is now on the Pacific Coast to assist in connection with the opening of the new telephotograph station at Los Angeles, and to supervise tests of synchronizing equipment to be installed for trial at San Francisco.

R. P. Martin, Jr., visited Pittsburgh during November in connection with tests of small engine generator-sets by the Westinghouse Company at their East Pittsburgh works.

R. L. Young inspected some Buffalo engines in Philadelphia, while J. L. Allison made a tour of the Exide Storage Battery factories in that city.

W. T. Breckenridge spent about a week at Reading, Pa., during December, on the tests of the new commercial-type charging-generators, one of which has been cut over in the new step-by-step office serving that city.

C. S. Gordon went to Detroit with G. D. Heald and C. B. Johnson to look into the results obtained with parallel drop-wire in the Michigan Bell Company's territory.

R. J. Kent went to the Bethlehem Steel Company's plant in connection with a preliminary inspection of new specifications for tool steel.

H. D. Bender has visited five Associated Companies and ten suppliers during the last month or so, in connection with tool standardization.

J. B. Dixon, formerly of the New York Telephone Company, is now a member of the Outside Plant Development Division, reporting to A. L. Richey.

F. D. Powers is still in the West, in connection with experimental treatments for poles, having moved from Texas to Oklahoma. A. P. Jahn has returned from a similar trip to Illinois.

L. V. Lodge went to Mobile to inspect the Montgomery-New Or-

Pictured on page 141 of the RECORD *for December, 1925.*

leans line, and is now in Bay St. Louis, Mississippi, continuing this inspection.

R. F. Hosford attended the meeting of the Wood Industries Division of the A. S. M. E. while in Chicago. Earlier in the month he visited Brunswick and Atlanta, Ga., in connection with creosoted pine poles. In Scranton he attended a conference at which were representatives of the Scranton Electric Light Company and of the Bell Telephone Company of Pennsylvania, and spoke to them on wood preservation. He also went to Boston to investigate the question of the supply of eastern cedar poles.

A. H. Schirmer is in Boston in connection with general protection problems of the New England Telephone and Telegraph Company. On his way back to New York, he expects to visit Mr. W. M. Gould, formerly of this department, who is now living at Easthampton, Mass. Our latest reports from Mr. Gould are that his health is continuing to improve.

W. C. Babcock is at the Phoenixville test station carrying on an investigation of crosstalk at carrier frequencies; an experimental line has been set aside for this purpose. F. A. Liebe has recently gone to Phoenixville to conduct an investigation of leakage of insulators.

R. P. Booth is at Linden, New Jersey, and J. H. Shuhart is at Point Pleasant, Pennsylvania, investigating crosstalk and transposition problems in connection with the type "D" (short haul) carrier telephone system. An experimental installation and specially transposed circuits are being employed.

A test station has been established at Elmira, New York, where an investigation is being carried on jointly with representatives of the National Electric Light Association of induction under conditions where power distribution and open-wire telephone circuits jointly use the same poles. The telephone representatives on this work are R. A. Shetzline and R. B. Stewart.

R. K. Honaman, A. E. Bowen, L. C. Peterson and J. M. Dunham are in Chicago in connection with a joint investigation with the Public Service Company of Northern Illinois. Mr. Honaman on this trip also visited Dayton, Ohio, for a discussion of joint tests with the Dayton Light and Power Company.

A. L. Whitman is in Terre Haute, Indiana, cooperating with a representative of the National Electric Light Association on tests of the effectiveness of coordinated transpositions, unbalances of telephone circuits, and other matters involved in the inductive relations between open-wire toll telephone and power transmission circuits. Five temporary test houses are being constructed for this work. An extensive series of tests is to be made on both the power and telephone circuits and it is expected that the field work will continue for a year or more.

R. G. McCurdy spent several days in Terre Haute in connection with this work and also visited St. Louis.

C. P. Bartgis has been in Devon, Pa., and Reading, Pa., in connection with capacity unbalance tests in the new Philadelphia-Reading "B" cable.

K. L. Maurer and J. Riordan have been in Chicago on some joint tests with the Illinois Central Railroad. H. M. Trueblood recently visited Chicago and Terre Haute in connection with these tests.

Magnetic Materials

By J. C. PETTIT

WHENEVER the telephone is used—from the moment one lifts the receiver from its hook until an instant after it is returned—the core of the matter is an electromagnet. The relay which closes the lamp circuit and thus attracts the operator; the repeating coil—that is, the transformer which transfers the speech current from one circuit to another; the bell which summons the distant subscriber—all operate as electromagnets. And even the telephone receiver which contains a permanent magnet acts as an electromagnet in varying its pull on the receiver diaphragm. Such devices depend for their operation upon cores of magnetic material; and what should be in the core has always been the subject of continuous inquiry and development work in our Laboratories.

In a very general way magnetic materials divide into two classes: those which can be easily magnetized, but will lose their magnetism when subjected to small reverse magnetizing forces; and those which, though more difficult to magnetize, retain a large part of their magnetism even under the action of considerable demagnetizing forces. The first class comprises the so-called magnetically soft materials used for electromagnets, among which are magnetic iron, silicon steel, permalloy, and electrolytic iron. In the second class, of magnetically hard materials for permanent magnets, are carbon-manganese steel, chrome steel, tungsten steel, and cobalt steel.

In the selection of a magnetic material there are five properties which serve as criteria of its quality. The first is the ease with which it may be magnetized, a quality known as "permeability," which is measured by the ratio of the flux density to the magnetizing force which produces it. Not only do materials differ in permeability but for the same material the permeability itself has different values under different magnetic conditions. The ease of magnetization, in other words, depends upon how much the material has already been magnetized. Permalloy, for example, has a very high initial permeability: that is, a small magnetizing force applied to an unmagnetized specimen produces a large effect. When the material, however, is already partially magnetized the permeability is lower. For high values of magnetizing force and, correspondingly, of flux density "magnetic iron," on the other hand, has a high permeability, although for small magnetizing forces its permeability is only a small fraction of that for permalloy.

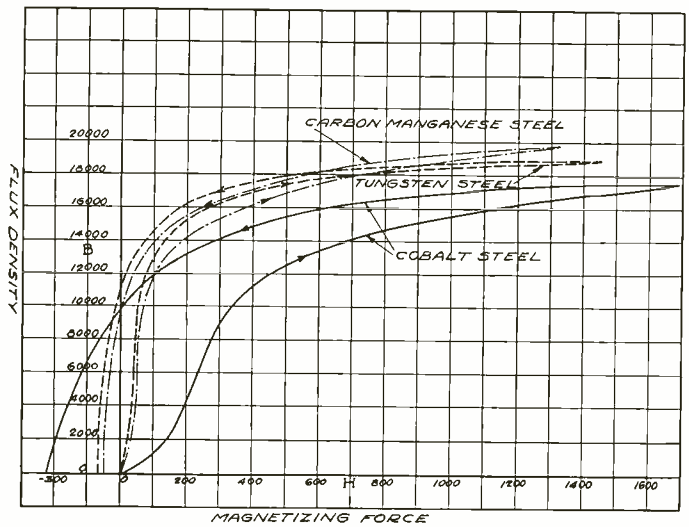
Another property of importance is the ability of a material to maintain a magnetized condition when the magnetizing force has been removed. This quality is measured by the residual induction: that is, the flux density remaining in a completely closed core of the material when a given magnetizing force is removed. Another closely related quality is the coercive force—the magnetizing force which must be applied in the opposite direction to remove the residual induction: that is, to demagnetize the material. These last two qualities are, of course, important in the selection of materials for the production of permanent magnets such as are used in polarized relays, in telephone receivers, and in magneto-generators.

The existence of the qualities of residual induction and coercive force means that the flux density within the magnetized core depends, at any instant, not only upon the magnetizing force then acting, but also upon the previous magnetic history of the core itself. In attaining its successive values the flux density lags behind a changing magnetizing force, much as if the molecular constituents of the core were being rearranged against the opposition of viscous or frictional resistance. This phenomenon, known as "hysteresis," gives rise to the term "hysteresis loss" which represents the energy required in such a rearrangement whenever the material undergoes periodic reversals in magnetization, as in an alternating-current electromagnet.

Another loss under these same conditions arises from the existence of eddy currents which are induced within the core of the electromagnet when it is energized by an alternating current. This loss, like the hysteresis loss, manifests itself by heat. Sectionalizing the core by laminations, insulated one from the other, reduces this loss. Similarly, using a material of high electrical resistivity means feebler eddy currents and smaller losses. Hysteresis loss and electrical resistivity are, therefore, two qualities of importance in the design of electromagnets for alternating currents.

The fact, for example, that the electrical resistivity of magnetic iron is relatively low, and hence that its eddy current losses would be large, practically limits its use in the design of telephonic equipment to cores for electromagnets which operate on direct currents. On the other hand, the fact that its coercive force is fairly low but its permeability quite high even when there is already a high flux density, indicates that it may be used for relays in which the armature rises when a current is sent through the windings, and falls back again under gravity of spring pressure when the current ceases.

In silicon steel,

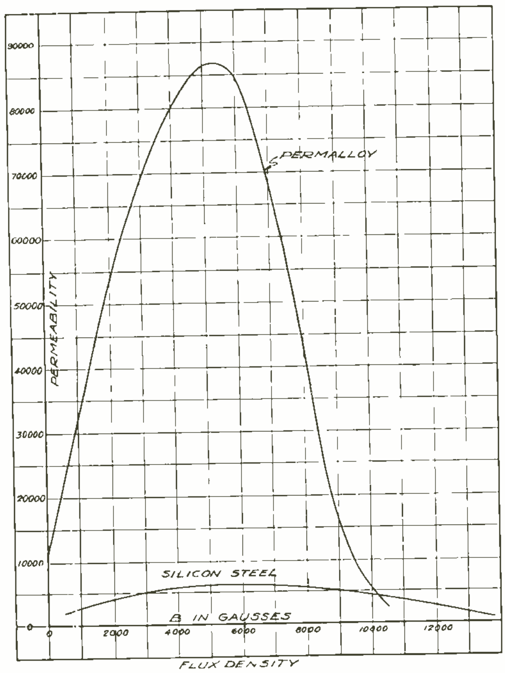


Curves showing how flux density in different materials varies as the magnetizing force is changed which may be considered a four per cent silicon alloy of magnetic iron, the resistivity is about five times that of magnetic iron. Eddy currents are greatly decreased in consequence and the material is, therefore, adapted for use in laminated cores in all apparatus operating within the audio-frequency range. This steel also has the advantage of a considerably higher permeability than magnetic iron at the low flux densities which are usually established in telephone apparatus operated by speech currents.

A material physically superior to silicon steel for the cores of audio-frequency apparatus is "45-permalloy." The name "permalloy" covers certain alloys of nickel and iron developed in our laboratories and possessing remarkable magnetic properties. Several of these have been standardized and each is designated by the amount of nickel which is contained in it. The "45-permalloy" has a resistivity nearly as high as silicon steel and a permeability, at low or moderately high flux densities, four or five times greater. Its coercive force is also considerably lower. Its cost, however, is considerably greater; and in designing apparatus this factor must be balanced against its better magnetic properties.

The "78-permalloy," which has very remarkable properties, is used in the form of thin tape for loading high-speed submarine cables and in sensitive relays. Its permeability at low and moderate flux densities is about twenty times that of silicon steel. Its coercive force is about one-tenth and its resistivity one-third less.

For apparatus such as the loading coils which are inserted in long telephone lines to improve transmission, a core material is required which will introduce very small losses. High resistivity in such cases is attained by making the cores of these coils from the very fine powder of electrolytic iron. Fine dust particles are coated with a thin insulating film and are compressed into suitable ring cores



How the permeability of permalloy differs from that of silicon steel at various values of flux density

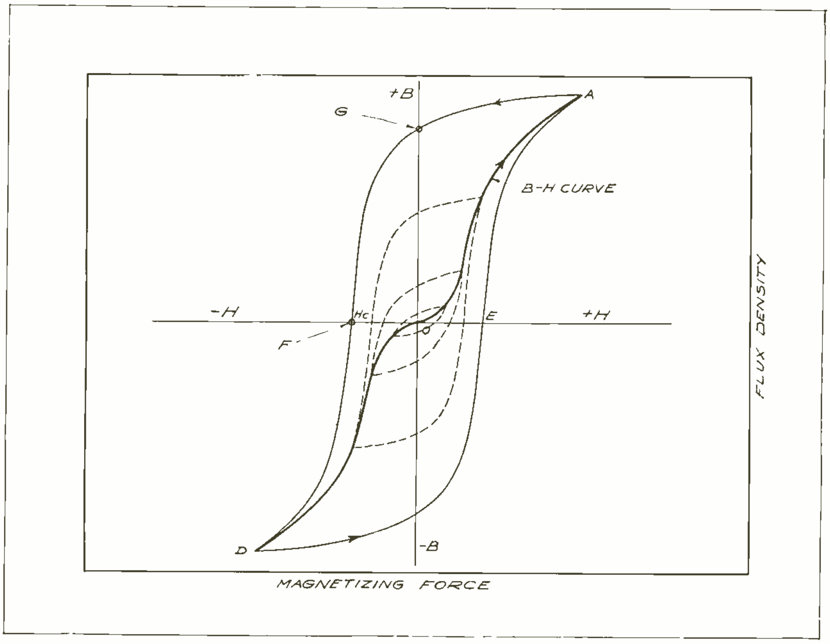
under a pressure of about 200,000 pounds per square inch. The coils made from these iron-dust cores have extremely small losses and also their characteristics continue very constant in service.

Those materials which a high coercive force classes among the permanent-magnet steels derive from a relatively small carbon content their peculiar property of retaining, after magnetization, a large amount of magnetism even under the action of considerable demagnetizing forces.

Other materials which may be added, such as chromium, tungsten and cobalt, add in producing steel of even higher coercive forces. The permanent magnets made from such materials are used in telephone design largely for providing a polarized magnetic field in the operation of ringers, polarized relays, and receivers, and for producing the magnetic flux through the armatures of magneto-generators.

demagnetizing action which is proportional to the relative lengths of magnet and gap.

Of the magnetic steels carbon-manganese and one percent chrome steel are nearly alike in their properties and may be used almost interchangeably. Since they are manufactured by the cheapest steel-making processes they are extensively used where the size of a magnet is less important than its low cost. Magneto-generators, coin collectors, and ringers are some of the equipment in which these steels are profitably employed.



A group of magnetization curves. The heavy line OA shows the behavior of the sample when first magnetized. The ordinate G indicates the residual magnetism; the abscissa F the coercive force. The area included by A G F D E measures the energy loss due to hysteresis; hence its designation "hysteresis loop." Dotted lines are for lesser degrees of magnetization

The requirements of the apparatus dictate to a large extent the shape of the permanent magnet, but its ends are usually brought close together and the magnetic gap partially closed by inserting some soft magnetic material. This is because the poles of the magnet exert on the magnet itself a

Tungsten magnet-steel is similar in composition to carbon-maganese steel except that it contains about five or six percent of tungsten. This steel has to be made in a crucible and its cost is four or five times that of carbon-manganese steel but its coercive force is twenty-five to fifty percent higher. It will withstand greater demagnetizing forces and it may therefore be used in shorter magnets. This steel is used in head receivers, loud speakers, polarized relays, selectors and some of the higher-grade magneto-generators.

High-cobalt steel is of rather recent development and marks a decided advance in permanent-magnet steels. It contains about thirty-five percent cobalt, about eight percent tungsten and three percent chromium. The carbon content is about the same as that in the other magnet-steels. Coercive force of this steel is from three to four times that of tungsten steel and consequently it is very resistant to demagnetization. Magnets made of it may be very short and still be of satisfactory strength. It is now employed in some receivers, in electromagnetic phonograph reproducers and in high-speed relays. The only drawback to its extended use is its cost, which is about ten times that of tungsten steel.

In the processes of rolling or drawing soft magnetic materials their structure is strained and distorted; and this greatly decreases their permeability and increases their coercive force. The condition may be relieved and the desired quantities obtained by a proper heat-treatment which differs somewhat with different materials. In general, the process consists in heating them at a proper temperature for a given time, sealed in metal boxes which are then allowed to cool slowly. As might be expected, the magnet-steels require hardening by quenching in water or in oil from a definite temperature.

In the investigation of all these magnetic materials there has been in the past an immense amount of work which is the basis of our present design-information on electromagnetic cores. All of the materials have been improved in their properties, but the most remarkable achievements have been in the development of the permalloys for high permeability and of cobalt steel for high coercive force.

A new day has thus come in design and a new field for improvement opens before the designer with each development of magnetic materials. The continuation of present investigations which are relating the physical and chemical constituents of a material to its magnetic properties give promise of even greater developments in the future.

Stroboscopic Analysis

By F. S. KAMMERER

WATCH the vibrating hammer of a doorbell. Only one hammer is present in person, of course, but two are distinctly visible, one at each limit of motion; and between them is a gray blur.

That sensitive surface in the human eye, called the retina, can record an image of an object only when its motion is comparatively slow; if the speed limit is exceeded, there is visible only a blur, or nothing at all. On the other hand, once the retina receives an impression, that impression stays a while, even though the object moves on.

By virtue of this characteristic, the eye plays many a bewildering trick on the watcher of moving objects. Even so does the camera. As the movie hero comes dashing down the highway, urging his snorting Buick to greater and greater velocity, the wheels of the vehicle appear to be going alternately backward and forward—a familiar illustration of what is known as the "stroboscopic* effect."

Stroboscopic illusions are often destructive of realism in the movies, but they are extremely useful to science in that they offer a means of studying motion too swift to be followed by the unaided eye. Suppose the doorbell already mentioned were situated in a dark room and illuminated by a momentary flash of light. To the eye, or to the lens of a camera, the hammer would appear to be standing still; its position would depend upon when in its cycle the flash occurred. If a series of flash-light pictures were taken, properly timed, observations could be made of the hammer's motion throughout its cycle. With steady illumination, on the other hand, because of the momentary stop at each end of the stroke, the hammer would appear in the photograph to be in two places at once.

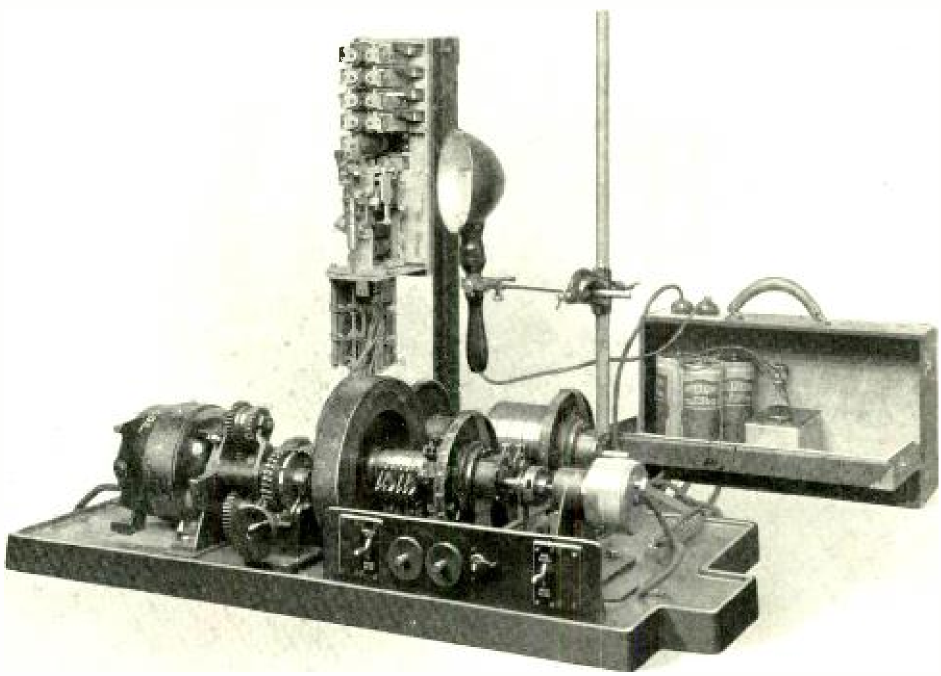
In the telephone plant, particularly in step-by-step machine-switching offices, there are many reciprocating devices whose motion, like that of the doorbell hammer, is too rapid for study by the unaided eye. Since the motion is repeated over and over, it is possible by an instantaneous light-flash to observe the moving part at the same place in its successive operations, and thus apparently make it stand still. Then by successive flashes timed to occur later and later in the cycle, the part seems to go through its operation as slowly as may be desired.

In this sort of study a machine called a Vibroscope is used in modified form. The light comes from a neon-lamp—a two-electrode tube filled with this rare gas. A momentary high voltage is applied to the tube, resulting in the break-up of gas molecules whenever a flow of direct current is broken in the primary of a transformer. This makes the gas glow a bright orange during the

** Stroboscopic comes from two Greek words: strobos, a whirling; and skopos, a watcher.*

moment required to discharge the energy magnetically stored in the transformer core. The primary circuit is closed and opened by an interrupter mounted on the shaft of a pulse-sending machine. The machine is itself a motor-driven interrupter designed for laboratory use to apply current-impulses of any length to apparatus under test. The point in the cycle of current-impulses at which the flash occurs is determined by the setting of the Vibroscope interrupter. If then a certain event in the cycle of the reciprocating mechanism is noted to take place at a certain setting of the interrupter, the time of its occurrence can be calculated in fractions of a cycle. Knowing the number of cycles per second from the speed of the pulse-sending machine, the time-interval in seconds can then be calculated very readily.

A concrete example of laboratory use illustrates the operation of the Vibroscope. In the accompanying picture is shown testing apparatus set up to study a switch used in step-by-step systems. This switch has an armature actuated by an electromagnet; instead of a hammer, the armature carries a pawl which engages and advances a ratchet. It was proposed that a new and improved type of magnet be used, but there was some question as to whether it would not move the armature so rapidly as to cause excessive wear. Field tests, involving the installation of a number of switches in actual service for an extended period of time, would of course have answered the question. But with the aid of the Vibroscope, the problem was quickly and con-



Vibroscope geared to pulse-sending machine, set up to analyze switch used in step-by-step machine-switching systems veniently solved within the Laboratories. The greater velocity with which it moved the armature was not dangerous; the new magnet was approved.

In such a study as this, the armature's "operate" stroke might be divided into three parts: that between make of current and beginning of motion; that from start of motion until pawl engages ratchet; and that required to advance the ratchet. Extent of movements being known, velocities at various points are easily calculated. Any irregularity of action also can be observed and its causes studied and if possible remedied. Similarly the action of the armature pawls, retaining pawls, and ratchets may be observed.

The stroboscope is not limited to testing; it is also useful in the operation of certain apparatus—for instance, in the Vitaphone. Here a number of vertical black marks, evenly spaced, appear on the turntable of the recorder. They are illuminated by a neon lamp in circuit with the motor operating the motion-picture camera. When these black lines appear to be standing still, the recorder and camera are in synchronism. This will recall to many the combination of arc-lamp and sector-disc to measure the slip of an induction-motor which forms a familiar experiment in college laboratories. The neon lamp is more efficient, more compact and more flexible than the arc. And so through the neon lamp the science of electronics makes one more contribution to the telephone art.

In the Month's News

Picture Transmission as a special case of the electrical transmission of intelligence, was the subject of a talk by J. W. Horton before the Pittsfield Section, A. I. E. E. on November thirtieth. A demonstration of particular interest was the reproduction, through a loud-speaking system, of a phonograph record of the electric currents which pass over a telephone line for the transmission of a picture.

During November, O. S. Markuson and R. M. Moody were in Hawthorne in connection with regular Survey Conference work.

P. B. Almquist, Local Engineer for the Inspection Department at San Francisco, recently visited Los Angeles, San Diego and Seattle in connection with regular field work in his territory.

A conference on the general situation with respect to Engineering Complaints and Questions from the territory of the Southern New England Telephone Company was held in New Haven on November 22nd. In addition to Southern New England Telephone Company engineers and Western Electric Distributing House people, R. L. Jones, G. D. Edwards, S. C. Miller and R. J. Nossaman were present from the Laboratories.

C. H. Amadon and J. A. St. Clair attended a conference in Atlanta on November 4th, pertaining to the quality of creosoted yellow pine poles furnished in the Southern Bell Telephone & Telegraph Company's territory.

On November 23rd, L. R. Stadtmiller and C. H. Amadon were in Chicago attending a meeting of the Wood Industries Division of the American Society of Mechanical Engineers.

At a joint meeting on December second of the Plainfield Section of the A. S. M. E. and the Engineers' Club, L. S. O'Roark of the Bureau of Publication spoke on "Recent Advances in Electrical Communication." The talk included discussions on carrier-telephony and of frequency requirements of telephone lines. The relation between frequencies transmitted and the quality of speech and music was demonstrated with the aid of special phonograph records. Mr. O'Roark delivered a talk along essentially the same lines at the December fourteenth meeting of the Detroit Section of the A. I. E. E.

Henry B. Arnold spent several weeks in Georgia in connection with the power line carrier telephone system of the Georgia Railway and Power Company.

R. E. Kuebler has completed a series of Vitapone demonstrations for the New York Telephone Company. These shows were held in the new building at Vesey Street.

H. M. Stoller visited the factory of the General Electric Company at Fort Wayne and discussed the production of Vitaphone motor equipment for the year 1927.

G. T. Lorance and A. Chaiclin spent several days at Houlton, Maine, in reconstruction work on the transatlantic radio equipment.

QUESTIONS CONCERNING gas engines and other power equipment have taken H. T. Langabeer to Buffalo, H. M. Spicer to Philadelphia, F. F. Sibert to East Pittsburgh and R. L. Lunsford and J. M. Duguid to Hawthorne and Pittsburgh.

THE SMALL UNATTENDED machine switching exchange at Sinking Springs, Pennsylvania, was placed in service on November 13th. This cutover, which occurred simultaneously with that of the large central office in Reading, was attended by L. D. Plotner.

L. W. PARKER visited Boston in connection with straightforward trunking development.

J. C. CROWLEY has returned from Nashville, where he was supervising the installation of a one kilowatt broadcasting equipment for the Life and Casualty Insurance Company.

W. L. TIERNEY is now in Los Angeles, California, supervising a one kilowatt broadcasting installation for the Trinity Methodist Church.

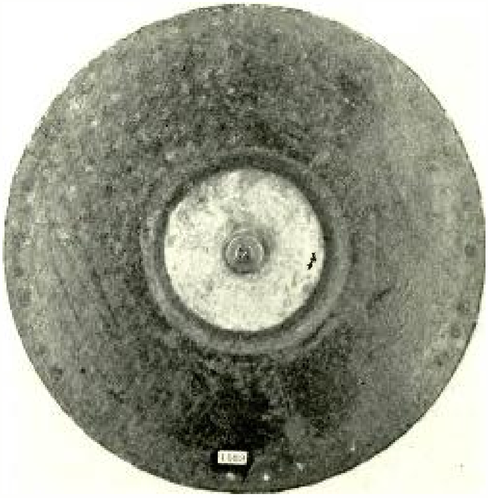
D. H. NEWMAN'S trip to South America has been postponed indefinitely and he is now in Urbana, supervising a one kilowatt broadcasting installation for the University of Illinois.

F. M. RYAN and A. B. BAILEY are in Glacier National Park assisting in a radio survey for the Great Northern Railroad. Tests to determine the feasibility of an emergency radio service across the Continental Divide are being made.

AS GUESTS of the New York, New Haven and Hartford Railroad, O. M. Glunt, N. H. Slaughter, E. L. Nelson, F. M. Ryan and S. E. Anderson recently visited New Haven. The trip was made on one of the railroad's inspection engines.

G. C. PORTER spent the latter part of November at the Hawthorne Works in connection with the production of electromagnetic reproducers for phonographs.

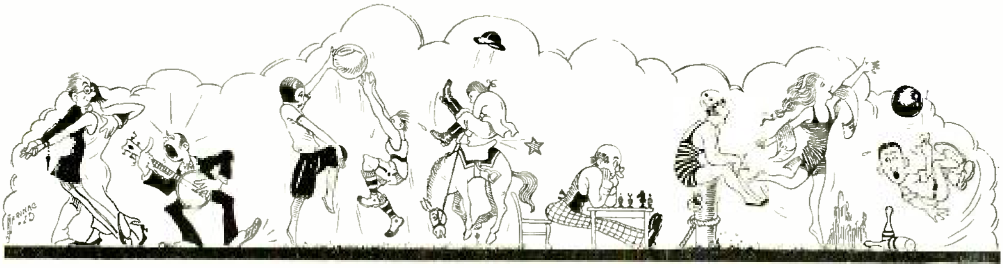
An acoustical telephone of the vintage of 1884 was recently presented to the Historical Museum by H. M. Durston of the Pacific Telephone and



An acoustical telephone used in 1884

Telegraph Company. This and a companion set were in use for a few years on a line, some 500 feet long, between a residence and a business office. The instrument, which is shown on the accompanying photograph, weighs about ten pounds. An iron disk, twelve inches in diameter, acts as a face plate. Back of this is stretched a diaphragm of the same size to the middle of which was attached the line, held fast by a button. Transmission was by longitudinal mechanical vibration of the wire.

H. A. ANDERSON has been appointed chairman of the Committee on Aluminum Die-Casting Alloys of the American Society for Testing Materials.



Club Notes

Do you enjoy seeing a real exciting game of basketball? If so, visit the Labor Temple Gymnasium any Tuesday or Thursday evening between the hours of 5:30 and 7:30 P. M. We promise you that the games being played in the Club League are every bit as interesting as those seen on outside courts between professional teams.

This is the third tournament that the club has promoted, and it seems that this year all "A" teams in the League have brought out additional strength, making all the games uncertain for either side until the final whistle has blown. Such scores as 15-14, 19-17, 25-24 and many others that are similar prove that these games are worth seeing. Some of our games are going into extra periods. Play such as this is making J. A. Waldron's job as referee a difficult one.

Once again this season we have our first string players fighting for high scoring honors with an old-time player breaking into the field for the first time and doing a good job of it by nearing the top. This gentleman is none other than A. N. Jeffries.

Plans are being made for a game with the Kearny Works team, the details of which will be announced on the Bulletin Boards.

League Standing December 16

Team	Won	Lost	Percent
Toll Exchange	5	0	1000
Equipment	4	1	800
Circuits	3	2	600
Development	2	3	400
Junior Assts.	2	3	400
Tube Shop	2	3	400
Commercial	2	3	400
Research	0	5	000

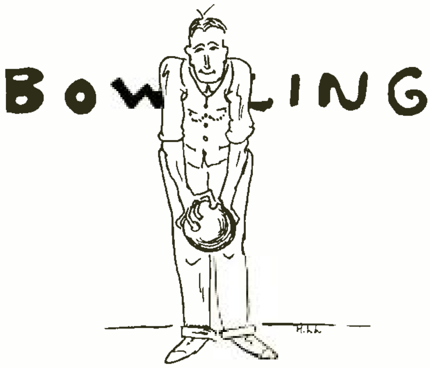
Individual Point Scores

Player Team	Games	Goals	Fouls	Points
Trottere, Equipt.	5	21	3	45
Otterman, Equipt.	5	21	3	45
Maurer, Tube Shop	4	19	6	44
Schneider, Devel.	5	17	4	38
Palmer, Jr. Assts.	5	17	4	38

Christmas Poster Contest

In the November issue of the Record we asked for contributions of posters for our Christmas poster contest. So many excellent designs were submitted that the judges had a most difficult time deciding which one should be accepted for reproduction and placed on the bulletin boards during the Christmas season. After considerable study of all the works submitted, the poster done by Miss Dorothy Bain was accepted. Miss

Bain received the $10.00 gold piece offered by the Club as a prize. The judges decided that the posters submitted by Miss Pease and Mr. Frampton were worthy of honorable mention.



Too much praise cannot be given to C. W. Lowe for the successful way the business of the Bowling League is being conducted. The greatest difficulty is that there are not sufficient teams in the League to take care of all the men who wish to enroll as regulars; this has meant, however, that each Friday evening there is always available a sufficient number of substitutes to give each team in the League its full quota.

Officials this year, who are men that have been connected with bowling since the organization of the League six years ago and who have made a close study of all the averages each year, report that so far this season there has been a greater improvement among the bowlers than ever before. It was no surprise to find that there is a general improvement of 4 to 5 pins in the season's individual averages.

Each year the League takes in men who have never bowled before, and at the end of the season these men are on the way to becoming finished bowlers. We do not claim that this can be accomplished in one year, but an investigation of the League records shows that many of our "A" class bowlers were in "C" class three years ago. "A" class this season represents men whose averages for 1925 were 156 or better.

Many League records have been broken this season, and high scores and high averages have been turned in for an evening's bowling which are a credit to any League.

Recently "Lamps" in "A" class rolled 1039 for one game; if our readers understand bowling they will realize that very very few five-man teams in the State are capable of making this score. There have been several scores of over 250 for a single game, and averages of over 200 for three games are getting to be very ordinary.

Our substitute committee is always ready to use new material, so if you have hopes of some day becoming a "Jimmy Smith," give your name to a member of this committee and let him start you on the way to fame. The League meets every Friday evening at Dwyer's Manhattan Alleys, 1680 Broadway.

Leading Teams in Each Group

A Class—Lamps: 24 won, 12 lost.
B Class—Signals and Coils: 22 won, 14 lost.
C Class—Buzzers: 27 won, 9 lost.

Individual High Averages

A Class—H .C. Dieffenbach, Signals, 186.9.
B Class—C. E. Flagg, Cables, 169.9
C Class—B. W. Kendall, Buzzer C, 155.5.

Individual High Scores

A Class—J. R. Kidd, Buzzers, 254
B Class—L. G. Hoyt, Plugs, 257.
C Class—A. J. Spielberger, Relays, 214.

Women's Activities

With Christmas came the close of the first half of the winter season's activities. With elections and shopping looming large before the eyes of everyone it seemed best to have a rest before opening the spring classes.

All of the sports this past year have been well attended, and the women enthusiastic for continuing them. The swimmers have been getting better and better every day and after this brief rest will re-open the class very soon. Judging from the interest shown in these classes, there will probably be one class the first ten periods and two classes the second ten periods. While a good many of the present members have been swimming now for some time, do not let the feeling that you can't swim at all keep you away. There is always a group of beginners.

The snow makes it difficult for regular riding or hiking, but for both there are days which promise good sport. The riders can satisfy their desire for interesting scenery along the park paths, providing the pavements are not slippery; and surely there is real sport in a snow-shoe hike. Miss Gilmartin will be glad to let you have tickets for the Unity Riding Academy and Miss Barton will be able to tell you good places for hiking if you'll just call them up.

Bowling

There are plans afoot to have bowling for the women this coming season. Are you interested? If so, let us hear about it. Several good bowlers have offered their services toward giving the new bowlers a good start.

The gymnastic and dancing classes, too, have been helping to keep the women in trim. After a day over the desk or typewriter this group get together at the Manhattan Trade School and for the time being, at least, forget all about the office and think only of the things Mrs. Watkins talks about. Some nights, after the preliminary stretching and relaxing exercises, each one is put in a group, which then proceeds to demonstrate good technique for the rest of the class. On other nights, when the crowd is not so large, Mrs. Watkins may pick out the best group to give a special demonstration. But the best of all is when she herself shows what is right and what is wrong. Then everyone enjoys it most. All the groups are most enthusiastic about the teacher and our hope is that we may be able to obtain her services for the next class, which will probably begin the end of this month or the first of February.*

Basketball

The Basket Ball games have not been having the support due to them. Come, folks, and cheer up the players. The teams have now been picked for inter-group games and we do want more side-line cheering. We plan before the season is over to have a Company team which will beat any other one in the Bell System.

**In the October magazine an error was made in saying that Mrs. S. S. A. Watkins was connected with the Noyes School. Mrs. Watkins has never had any connection with this school but is with the Neighborhood Players.*

Picture Contest

The Picture Contest has proved a great success. A great many very fine pictures were submitted and judged. The prize pictures will be printed with a full report in the February Record.

Club Elections

As a result of the recent club elections held on Monday, December 13, the following officers have been elected:

President—E. J. Johnson.

1st Vice-President—J. V. Moran.

2nd Vice-President—Vivian Kilpatrick.

Departmental Representatives

Commercial—A. A. Redding.

Research—A. L. Johnsrud.

Tube Shop—P. Higgins.

Telephone System—T. J. O'Neil.