Bell Laboratories Record

Volume Four | July, 1927 | Number Five

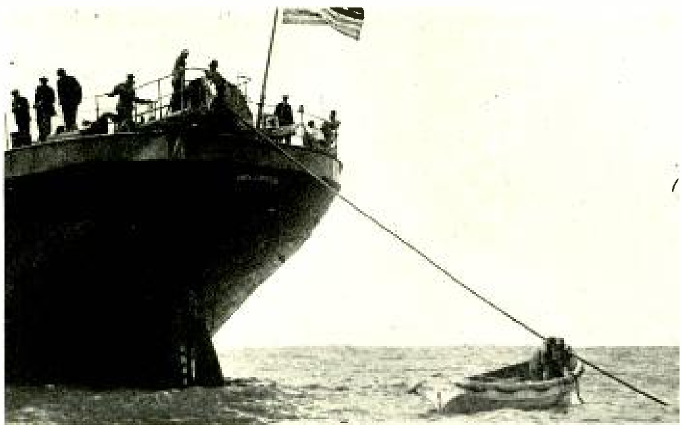
Insulation for Submarine Cables

By R. R. Williams

All electrical engineers are concerned at times with the effect of water on insulating materials. Sometimes it is rain flowing over glass or porcelain insulators or penetrating into crevices at wire or cable connections. Very often, especially in telephony, it is the humidity of the atmosphere which condenses on surfaces of panels or mounting strips or in the fibres of textiles or paper. But that the water hazard is acute is nowhere so obvious as in the submarine cable. Under the trying circumstances in which such cables are used all insulating materials have shown some surprising weaknesses, and the word "waterproof" has therefore become a term which may be considered descriptive of an ideal rather than of any material actually available.

A variety of constructions are used for cables classed under the general name "submarine." For shallow waters of rivers and harbors, lead sheathed paper insulated cable is often used, especially when a demand exists for numbers of circuits following the same course. But for more than about a thousand feet of water, such a cable will not do. For greater depths attempts to use lead-sheathed cables would lead to very special designs of rather doubtful practicability. Moreover, for long cables the attenuation per mile must be kept very low, for one cannot install repeater stations at many intermediate points. Heavy conductors are required to keep resistance low; thick insulations to reduce capacity and leakance; minimum feasible weight to facilitate laying and repair; and a compact and rugged structure to avoid damage in handling or by great hydrostatic pressures. Modern cables also require loading for the same reasons that land lines do. For mechanical reasons, the loading must consist of a continuous layer of magnetic material which, to be effective in long cables, must be of high permeability. Above all else, the submarine cable needs to be made mechanically sound over every inch of its length, for a local damage to the relatively tender gutta percha insulating sheath which develops after the cable is laid means a heavy expense for repair.

Our study of insulating materials for submarine use has consisted to a great extent in prolonged soaking in water with observations from time to time of their chemical, mechanical and electrical properties. Rubber in its familiar forms was tried at the start, using genuine sea water from Rockaway Beach, as well as a synthetic imitation and the pure distilled variety. All the rubber specimens gained in weight by soaking up water and many of them swelled visibly, especially those in the distilled water. In this medium some circular rubber sheets originally five inches in diameter enlarged to a diameter of seven inches after a few months, while their counterparts in sea water swelled barely perceptibly.



Laying a transatlantic submarine cable

This phenomenon brought to mind an experience with the preserving of mangoes. This fruit has a tough skin which is not removed for preserving. The mangoes sometimes swelled and burst; and sometimes they shriveled and the skins wrinkled; in either case an offense to the housewife's esthetic sense. But sometimes they behaved properly, which gave the clue to the cause. It proved to be merely a matter of the sugar content of the syrup in which the fruit was immersed; if too thin the mangoes swelled and burst, if too thick they shriveled. But if the sugar content of the syrup was very near that of the juice of the mango, the original form was preserved. The reader will instantly recall experiments upon osmotic pressure in his high-school physics course and realize that a suitable strength of brine might have been substituted for the syrup with equally good effect on the form, if not on the flavor of the fruit. The physician, too, makes use of this principle when, to avoid swelling or shriveling of the tissues, he uses "physiological salt solutions" in which to dissolve the drug he wishes to inject under the skin or spray into the nasal passages.

Solutions which do not change in relative volumes when brought into contact with one another through semi-permeable membrances are called isotonic. If not isotonic, the weaker solution will lose water to the stronger, because, in the simplest terms of the kinetic theory, the bombardments of free water molecules are unequally dense on the two sides of the membrane, the water being diluted with more foreign molecules in the stronger solution.

Osmotic exchange of water between the interior and exterior of the insulating mass has proved to be the theme of the first chapter in the study of submarine insulation. Such exchange goes on in all insulating materials whether immersed in water or exposed to humid atmospheres, for osmotic pressures and vapor pressures are closely akin. Wide variations in behavior can be observed among the various substances we commonly use, but in Kipling's words they are "sisters under the skin," or external membrane, if you prefer. Gutta percha, the princess of the South Seas, is no exception.

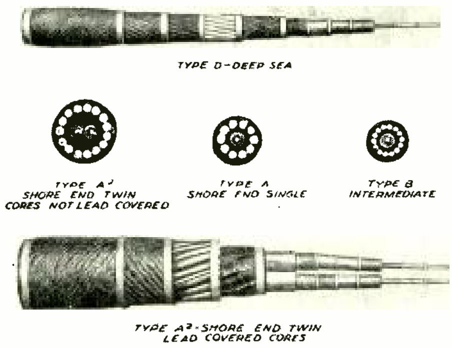
The principle means for controlling this osmotic exchange is the exclusion of water soluble substances from the interior of the mass, since we cannot increase the salt in the sea. Rubber globules, as they are caused to coagulate and cohere in masses in the plantation tanks, entrap considerable quantities of the serum of the latex containing mineral salts, organic acids, sugars, proteins, etc. These are only partially removed by the subsequent light washing to which the rubber is subjected, but they can be removed by more thorough washing. Rubber has recently come on the market which is made by evaporation of the entire latex and which therefore contains large amounts of water soluble substances. Such rubber when soaked in sea water has been observed to absorb more than three times its own weight of water, while the usual plantation product will not ordinarily absorb more than a few percent of its weight under the same circumstances.

In the case of gutta percha, the material is normally so contaminated with bark and dirt that it has to be washed thoroughly. It also lends itself more readily than rubber to thorough washing, since it becomes soft and plastic in hot water.

The crude products of nature are not alone in the property of absorbing water osmotically. A piece of clear amber bakelite, which you would be proud to have in your pipestem, absorbed seven percent of its own weight. This is especially interesting in view of the rigidity of bakelite. Rigidity has been found to diminish water absorption because it tends to prevent the expansion of internal volumes necessary to accommodate the water. Partly, at least, on this account, rubber which is vulcanized to a hard state absorbs less water than do the less firm forms.

When we come to consider the electrical effect of water absorption, we have no such simple theorem. The effect of entrance of water is never beneficial to dielectric constant, to leakance or to insulation resistance, which are the characteristics of interest to the cable designer. In a rough way the electrical damage increases with the quantity of water, but in no

How cable is stored in the hold of a ship simple mathematical way. That this is so is not surprising, for we have only to make a mental comparison of cream and butter to perceive that the mode of distribution of the water is as important as its quantity. Cream consists of fat globules in a matrix of water, while butter contains water globules in a matrix of fat. Since the continuous phase largely determines the electrical properties of the mass, one can readily predict that butter is a better insulator than cream. Many gradations between the butter and cream modes of distribution of water are to be found in recognized insulating materials.



Some of the forms in which submarine cable is made

A troublesome feature of the study of submarine insulation has been the slowness with which equilibrium is established between the insulator and its surroundings. In general, according to both theory and experience, the time required for a sheet of material to reach a given state of saturation with water is nearly proportional to the square of the thickness. The use of thin sheets for soaking experiments has therefore greatly speeded the experimental work. Fortunately, if the material is fairly good it comes to equilibrium months sooner than if highly absorptive. Nevertheless sheets of good material fifty mils thick, if they are dry at the outset, require a month or more to reach a steady state.

In the form of insulation on a cable core of the usual dimensions, change of water content and of electrical characteristics extends over three to five years if the insulating material is dry at the start. Although he has never publicly acknowledged it, the maker of gutta percha cable provides against this difficulty by leaving the proper amount of water in the gutta percha in the beginning. This also prevents oxidation during working of the gutta percha. Electrically, and because of the characteristics of gutta percha, this small amount of water is only slightly detrimental, and since he must bear with it ultimately, the cable man avoids disquietude in the mind of his customer, as well as the necessity for readjustment of terminal apparatus of the cable by including water in his mixture.

Physical changes attendant upon the entrance of water are the chief but not the sole concern in devising a cable insulation. Its specific electrical characteristics to a great extent determine the whole design of the cable. A lowering of 0.1 in dielectric constant permits a substantial economy in any of the several principal elements of the cable. In loaded cables dielectric leakance is almost equally important, especially if for telephone use. This characteristic is subject to wider fluctuation from one lot of material to another than is the dielectric constant and probably offers opportunity for greater future improvement. The insulation resistance is usually important only as an indication of continuity of covering.

Chemical change is not serious, for the complete darkness, the frigid temperature and deficiency of oxygen in deep water are inhibitive of the usual types of degradation. Mechanical characteristics are vital. The insulating material must be made plastic enough to be extruded about the conductor to form a continuous sheath, and must, when in place, be capable of being made firm enough and tough enough to withstand the very considerable strains involved in subsequent manufacturing and laying operations. The material must be adapted to be joined reliably to new material over the splices in the conductor at joints between core lengths. It must not be brittle at freezing temperatures, nor must it soften too readily in the heat of the sun.

While rubber can be made to serve as insulation for ocean cables, it does not offer the excellent combination of properties possessed by gutta percha. This truly unique and remarkable material forms an indispensable part of almost every section of the world's cable network. Unfortunately it is derived almost entirely from wild forest trees of slow growth which are cut down for the collection of the latex. Plantation cultivation, offering as it does, many difficulties which do not affect rubber growing, is still largely in the experimental stage. As a result the world's supply of gutta percha is constantly diminishing, which is a great pity for it would doubtless find many other uses if cheaper and abundant.

Columbia Honors Research and Development Head of the Bell System

The degree of Doctor of Science has been conferred by Columbia University on Doctor Jewett. In conferring the degree, President Butler referred to the recipient as "bringing to the art of telephony and its development the full weight and power of modern scientific knowledge; building on this foundation a notable organization of research workers and applied scientists, and thereby contributing in highest degree to the perfection of the art of communication between human beings and over increasing distances; a true and genuine benefactor of mankind, who illustrates so that he who runs may read the significance and value of scientific research in industry."

The Television Timer

By H. M. STOLLER

ONCE the general scheme of television had been conceived, one of the most interesting problems to be solved was that of timing the appearance of two light-points at distant places so that they would occur accurately at the same instant. Descriptions of television equipment which have appeared in the BELL LABORATORIES RECORD, together with the public demonstrations, have undoubtedly made the general principle familiar to most of us. A very intense beam of light passing through one after another of the fifty small holes of the scanning disc illuminates, in succession, corresponding small spots of the object in the field. The light reflected from these points affects the photoelectric cells which emit a proportional electrical impulse. At the receiving end these impulses are reconverted, by means of neon tubes, to light of the same relative intensity, which by a second scanning disc becomes a reproduction of the original object. In the timing of the light-impulses lies the crux of the situation, for if the hole on the scanning disc at the receiving end is not in exactly the same relative place as the corresponding hole of the sending disc the figure will be distorted.

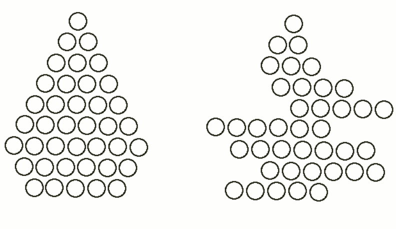


Figure 1

Consider, for example, Figure 1-A and let your imagination minify, multiply and tone these spots so that instead of being a slightly irregular triangle of small circles it becomes the picture of a human nose. The spots indicate the successive areas illuminated by the sending disc and the corresponding beams sent out to your eye through the receiving disc. If the receiving disc, instead of being accurately in step with the sending one, should at times speed ahead of it and at other times fall behind it, the result might be like that suggested by Figure 1-B, which by no effort of the imagination can be made to resemble even remotely a nose—human or otherwise. Thus, whether merely a blotch of miscellaneous lighting intensities or a clearly defined picture is transmitted rests with the effectiveness and accuracy of the timing of the two scanning discs.

Actually, one hole on the scanning disc, as it crosses the field, makes a streak of light; the next hole a second and similar streak just below it. Practically, however, it may be considered that each streak is made up of fifty spots each of which is one of the successive positions of one of the holes on the scanning disc as it crosses the rectangular field. It was found that to produce a satisfactory picture the two scanning discs must never be out of step more than one-half the width of a single spot. As there are fifty streaks of light due to the fifty holes on the scanning disc and each streak is considered as divided into fifty parts, there is a total of 2,500 points of light for each revolution of the disc. In other words, each spot endures one twenty-five hundredth of a revolution. As there must never be a difference of more than half a spot the two discs must thus be kept within one five-thousandth of a revolution of each other.

Suppose the successive pictures of a moving picture, instead of being bound mechanically in one film were each entirely separate and passed in front of the projection beam separately but in proper succession. Imagine the confusion in the result if the time interval between the pictures became irregular. The motion would be jerky and uneven, decidedly unlike the original movement of the actors which it was supposed to duplicate. In television, however, there are not only the 17.7 pictures per second to keep properly timed but each picture is composed of 2500 impulses which must be controlled with proportionately greater accuracy. Here the importance of timing is thus 2500 times greater than in a motion picture and no film is available for the task. Any such scheme of material coupling is impossible, of course, where a distance of 250 miles or more intervenes.

The basic principle decided upon as a substitute for the simpler but impossible physical coupling was that of the interaction between a synchronous generator and a synchronous motor. When such a pair is electrically connected they will each make the same average number of revolutions per minute. With fluctuations in load or voltage, however, one may momentarily jump ahead or lag behind the other by as much as twenty

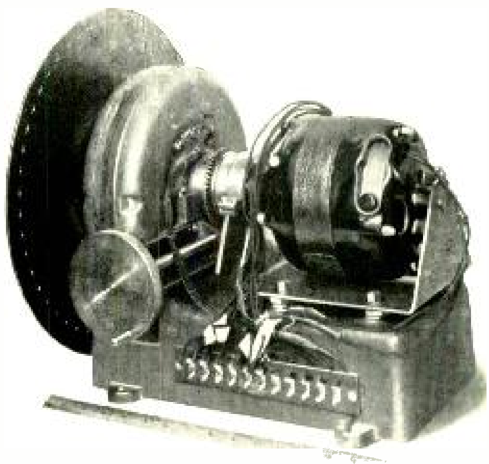


Fig. 2—Fifteen-inch scanning disc on left, 240-pole synchronizing motor with framing hand-wheel in center, two-pole converter on right

electrical degrees. The circle of 360 electrical degrees runs from a north pole around through the south pole to the next north pole. For a motor with one pair of poles, therefore, an electrical degree corresponds to an ordinary circular degree. Should the motor have two pairs of poles an electrical degree is equal only to half a circular degree. If the possible variations of a synchronous motor are twenty electrical degrees and the variation in speed of the discs must be kept within one five-thousandth of a revolution, it is obvious that a motor must be chosen that has sufficient number of poles to make twenty electrical degrees equal to one five thousandth of a revolution or .072 circular degrees. It was felt, however, that under the naturally steady load conditions existing there was little liklihood of the full twenty-degree deviation's being attained, and that a little less than half of this would be sufficient allowance. This judgment has been borne out in practice. A motor was chosen, therefore, with 240 poles or 120 pairs of poles. The design of this motor was a special problem of considerable proportions itself. The details of the design are probably not of general interest, however, and may be passed over.

The complete problem of synchronizing the scanning discs was not solved, however, by the design of this motor alone. Two such motors, one on the sending and one on the receiving disc, may lock in step at any of 120 possible positions and thus while the parts of the picture would be in proper relation to each other they would be displaced. The top half might be at the bottom or in some similar disarrangement. To avoid this difficulty a second motor with only two poles (one pair) was coupled to the one with 120 pairs. Motors with only one pair of poles can lock in step in only one position so the two-pole motors were used for synchronizing the discs and then the 240-pole motors were connected to maintain the required high degree of synchronism.

The work was still not ended, however. It seemed desirable to reduce the load on the synchronous motors to as small a value as possible to cut down possible changes in speed. Also some more effective means than the synchronous motor was wanted to bring the discs up to the normal speed of 1062.5 revolutions per minute. Nothing could fulfill both of these requirements better than a direct-current motor with adjustable speed. But rather than add a third motor, one piece of equipment was made to serve two purposes. A standard direct-current motor was modified by bringing out from the armature a couple of connections to slip rings. This changed it into a rotary converter which could act both as a two-pole synchronous motor and as a direct-current motor. This gave the compact unit shown in Figure 2, and disassembled, in Figure 3. The first of these shows the fifteen-inch scanning disc to the left, the 240-pole motor in the center and the modified two-pole direct-current converter on the right. The use of the two-pole motor removed most of the difficulties of framing or locating the picture, but while the motors were bound to lock into step at the proper point there still might be a slight relative

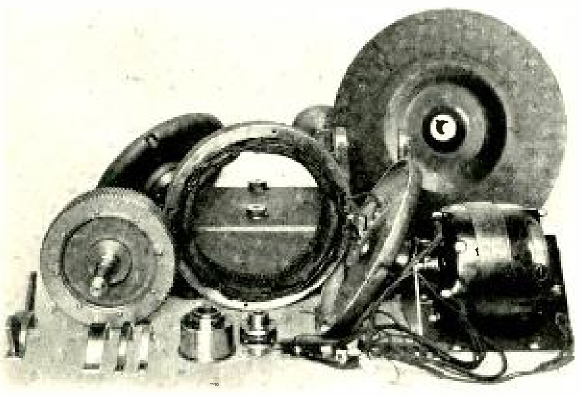


Fig. 3—Synchronizing drive disassembled. Rotor and stator of 240-pole motor shown at left

displacement between the receiving and sending discs. To be able to correct this, therefore, the motors were mounted so that the frames could revolve and a hand wheel driving a worm and gear, shown in the illustrations, enabled this adjustment to be made.

Thus the heart of the timing system consists of two small double units with their connecting circuits. The power to start and drive the disc is obtained from a direct-current motor taking its energy in each case from a local source. A very special 240-pole synchronous motor is used as a metronome to hold the play of the light spot to the proper time. The alternating-current side of the modified direct-current motor, acting as a two-pole synchronous motor is used as an aid in synchronozing the motors and in properly framing the picture. In an alternating-current motor or generator the frequency of the current alternations is equal to the speed of the motor multiplied by the number of pairs of poles. Thus the 240-pole motor operates at a frequency of 2125 cycles and the two-pole motor at 17.7 cycles.

Transmitting this synchronizing power is an interesting story in itself. Limitations of the transmitting channels enter and cause many complications and added difficulties. Because of this the synchronizing current is attenuated to a very low value for transmission and then amplified at the receiving end. The 17.7 cycle current, being an undesirable frequency to transmit over telephone cables, is used to modulate a 760 cycle current which is transmitted and later demodulated.

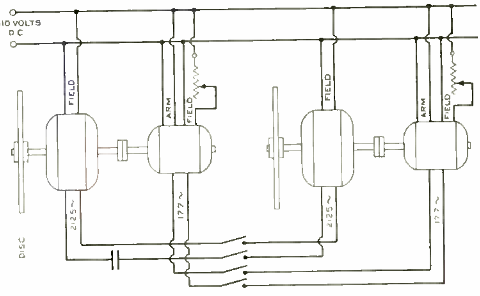


Fig. 4—Diagrammatic arrangement of synchronizing equipment

The control problem is another whole story in itself. So far as the synchronization of the two discs themselves is concerned, however, it may be considered that the motors are connected by ordinary wire circuits as shown in Figure 4. This shows diagrammatically the equipment which by its peculiar design holds two minute spots of light in step to one ninety-thousandth of a second, even though those spots be 300 miles apart.

Wax Lubricants

By D. W. MATHISON

FEW lubrication problems relating to telephone equipment can be solved by conventional procedure or materials, particularly in the machine-switching field where parts are small and cost and space are important considerations.

For the rotating members of machine-switching frames special lubricators to deposit oil and grease in the bearings have been developed in accordance with established practice, but for brushes, contact-points, and current-carrying members quite different treatment is needed. Certain movable parts of manual switchboards, especially those adjacent to contact points, present the same lubricating problem as the machine-switching elements. Lubricants for such parts of switchboards must meet a number of requirements in addition to that of reducing friction, requirements to which usually no thought need be given. A lubricant to be satisfactory must be non-evaporating, on account of the long life of the equipment itself; it must be adherent, but not sticky or corrosive; must not spread; and must be a non-conductor.

Although light oils, such as are used for typewriters and sewing machines, are volatile to a scarcely perceptible degree, the film required on a bank of machine-switching contacts is so thin that such oils would last only a small fraction of the life of the equipment. The tendency of most oils and greases to spread over adjacent surfaces, collecting dust as they go, is notorious. Not cleanliness for its own sake, but protection of molded insulators from softening and prevention of electrical leakage between terminals across such a film of dirty oil make it essential that a non-spreading and non-adhesive substance be used. Non-conductivity, on account of the arrangement of terminal banks, is probably the most important requirement of all; it bars a lubricant excellent in other respects: graphite.

Even surface tension is important, on account of the moisture film deposited in humid weather. Friction of certain of the moving parts of the panel frames is increased greatly by such a film; an ideal lubricant should therefore have a surface tension lower than that of water, so that the condensed vapor will form in small drops rather than spread over the surface. This consideration is especially important where the force available for operation is limited.

Although lubrication was not an urgent question until the introduction of machine-switching, problems connected with certain parts of manual equipment presented similar difficulties. An example is the hard rubber roller of a lever-type key. Without lubrication, friction increases so greatly after comparatively few operations that the keys become quite difficult to operate; sometimes the levers of non-locking keys might stick in the operated position. Oil or grease could not be used on account of their softening effect on the hard rubber; furthermore, nearness of the contact points prevented use of any substance whose spreading would contaminate them. After experimentation with various substances, thorough satisfaction was obtained by dipping the rollers into melted ceresin wax, a substance similar to paraffin but with a higher boiling point. The excess wax is drained off and a light coating is left, most effective in reducing wear and friction, which meets the ideal requirements in all respects.

The operating stud, of hard rubber, used on the switchhook of coin-collect telephones gave another use for ceresin wax. Investigation of a complaint that the hinge squeaked showed that the stud was the cause of trouble. A saw cut was made in the end of the stud, where it slides on the contact spring, and was filled with the wax; that silenced the squeak and the complaint as well.

It is not always possible to dip the parts to be lubricated in melted wax; for relubrication after a period of service this procedure is rarely feasible. Banks of terminals on machine-switching frames are an example. The experiment was, therefore, tried of dissolving the wax in carbon tetrachloride and spraying it. The solvent, however, evaporated instantly on leaving the air-brush and left a spongy mass of wax attached to the nozzle; the coating deposited on the terminals was rough and lumpy and of little value. On account of fire hazard no attempt was made to use an inflammable solvent, but after experimentation with various waxes it was found that a mixture of spermaceti wax and vaseline dissolved in carbon tetrachloride could be sprayed successfully, to give an even film of good lubricating value.

Shortly after development of this wax mixture the operating companies experienced trouble with plunger-type keys which became badly abraded, and often stuck in the guides. Trials of the wax-vaseline mixture yielded such good results that plungers of the keys are now painted with it; no further trouble has been encountered.

More recently the same mixture has been adopted for the restoring system of multiple brushes on panel-type frames. After a conversation is finished, the restoring mechanism associated with an elevator rod spreads the pair of brushes which had been used. As the rod approaches the bottom, the end of a small projecting lever is stopped by a sheet metal plate; final downward travel of the rod, which carries the fulcrum, swings the lever to a horizontal position and in doing so swings a pair of tiny hard rubber rollers between the inner contact points of the brush, spreading them to their unoperated position. Previously no lubricant had been used for this mechanism. Now the rollers, and the plate against which the lever rubs, are painted with the mixture. Although usually so thin that it cannot be seen, the wax-vaseline film has brought a great decrease in friction and hence smoother operation.

Further uses for wax lubrication appear from time to time, sometimes on parts for which no suitable lubricant had previously been available and in other cases where a partially satisfactory lubricant had been used. Wax is not the solution for all problems of telephone lubrication—in fact for many it is not suitable at all—but for an important group its usefulness can scarcely be overstated.

Quality Rating of Telephone Products

By H. F. DODGE

AFTER you have dined at the Waldorf, or at Childs', or wherever your fancy may have led you, you often comment on the quality of the meal. Considering what you have had to pay, each of the courses measured up to your expectation, surpassed it or fell short of it; and the service was good, bad or indifferent in comparison with what your experience indicated that you had a right to expect in restaurants of that sort. In effect, your mental summing up of the various contributing factors and your final verdict of "excellent" is a rating according to your personal standards of expectancy. With experience along this line your rating would carry weight: without experience your rating might be quite distorted and possibly valueless to others. We all go through such mental processes in judging the quality of clothes, automobiles and what not, merely comparing the object of current interest with a standard of reference. Although this standard is established by the individual, he is largely guided by the opinions and experiences of his associates.

There is no reason for departing from these everyday methods when it comes to rating the quality of telephone products. Instead of placing our measure on a purely qualitative basis, however, by the use of such descriptive adjectives as "excellent," "good," and "poor," it is desirable to reduce our ratings to some simple numerical scale which expresses the level of quality relative to some easily understood and definable standard.

In the course of inspections made

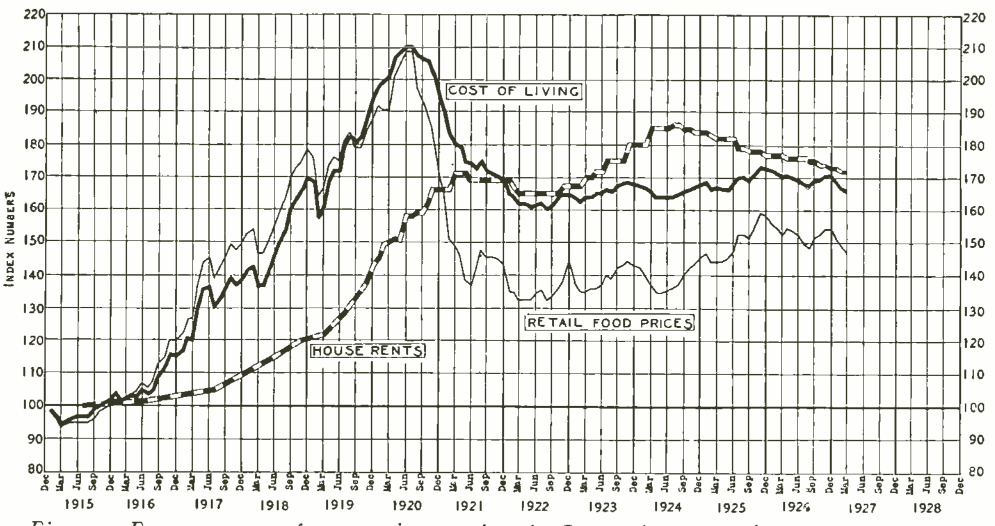


Fig. 1—For purposes of comparison, prices in December 1914 *have been taken as a base and made equal to Index Number* 100

on all classes of apparatus, equipment and supplies, data have been gathered for many years, which show how satisfactorily these products conform to their specification requirements. We thus have the experience necessary for setting up expectancy levels for quality which are determined not by personal preference but rather by the grouped opinions of many individuals and further tempered by considerations of economy in production. It only remains to establish a means for putting data together which will make use of these expectancy levels as standards of reference. Ratings thus derived should be of material assistance in determining how satisfactorily the current production of the Western Electric Company and other suppliers meets the specifications, and what is the trend in quality.

The idea of comparing actual conditions with a standard is widely used commercially to give us index numbers of corn prices, industrial production, and the cost of living. Take for example the matter of cost of living. We all realize too well that it costs more to eat, drink and be clothed than it did years ago. How much? This is usually answered in the manner shown in Figure 1 where "cost of living" is represented by an index number. This number is the ratio of current cost to the cost of living in the last year when normal conditions were assumed to obtain—in this case, 1914. A factor of 100 is customarily introduced to make the index number look like a percentage figure. The curve shows the more or less continuous increase up to 1920 at which time a change in the trend of affairs appeared.

Now it is a fairly simple thing to determine indices for things like the cost of corn or the output of pig iron, since these can be expressed as simple ratios. But for the quality of telephone products even for a simple thing like a cord, there are a relatively large number of characteristics which as a group determine the quality.

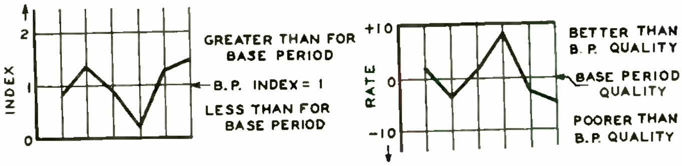


Fig. 2—Relation between Index and Rate for a given item and period of time

A defect is any failure to meet the requirements of the specifications or the recognized standards of workmanship. Defects come in all varieties and vary over a wide range in seriousness. A broken conductor will render a cord entirely worthless, a tip missing is serious but can be remedied, and slightly torn braiding will mar the appearance but will not necessarily involve any trouble in service. For a month's output a small number of defects may be found in the course of check inspection. If these defects are individually weighted according to seriousness by assigning a number of "demerits" to each type of defect, we can find a cumulative figure of "demerits per cord" which will serve to define the quality of the month's product. Current quality may then be compared with that of a previous period which is taken arbitrarily as a standard of reference, and an index may be established for "demerits per unit of product."

In rating telephone products, the

procedure has been to select a base period during which the same essential conditions existed as currently, relative to manufacturing methods, to inspection methods and to character of product. Base-period quality is of the nature of an expectancy for staple products of long standing. For newer products the expectancy level may rise appreciably as the production technic improves. The index is expressed as the ratio of current demerits per unit to base period demerits per unit. Since the demerit is an element of badness, the index increases as the quality grows worse, as shown in the left-hand chart of Figure 2. We prefer just as a matter of habit of thought to have the rate high when the quality is good and low when it is bad. This is done by using the factor (1 — Index) in the rate equation.

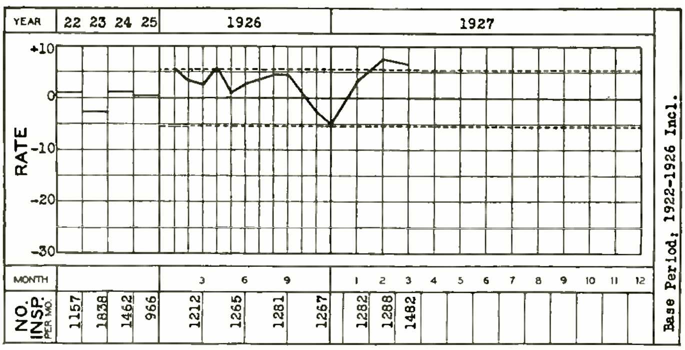


Fig. 4—Rating chart portraying changes in subset quality

For Hawthorne-manufactured products, the equation is therefore

$$\text{Rate} = 10(1 - \text{Index})$$

where the 10 is a convenience figure. This equation as portrayed in the right-hand chart of Figure 2 is merely a numerical way of saying "better than" or "poorer than" base period quality, and it tells as well "how much" better or poorer.

As an illustration of the practical application of this method of rating quality there are shown in Figures 3

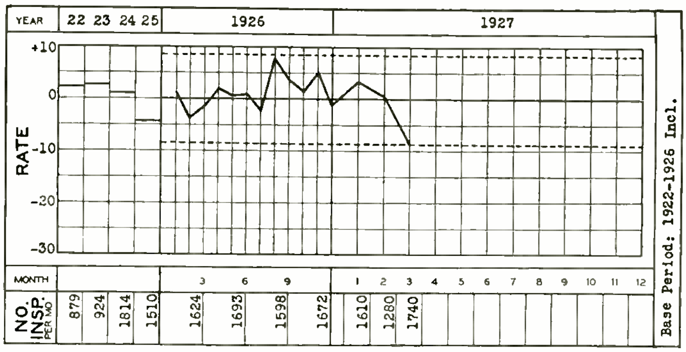


Fig. 3—Rating chart for condensers

and 4 rating charts for two kinds of apparatus—condensers and subscribers sets. These reflect the data obtained in the course of a percentage inspection of the material produced by the Western Electric Manufacturing Department. The samples inspected are selected in such a manner as to make the data representative of the product delivered to the customer. These two rates are computed with five-year base periods, 1922-1926 inclusive, and for each current month the rate is determined by the ratio of the current demerits per unit to the average demerits per unit for the five-year base period. A rate of + 10 indicates perfect performance with requirements, a positive rate indicates quality better than base period quality and a negative rate indicates quality poorer than base period quality. On the chart is given a substantial portion of past history by means of which either upward or downward trends may be observed. An additional feature which is of particular importance from the standpoint of quality control is the use of two dotted lines which are called "Limit Lines." Under perfectly stable and normal conditions we expect to get fluctuations in quality, but some indicator is needed to show when the deviations are greater than could be expected as a result of normal causes. In the case of subscriber sets we note one such instance in February, 1927, when the quality was significantly better than base period quality.

Similar rates are currently being constructed for many other principal products manufactured at Hawthorne. By an additional step it is a relatively simple matter to rate these products collectively, merging the several rates into a single overall rate. Carrying the consolidation feature further we can at least entertain the thought that equipment installed in central offices as well as supply materials can be rated individually and then collectively, leading in the end toward an overall rate for all current additions to plant.

In Recognition of a Group Achievement

For the third time the John Scott Medal has been awarded to a member of Bell Telephone Laboratories: to Herbert E. Ives, as a result of "research and invention in electrical telephotography and television." Upon announcement of the award, President Jewett wrote to Dr. Ives:

"Please accept my very sincere congratulations on your receipt of the John Scott Medal, announcement of which I have seen in the press. It is richly deserved, both for you personally and through you for the group who worked so effectively on those most intricate of problems."

To this Dr. Ives replied:

"In acknowledging your kind letter of congratulation on the John Scott award, I want to make the acknowledgment not only personally, but on behalf of that group of men to whom you have so justly referred. While it has been my privilege to be so connected with these developments that the award has been associated with my name, I am sure it is the intention of the Board of Award to pay tribute to the Laboratories which you direct, and to all the members of the Bell System who have cooperated so effectively in adding a new field to the art of communication."

Drafting of Telephone Systems

By W. L. HEARD

DRAFTING may be compared to a great language with each particular type of engineering work having its own dialect. In this language of drafting, symbols and conventions take the place of words and the greater the extent to which simple conventions replace more complicated sketches, the greater becomes the efficiency of the drafting work. The extent of the saving made by these methods is well illustrated by comparing Figures 1 and 2. The first is a drawing of a simple cord circuit made in June, 1889; the second, a present day drawing of the same circuit. Whether they are compared by the relative space required, by the labor involved in drawing, or by the ease of following through and interpreting the circuits by the field engineer, an enormous improvement is evident. Multiply this advance by the same ratio that the complexities of a large systems drawing bear to the few lines of this simple circuit and some conception may be obtained of the savings that have been made in time and men, or their common evaluation—money.

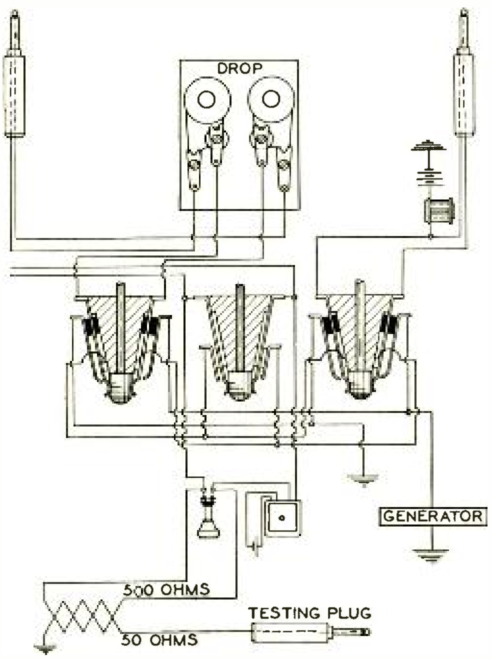


Figure 1

This progress which has been made and is still going on might be called a development of symbols. It has been the result of a constant search for simpler ways of doing things and for quicker, clearer methods of indicating complex ideas. A relay which to actually draw would require hours and perhaps days has been stripped to its innermost essentials and then represented by a suggestive symbol. Thousands of such conventions are used of which a few are shown as Figure 3. The large number involved brings up the problem of classifying, arranging, and indexing them so they will be instantly available for the engineer working on design and the draftsman putting the design into standard form, as well as to the men in the field who have to interpret the drawings. For this purpose the Circuit Convention Book, made up of letter sized loose leaves and very carefully and completely indexed, has come into use.

A glance at the symbols of Figure 3 shows how the convention used indicates the essential function of the

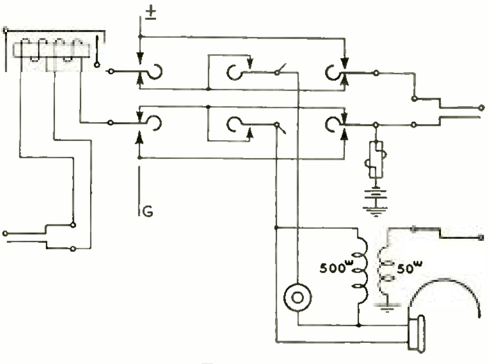


Figure 2

piece of equipment and nothing of the less important detail. Figure 3a, for example, shows a relay with a double winding, suggested by the two looped lines around the narrow rectangle indicating a magnetic core. In operating it breaks contact 3 first and then makes contact 1. In figures 3b and 3c a similar symbology may be followed. Certain functions which are difficult to picture are indicated by suggestive code letters. Thus SO is used to designate a slow operating relay, the simple letter D stands for differential, while FR indicates fast release. Many such shorthand notations are used.

Also a very large number of subconventions are incorporated into the major conventions. The black dot shown on Figure 3a, for example, identifies that end of the winding nearest the core; which, with a standard method of winding, serves to indicate definitely the magnetic polarity. An arrow universally indicates a contact. A circle is used for a pivoting point, and a zig-zag line stands for a chatterless contact. Figure 3d shows two of the lamp conventions, while 3e gives some of the familiar vacuum tube conventions.

Standing back of the Circuit Convention Book, ready at all times to give more complete information regarding any of the equipment shown on the drawing by a simple convention, is a card catalog giving all data regarding every piece of equipment used. Again back of this card catalog, covering items of more complicated detail, are the specification sheets. All this large mass of information is indexed and cross referenced so that any piece of information is available in the shortest possible time. Duplicate files are available for the engineers and for the draftsmen putting the drawings into final form.

In a similar manner a different class of conventions is embodied in the Equipment Handbook. The making of equipment drawings in-

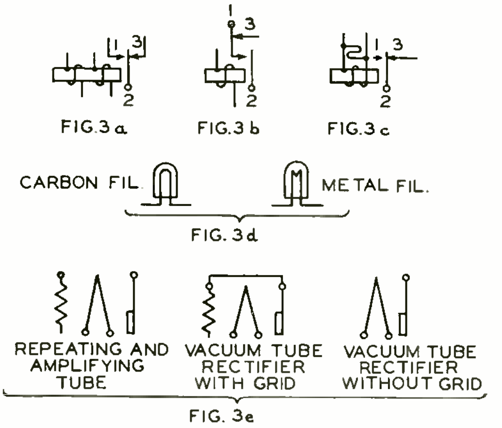


Figure 3

volves more or less the same complexity of detail that the circuit drawings do and requires equally the repeated use of simple conventions and notations. Each individual construction is detailed on a standard sheet and assigned a code number. On the actual drawings only these code numbers are shown, thus greatly cutting down the labor involved. This is illustrated by Figure 4 showing a front panel of a typical switchboard. Each joint such as J-6 or J-7, which are glued, deep square tenon joints, has a detailed standard drawing which completely describes its construction. A similar scheme is carried out in the method of indicating welds and in fact to every detail that lends itself at all to this method of treatment.

To meet the varied engineering requirements many sizes of drawings are needed. Here also standardization has been used and at the same time care has been taken not to hamper the drafting work by too strict a limitation. A unit of length and width of eight or thirteen inches has been selected. All drawings are some multiple of one of these numbers in length and some multiple of the other in width. This insures that any sheet from the smallest, thirteen by sixteen, to the largest, thirty-nine by sixty-four, may be folded up to an eight by thirteen size.

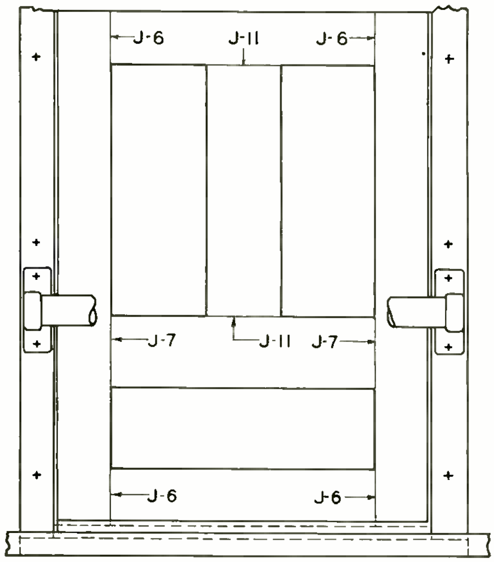


Figure 4

All of these standardizations, Circuit Conventions, Equipment Handbooks, etc., are of inestimable value but after all they do not and cannot serve to make the work mechanical. Back of and vitalizing the whole system is the intellect of the draftsman which has been trained where and when to use all the means put at his disposal. When it is realized that every year nearly five thousand new drawings are added to the files and ten thousand changes made, the economy from slight improvements in system or technic is evident.

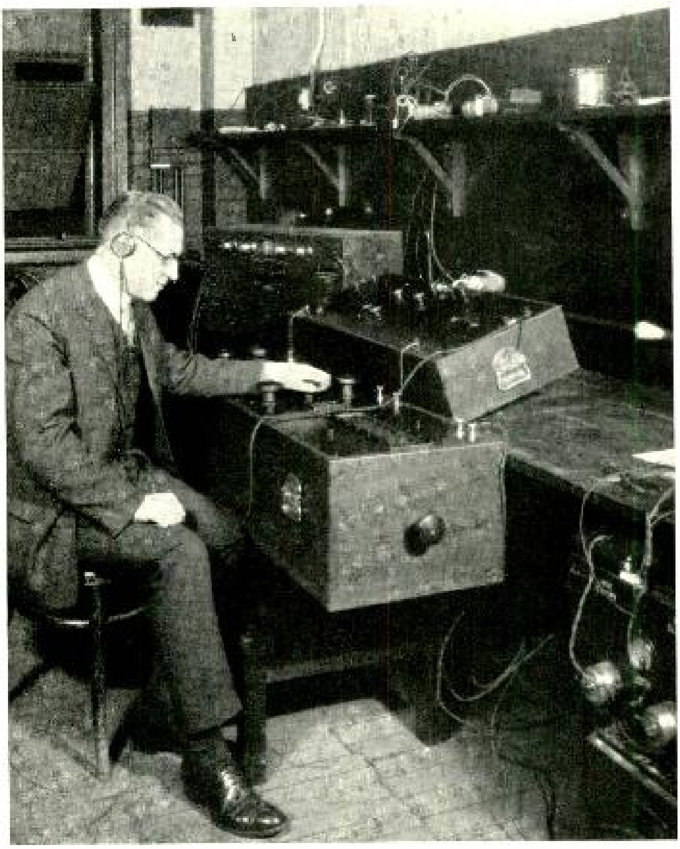
A Direct-Reading Inductance Standard

By J. C. VOGEL

MANUFACTURE of the half million loading coils needed each year by the Bell System requires about two and a half million measurements of inductance, for which testing equipment is necessary giving a high degree of accuracy with but a short period for an individual test. Such a combination of requirements demands a testing set arranged for convenience of manipulation—since it is here that time saving can be achieved without sacrifice of accuracy—and arranged furthermore to give the ultimate result with a minimum of computation.

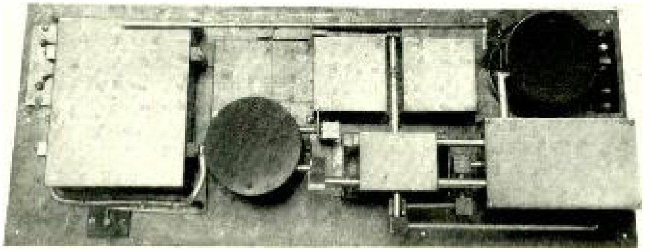
Recent loading developments required testing apparatus of greater accuracy than that previously used. Thereupon engineers of the Apparatus Development Department used the opportunity to combine the maximum of convenience and rapidity of operation with the high accuracy needed, and produced a testing set on which inductance values of the coils to be measured are read directly.

The set consists of a bridge unit and an inductance standard; the latter in turn contains in series four coils of fixed inductance, a continuously variable inductance called an inductometer and a variable resistance. When used, the capacity of the set is first balanced out with variable condensers, after which the coil to be tested is inserted into the circuit. Then, by alternate adjustment of resistance and inductance in



J. C. Vogel measuring the inductance of a loading coil with the direct-reading bridge the measuring arm of the bridge, balance is reached; on a scale attached to the inductometer, inductance of the coil is shown in henries, and effective resistance in ohms.

To insure accuracy and stability, the set has been shielded most thoroughly. Individual shields surround the ratio arms of the bridge, the input and detector transformers and the inductance standards, and in addition all of these parts and the wires as well have been enclosed in a general outer shield.

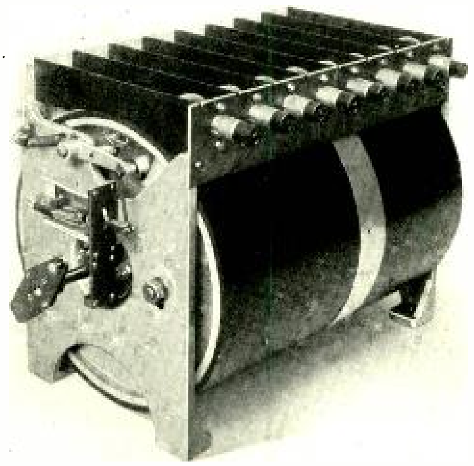


Rear view of the bridge unit, showing the shielded members

The inductance coils are wound on toroidal magnetic cores of high efficiency and stability, but of unique design, consisting of finely laminated permalloy punchings of high specific resistance, carefully annealed and assembled to shape. So fine are these punchings that as many as 8300 are used on one core. The winding is sectionalized to avoid distributive capacitance, and is of insulated stranded conductor similar to Litz wire. After adjustment the wound coils are sealed in protective cases with moisture-proof compound.

Convenience and rapidity of manipulation are obtained by use of two rotary switches which short-circuit the inductance coils not wanted, but leave the inductometer and the variable resistance in the circuit. Each coil terminates on a pair of contact springs, between which is a horizontal bronze disc, partly cut away; the coil is short-circuited or connected as its springs are separated by a solid part of the disc or by an air space. Two such discs are mounted on a vertical shaft which, on being turned, connects the corresponding coils to the measuring circuit separately or together. A like switch controls the other two coils; by use of both switches any combination of the four coils can be made. There are thus provided sixteen ranges of inductance, overlapping slightly, within which final balance is reached with the inductometer.

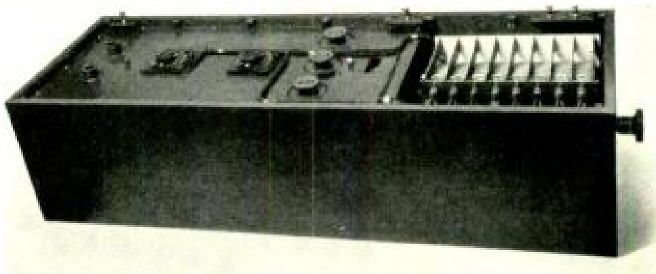
In the inductometer, two thin coils are mounted on a disk rotor, whereby they are rotated between two pairs of similar stationary coils. As they are



Drum assembly, with one scale attached; above are the lamps and separating compartments turned and the coupling is changed from addition of the inductive values to cancellation, fine adjustment is made until the balance point is reached. Fastened to the end of the rotor shaft by aluminum flanges is a drum of phenol fibre, supported in self-aligning ball bearings and carefully balanced to remain in any position. Direct reading of total inductance and of effective resistance as well in any of the sixteen ranges is obtained on eight flexible scale strips fastened side by side around the drum. Each scale extends through about 180 degrees; there are two on a strip, made possible by rotation of the inductometer rotor through 360 degrees. Each scale is calibrated to correspond to one of the combinations of measuring coils, and gives a total value of the coils plus the inductometer. The scale strips are of brass, nickel plated, on which calibration is marked with black cellulose lacquer.

To aid rapid operation and to prevent mistakes from carelessness, a system of lamps indicates the proper scale for each inductance range, and provides enough light for it to be read distinctly. Each lamp is enclosed in a small compartment which shields the adjoining scales; the system is controlled by auxiliary contacts on the inductance coil switches and by a key switch fastened to the inductometer rotor, so that the correct scale for the combination of coils connected is the only one illuminated. Despite the compactness lamps can be renewed, and the scales removed from the drum or replaced, without disarrangement or removal of the lamp compartment structure.

Two of these sets are used by Standard Telephones and Cables, Ltd., the British manufacturing organization of International Standard Electric Company. At Hawthorne, all inductance tests are made on bridges essentially the same—identical electrically and in shielding, but differing in location of scales and in the indicator showing which one is to be read.



Complete inductance standard assembly with cover removed

Development and extended application of loading during the past few years and the likelihood of further advance required corresponding improvement in measuring facilities. In answer the new equipment, on account of its arangement, brought the utmost testing speed; its thorough shielding resulted in accuracy within a quarter of one per cent, a precision previously unknown for routine measurements. Continued development of loading can proceed therefore unhindered by inaccuracy or excessive cost in the field of inductance measurement.

———

The theory and development of the shielding used in this circuit are explained by W. J. Shackleton in the Bell System Technical Journal for January, 1927.

Flood-Time Telephone Service

DURING the disastrous flood in the Mississippi Valley, every effort was made by the companies of the Bell System to maintain the maximum possible telephone service and to cooperate fully with the army engineers, Red Cross, and other agencies for the relief of the stricken areas. A number of special circuits were placed at the disposal of the relief organization; telephone employees fully lived up to their traditions of courage and resource in providing the vital lines of communication between places otherwise isolated.

Of the vital part played by the telephone in combatting the flood and in relieving distress, R. T. Barrett writes in *Bell Telephone Quarterly* for July: "The greater part of the responsibility of forecasting the movements of floodcrests throughout the lower part of the valley rested upon Dr. I. M. Cline, meteorologist in charge of the U. S. Weather Bureau, New Orleans. Of his work, Mr. Hoover said, 'Dr. Cline is a wonder. His flood forecasts have been absolutely uncanny in their accuracy. He has without doubt saved the lives of thousands of people with these bulletins.' Practically every bulletin he has issued has been based to a very considerable degree upon information gathered at points up the river and transmitted to the state headquarters of the Southern Bell Telephone and Telegraph Company, at New Orleans, and thence communicated to the Weather Bureau officials.

"If the telephone system had never done anything else in all of its fifty years," says Dr. Cline, "it would have earned all the credit it could possibly receive for the assistance it has rendered in this single phase of flood work during the present year."

Says John M. Parker, Flood Director for Louisiana:

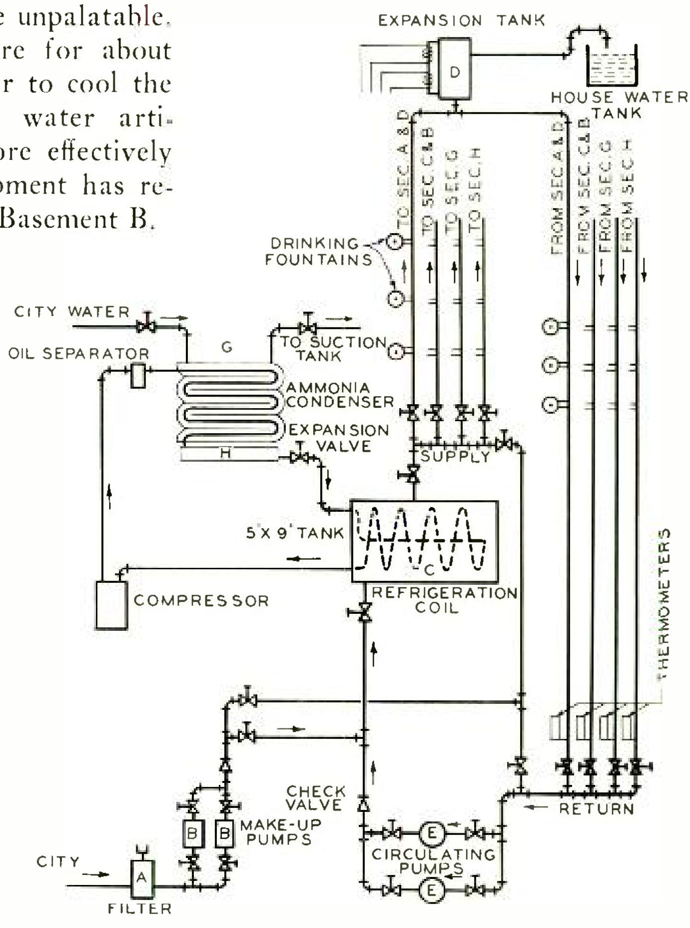
"In our part of the territory we have moved thousands upon thousands of men, women and children out of the path of the flood and, so far as we now know, we haven't lost a single human life. It never could have been done . . . it just simply could not have been done without the telephone."

Cooling Our Drinking Water

By G. F. MORRISON

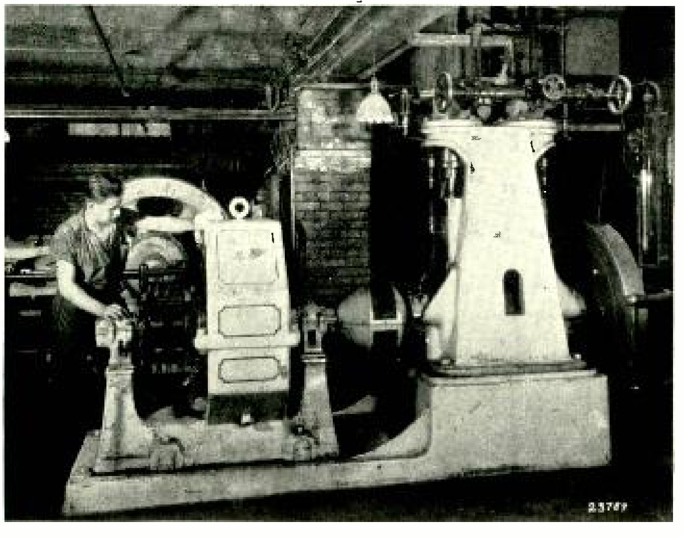
EACH spring, as the sunshine becomes brighter, the snow and ice on the Catskill and Croton watersheds melt, and at the same time the temperature of the air rises. As a result the water in New York City's mains, after flowing over the warmer earth and being exposed to the stronger sunshine rises in temperature until it is quite unpalatable. It is necessary therefore for about eight months every year to cool the Laboratories' drinking water artificially. To do this more effectively new refrigerating equipment has recently been installed in Basement B.

The central point of the system is the refrigerating coil, enenclosed within a storage tank in the basement. Two streams move past constantly, transferring heat as they meet at the surface of the coil; inside a stream of ammonia gas flows steadily, taking up heat from an outer stream of water passing through the tank. From the refrigerating coil the ammonia goes to a compressor where its pressure is increased to a hundred and fifty pounds per square inch and its temperature raised at the same time. Then it passes through a pipe coil in which it is cooled by a stream of water in contact with the pipe. The reduced temperature, although above the boiling point of ammonia at the low pressure maintained in part of the sys-



Schematic diagram of the cooling and circulating systems tem, is considerably below the boiling point after compression. As the ammonia cools therefore it condenses, until it is liquid by the time it reaches the end of the coil. From there it enters the refrigerating coil, passing through a needle valve which restricts the flow and so maintains a pressure in the coil of about twenty-five pounds per square inch. At this low pressure the ammonia vaporizes instantly Since evaporation is a heat-absorbing process, the ammonia gas is quite cold and takes up heat from the water surrounding the coil.

The water flows in a corresponding cycle, but after leaving the refrigerating tank divides into four loops. In each of these the water rises to the top of the building at one point and descends at another; connection of eight fountains in all on each floor is thereby made possible. The water however flows through, not a closed system, but through one in many respects an equivalent. It is heated to a degree in flowing through the loops, but that process is minimized by thorough cork insulation on the pipes. The principal heat absorption comes from loss of cold water at the fountains and replacement by warm water from the city pipes.



Compressor of the old cooling equipment, with its motor

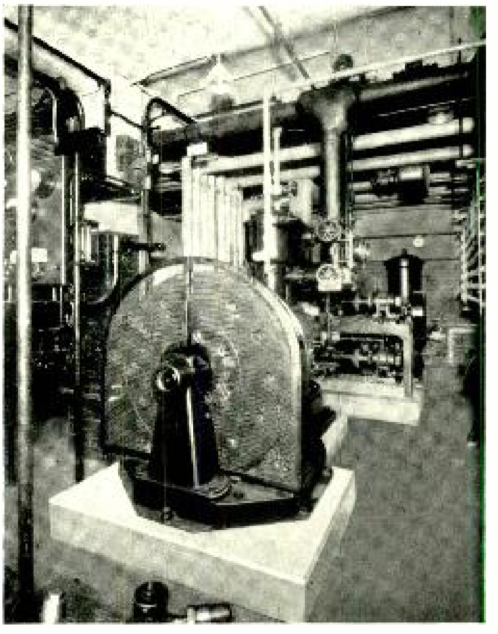
The new compressor is of fifteen tons capacity—if used for freezing water with an initial temperature of thirty-two degrees its output would be fifteen tons of ice every twenty-four hours. It is driven by a directly-connected synchronous motor instead of through the customary belt drive; by this arrangement the space required is reduced to about half, and in addition the power factor of the alternating current equipment throughout the building is raised. To prevent danger of freezing, the motor is stopped by a thermostatic switch when the temperature in the tank falls to thirty-six degrees.

Cooling is only part of the task of providing drinking supply; the water must be kept fresh and at a suitable temperature until used. Pumping and circulating are therefore just as important, and so circulating pumps have been provided to maintain a stream of cool water past all the fountains continuously. As an insurance of reliability, pumps and motors are provided in duplicate.

Water enters from the city mains through sand and charcoal filters and goes to "make-up" pumps which, increasing its pressure enough to carry it to the top of the building, introduce it to the circulating system. Here it enters the refrigerating tank in the basement and from there is divided, going to the four loops. In the basement the four return pipes join, running through the circulating pumps to the refrigerating coil, where the water starts its journey again.

To prevent starting and stopping of the make-up pumps each time one of the fountains is used, an overflow tank at the top of one of the loops regulates, through a float switch, the pump action. As water is used, the level here falls until the pressure pump starts; then pumping continues until the tank is almost full. Thus intermittent pump action keeps the circulation loops full at all times, while the constant action of the circulating pumps keeps a steady stream moving past the fountains. The tank is completely enclosed, except for a small outlet near the top; thus the water is protected from dust and impurities at the point where such protection is often neglected.

In winter, when no artificial cooling is necessary, the same equipment is used, but differently arranged. The circulating pumps are continued, but in addition the make-up pump is run continuously. By this arrangement a steady stream of cold water runs through the system, and is made to reach all parts of the pipes. At the top of the building the excess water runs into the expansion overflow tank,



Compressor and synchronous motor of the new apparatus, on a common base

where the float switch is disconnected. Here the water rises to the overflow outlet, through which it runs to the house water tank. From here it flows by gravity to cold-water faucets throughout the building as needed.

Irving B. Crandall

By R. W. KING
Editor, Bell System Technical Journal

IN the death of Irving B. Crandall, a valuable and devoted student was lost to that domain of physical science which is concerned with the study of the sounds of speech and their propagation and recording. Dr. Crandall was probably one of the first to become convinced that a full and complete knowledge of the composition of speech sounds would be of fundamental value to the art of telephonic transmission. Certainly, he was one of the first to attempt to give expression to his conviction by the formulation and execution of an energetic program of research.

This program proved to be a very fruitful one. In the first place, he was instrumental in developing exceedingly accurate oscillographic means for photographing speech sounds. Once in possession of this apparatus, he set to work to make an extensive catalog of all the fundamental sounds. This record was largely completed and its results analyzed and stated in general terms. Much work, of course, remains to be done in this particular field, but it will probably be largely supplementary to that which he succeeded in finishing. The extent of his investigations is indicated by these scientific papers:

Theoretical Calibration of the Condenser Transmitter
The Thermophone as a Precision Source of Sound (with H. D. Arnold)
The Sounds of Speech
The Dynamical Study of Vowel Sounds
Analysis of the Energy Distribution in Speech (With D. Mackenzie)

In addition to these publications he had completed just before his death a text book entitled "Vibrating Systems and Sound."

Much of his research was of a pure-science character and has not as yet received practical application. On the other hand, some of his investigations he undertook because of their practical value, and his developments are now extensively employed in the recording and reproduction of speech and music.

Because of the importance of the work which Crandall had done and was carrying forward, we regret his loss, but such feelings are greatly intensified in those who were well acquainted with the man himself. In all of his thinking, he was actuated essentially by scientific motives. He was delightful in conversation and a man with whom it was a pleasure to be associated professionally. The gap which his death leaves in our ranks will not soon be closed.

Coming into Bell Telephone Laboratories in 1913, Crandall was one of a highly skilled group of research physicists who began their careers in electrical communication at about the same time and under the same guidance, and whose work, both as individual research workers and as directors of younger men, has done much toward lifting the telephone art of America to its present position of pre-eminence.

News of the Month

BANCROFT GHERARDI, Vice-President and Chief Engineer of the American Telephone and Telegraph Company and a Director of these Laboratories, has been elected President of the American Institute of Electrical Engineers.

* * * *

THE DEGREE of Doctor of Science has been conferred on President Jewett by the University of Wisconsin.

* * * *

HERBERT E. SHREEVE, technical representative in Europe of American Telephone and Telegraph and these Laboratories, has recently returned from New York to his post in London. During his stay here, Mr. Shreeve communicated to Bell System executives his observations of the viewpoints of European telephone administrations.

* * * *

TELEPHOTOGRAPHY found an interesting application in the engineering of a new number eleven central office for Torrance, California. Although a manually operated power plant had been specified by the Southern California Telephone Company, analysis of requirements showed that use of an automatic power plant, the plant developed for P. B. X. use,* would result in an appreciable saving and in faster delivery as well. The Telephone Company was notified of the suggested change by telegraph. The next day traffic data needed to figure requirements for the automatic power plant units were received by the

* *The automatic power plant was described in the* RECORD *of November, 1926.*

Deliver to A.F. Dixen
Bell Telephone Laboratories
New York

MANUAL PLANT

NO.11 SWITCHBOARD

Dem l GBN

TRAFFIC DATA FOR POWER PLANT ENGINEERING

TORRANCE, CALIFORNIA - UNIT NO. 1, 1926

Period Ending:	Present	Initial	Inter-mediate	Ultimate
Lines	389	635	885	1135
Stations	675	1125	1560	1998
Calls per station per day	3.50	3.50	3.75	3.75
Ratio B. H. to day	.12	.12	.12	.12
B. H. originating calls - total	284	472	702	898
B. H. local calls, total	207	345	527	655

Part of the data sheet sent from Los Angeles to New York by telephotograph

Laboratory engineers, having been sent by telephoto from Los Angeles to New York. The reproduction of part of the Telephoto print shows how data of this character can be sent rapidly, and with perfect assurance of accuracy. Transmission of this type of data, and of diagrams and sketches has increased steadily.

* * * *

DURING FEBRUARY, March, April and May of 1927, patents were granted to the following members of the Laboratories staff:

W. J. Adams (2)
S. E. Anderson
W. M. Beaumont (2)
H. S. Black
F. A. Bonomi
O. E. Buckley
S. C. Burkholder
W. W. Carpenter
W. L. Casper (2)
A. J. Christopher
E. H. Clark
A. A. Clokey (2)
R. D. Conway
E. B. Craft
G. C. Cummings
S. T. Curran
A. M. Curtis (3)
R. C. Davis
B. G. Dunham (2)
G. W. Elmen
F. E. Field (2)
H. Fletcher
C. B. Fowler (2)
E. S. Gibson (2)
T. R. Griffith
A. Haddock (2)
H. C. Harrison
R. V. L. Hartley (2)
J. M. Hayward
R. E. Hersey
R. A. Heising (3)
E. E. Hinrichsen
J. W. Horton (3)
W. G. Houskeeper
H. Hovland (2)
K. S. Johnson (2)
L. H. Johnson
C. G. Jones
W. C. Jordan
A. R. Kemp
R. E. King
R. W. King
J. J. Kuhn
G. A. Locke (2)
M. B. Long
F. F. Lucas
G. R. Lum
H. W. MacDougall
R. C. Mathes
D. D. Miller
R. B. Miller
John Mills (2)
R. H. Mills
F. Mohr
C. R. Moore (4)
G. T. Morris
A. L. Mortimer
E. C. Mueller
A. M. Nicholson
H. W. O'Neill (2)
J. C. R. Palmer
E. B. Payne
H. Pfannenstiehl (3)
L. M. Potts
H. M. Pruden
D. A. Quarles
J. B. Retallack
C. D. Richard
J. G. Roberts
T. H. Roberts
J. E. Rogers
V. L. Ronci (3)
F. M. Ryan
C. F. Sacia
J. C. Schelleng
E. E. Schumacher
P. Schwerin
W. J. Shackleton (2)
T. E. Shea (2)
L. J. Sivian
E. R. Smith (2)
H. C. Snook
C. A. Sprague
H. M. Stoller
A. R. Swoboda
H. Vaderson
E. Vroom (3)
R. L. Wegel
H. W. Weinhart
J. F. Wentz
H. Whittle
S. B. Williams (2)
W. V. Wolfe
E. B. Wood

L. W. MCKEEHAN presented a paper on Iron Crystals at the Washington meeting of the American Physical Society. At the same meeting C. J. Davisson and L. H. Germer presented a joint paper on Scattering Electrons by a Single Crystal.

DR. H. E. HOWE, editor of the *Journal of Industrial and Engineering Chemistry*, visited the Laboratories on June 9th and addressed the members of the Chemical Group on some of the activities of the American Chemical Society.

J. F. FARRINGTON AND F. A. HUBBARD recently returned from a round trip on the *Leviathan*, on board which they made studies of noise conditions affecting radio telephony.

SIR JAMES IRVINE, of the University of St. Andrews, Scotland, was a recent visitor at the Laboratories.

A. A. CLOKEY sailed for Emden, Germany, June 10th, on board the *Columbus* in connection with his work on the Azores-Emden cable. He plans to be in England for a short period in connection with the North Atlantic cable job and to spend a short time at Horta inspecting that terminal of the Azores-Emden cable.

R. M. BURNS was in Chicago June 7th, where he attended a meeting of the American Water Works Association on soil corrosion.

H. A. LARLEE was in Hawthorne May 30th-June 5th attending a meeting of the Survey Committee on the development of the handset.

R. R. WILLIAMS, F. F. FARNSWORTH, L. W. MCKEEHAN, A. R. KEMP AND J. A. LEE attended the

These two graceful statuettes, carved from soap and only a few inches high, won for George R. Lum first prize against 2500 *entries in a nation-wide contest*

annual meeting of the American Society for Testing Materials held at French Lick Springs, Indiana, from June 20th to 25th.

R. Burns spent the first week of June at Hawthorne in connection with testing cable terminals.

During the first week of June H. O. Siegmund was at the South Orange office of the New York Telephone Company to study the elimination of plant noises associated with the use of electrolytic condensers.

J. T. Wilmarth visited the General Electric Company's plant at Pittsfield, Massachusetts, to investigate problems of manufacturing electrolytic condensers.

J. R. Townsend represented the Laboratories at the meeting of the Special Research Committee on Spring Materials held in connection with the annual meeting of the American Society of Mechanical Engineers at White Sulphur Springs, Virginia, on May 18.

D. T. May attended a meeting of the Committee on Electrical Protection of the American Railway Association.

W. J. Shackelton, J. G. Ferguson and T. E. Shea attended the recent regional meeting of the A. I. E. E. at Pittsfield, Massachusetts. Mr. Shackelton and Mr. Ferguson delivered a joint paper on High Frequency Measurements for Communication Apparatus.

J. T. Butterfield was in Philadelphia June 2 in connection with bearings for sequence switch shafts at Rittenhouse Office.

R. M. Vail was at the Philadelphia Instrument Shop on June 13, to calibrate the shop's vacuum tube test set.

J. C. Wright and J. H. Bower were at Hawthorne June 13 to 18 to study problems connected with the development of switchboard lamps.

H. N. Van Deusen, J. R. Townsend, W. S. Hayford, H. A. Anderson and W. J. Shackelton attended the convention of the American Society for Testing Materials at French Lick, Indiana, the week starting June 20. Mr. Townsend delivered a paper on Fatigue Studies of Telephone Cable Sheath Alloys, and Mr. Van Deusen delivered a joint paper with T. J. Shaw of Hawthorne and C. H. Davis of the American Brass Company on Physical Properties and Test Methods for Sheet Brass.

Following the convention Mr. Shackelton went to Hawthorne for a few days in connection with development work on permalloy dust core loading coils.

Mr. Hayford also went to Hawthorne, where he will spend the next few weeks in work on several problems of materials.

H. Pfannenstiehl was in Boston investigating a type of motion picture projector in connection with the development of talking motion picture machines.

L. A. Elmer visited the Pratt and Whitney Company at Hartford, Connecticut, in connection with the manufacture of gear drives for Vitaphone recording machines.

* * * *

B. W. Kendall and C. W. Green attended the Fourth Regional Meeting of the A. I. E. E. at Pittsfield, Massachusetts.

J. A. Krecek, R. L. Case and A. J. Sanial spent several days at Pittsburgh, where they tested some new echo suppressor equipment which is being tried out there.

C. White and F. B. Anderson visited Philadelphia and Reading to arrange for the making of tests on long cable circuits.

Extension of the C. L. R. method of toll operation brought about a visit of J. F. Toomey and R. H. Miller to Pittsburgh. Mr. Toomey also visited Boston to discuss new toll equipment at Concord, New Hampshire.

Extensive tests on the transatlantic toll lines looking towards the suppression of lightning interference on certain of the circuits called R. B. Steele to Denver, Colorado, and El Paso, Texas.

C. Borgmann visited Michigan City, Indiana, Detroit and Cleveland in connection with new installations at those places.

J. R. Stone and F. F. Siebert spent several days at the General Electric Company's factory in West Lynn, Massachusetts.

R. E. Noble inspected several new developments at Michigan City, Indiana, and Utica, New York.

J. W. WOODARD AND J. C. GREEN discussed several new No. 11 installations with the Telephone Company at Albany, New York.

A NEW LINE of gasoline driven emergency generating sets were tried out at Buffalo during the month. A. E. Petrie and V. C. Callahan witnessed these tests for the Laboratories.

THE CIRCUIT ENGINEERS defeated their associates of the Equipment Division by the score of 9½ to 8½ in a golf match held on May 21. Play was over the Newark Country Club course in West Orange, and was followed by a dinner in the club house. Scoring was on the Nassau basis, with points for best ball and low aggregate.

W. BENNETT visited the new step-by-step machine switching office at Battle Creek, Michigan, making certain tests on the new equipment.

R. E. KING went to Omaha and Minneapolis in connection with new centralized intercepting service in the dial system at Minneapolis.

DEVELOPMENT WORK on cordless "B" switchboards called C. F. Seibel to McKeesport, Pittsburgh and Philadelphia.

G. M. LATHROP AND H. C. CRAMER made several tests at Reading, Pennsylvania, on new testing devices for step-by-step offices.

* * * *

G. D. EDWARDS AND W. H. MATTHIES have recently returned from a survey trip through the territories of Telephone Companies in the Middle West. Conferences with Telephone Company engineers and Western Electric Installation Department and Distributing House people were held in Cincinnati, Indianapolis, St. Louis, Omaha, Chicago, Detroit and Cleveland, and the general situation with respect to field activities was discussed. I. W. Whiteside, Local Engineer for the Inspection Department at Cleveland, attended the conference in Cincinnati, Indianapolis, Detroit and Cleveland. R. C. Kamphausen, Local Engineer at St. Louis, attended the conference in that city, and J. M. Schaefer, Local Engineer at Omaha

Circuits	*Medal Score*	*Team Points*	*Equipment*	*Medal Score*	*Team Points*
E. H. Clark	92	2	W. L. Kidde	103	1
J. A. Burwell	102		E. J. Johnson	92	
O. Cesareo	112	..	G. T. Lewis	98	3
O. H. Williford	120		N. H. Thorne	107	
R. E. Collis	107	2	E. H. Smith	113	1
J. B. Retallack	108		C. H. Achenbach	110	
C. W. Keckler	114	3	E. J. Kane	126	..
W. E. Viol	124		C. D. Walker	137	
W. L. Filer	120	2½	H. H. Lowry	131	½
W. H. Matthies	125		I. W. Brown	120	
E. A. Looney	118	..	J. W. Woodard	115	3
J. Irish	144		C. D. Dusheck	130	
		9½			8½

Individual scores in the golf match between the Circuit and Equipment departments conference. A. I. Rivenes, Local Engineer at Chicago, attended the conference held in Chicago.

ON MAY 23RD, O. S. Markuson attended at Kearny the Inspection Survey Conference which dealt with lead covered cable.

L. E. GAIGE was in Rochester, New York, May 26th and 27th in connection with the preparation of testing instructions for P. B. X. Switchboards manufactured by the Stromberg-Carlson Company.

P. B. ALMQUIST, Local Field Engineer for the Inspection Department at San Francisco, visited Portland, Seattle and Spokane in connection with regular field work in his territory.

W. C. MILLER was in Philadelphia June 6th, 7th and 8th in connection with a Survey Conference on Vitaphone Apparatus and on Rating of the Product of the Philadelphia Instrument Shop. Mr. Miller also visited the laboratory and warehouse of the Electrical Research Products, Inc.

DURING THE EARLY PART OF JUNE, C. D. Hocker of the Outside Plant Development Department visited plants manufacturing clay conduit at Brazil, Indiana, and Aultman, Ohio. Mr. Hocker was also in St. Louis, making observations regarding the manufacture of cable rings and other outside plant articles.

W. A. HYDE was in Washington, D. C., during the first week in June, in connection with insulator and soil-corrosion studies.

W. H. S. YOURY attended the convention of the National Electric Light Association held in Atlantic City during the early part of June.

J. A. CARR was in Reading, Pennsylvania, during the last week in May for development studies in regard to cable testing.

DURING THE EARLY PART OF JUNE, L. M. Lindemuth was in Norfolk, Virginia, for the study of questions relating to timber preservation.

* * * *

FOURTEEN THOUSAND new stockholders were secured at the time of the American Telephone and Telegraph Company's 1926 issue of stock. The million and a half new shares were taken by two hundred and twenty-five thousand subscribers. Of these subscribers about one-fourth used the installment plan of payment. More than half of the stockholders on record at the time of the offering took advantage of their "rights."

* * * *

THE NUMERICAL CENTER of telephones in the United States was in Huntington County, Indiana, at the end of 1924, according to calculations recently completed. From 1920 to 1924 this median point moved about one mile north and thirty-nine miles east. No accurate determination of the location of the point has since been made, but indications suggest a continued easterly movement at a somewhat slower rate.

* * * *

TWO RECEIVER STANDARDS have recently been returned to C. A. Finley after passing through a part of the Mississippi Flood. These standards were part of the testing equipment of the New Orleans Shop of Western Electric, and when this shop was flooded, the standards were under water for two days. Eventually they were shipped back to these Laboratories for examination. Receiver standards are similar to the familiar No. 144 receiver, but the diaphragm is clamped to the supporting bell by a heavy steel ring. So tightly had all the joints been made that no water reached the windings, and the calibration was found to be unchanged. With the replacement of cords, the receivers are as good as ever for further service.

The Men Behind Television

To at least one witness of the demonstration of television the most important part of the proceedings was . . . a human spectacle not intended, one imagines, to be noticed at all. As the demonstration began there filed to their posts beside each unit of the apparatus an eager regiment of youthful engineers. There each one of them stood, a sentry of science; eyes glued to his meters, ears listening at his telephones, trained fingers adding a needed touch now and then to the levers or dials in front of him. This human machinery of the occasion carried by far its deepest meaning.

. . . The success is another vindication for that method of scientific investigation which the Bell Telephone Laboratories has made so peculiarly its own, the method of group research. There are a few scientific problems which can be solved, perhaps best solved, by a single genius working alone in a garret. Other problems, like television, are unlikely to come to full fruition by this path. Many minds are needed and many hands, each busied with that particular detail most suited to each man's abilities.

(From an editorial in the New York Herald-Tribune.)

D & R News Notes

GEORGE WASCHECK, until recently an instructor in electrical engineering under Professor Morecroft at Columbia Universty, entered the D. & R. Department on June 2. His work will be on problems of inductive interference.

A. R. BONORDEN was recently transferred from the Engineering Department of the Pacific Telephone and Telegraph Company, where he had been employed since receiving the degree of E. E. from the University of California in 1920. Previous to that Mr. Bonorden had worked for the Bell System on central office and P. B. X. installations at various times, starting in 1912. He will join the group handling development of local telephone systems.

R. A. HAISLIP sailed on June 4th for a three months' business trip to Europe to observe outside plant practices and conditions in several countries. C. G. Sinclair, Jr., of the O. & E. Department accompanied Mr. Haislip. R. L. Jones of the Laboratories will join them shortly.

R. F. HOSFORD attended the Sectional Committee Meeting on Wood Poles and two other Subcommittee Meetings of the American Engineering Standards Committee in Chicago during the last week in May.

E. I. GREEN AND F. A. LEIBE are at St. Louis, in connection with tests of new methods of reducing office wiring losses and reflection coefficients for carrier frequencies.

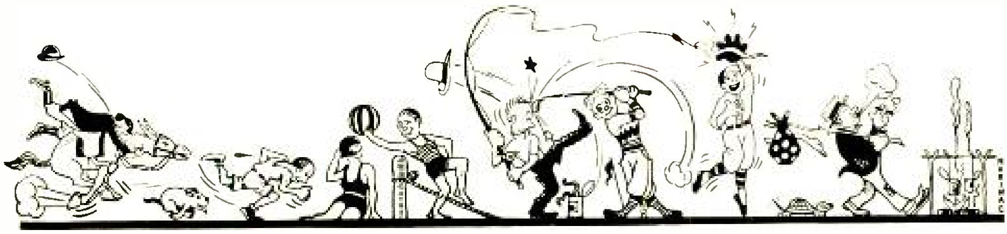
L. A. KELLEY is at Denver, Colorado, collecting data on lightning interference on carrier telegraph systems.

H. A. AFFEL AND J. T. O'LEARY presented a paper at the A. I. E. E. Regional Convention at Pittsfield, Massachusetts, on "High-Frequency Measurements of Communication Lines," and E. I. Green presented a paper on "Measuring Insulation of Telephone Lines at High Frequencies."

F. C. BISBEE recently visited Washington, Cleveland and Springfield, Massachusetts, in connection with service observing in the commercial offices.

R. P. MARTIN, JR., visited the Buffalo Gasoline Motor Company in Buffalo on May 20th to witness tests on the type BA gasoline-engine generator set and to secure information on the type R engines.

L. ESPENSCHIED presented a paper on "Factors Governing the Service Area of a Broadcast Transmitting Station" before a meeting of the Radio Club of America held on June 8 at Columbia University.



Bell Laboratories Club

The 1926-27 bowling season came to a close with the annual banquet held at the Fraternity Club on Tuesday evening, May 24th, attended by one hundred and twenty-five bowlers. Following the dinner Chairman Lowe gave a short talk in which he outlined what the bowling league had done during the past season, and thanked all the bowlers for making his term in office successful. E. J. Johnson, President of the Bell Laboratories Club, made a short speech after Mr. Lowe had finished; then Mr. Lowe introduced Mr. Craft, who distributed the season's prizes. After that the Club members went to the Eltinge Theatre to see "Tommy."

Following is the final team standing for the season:

		Won	Lost
	Group Winners		
Class A	Lamps	53	31
Class B	Buzzers	48	36
Class C	Buzzers	53	31
	Individual High Averages		
Class A	H. C. Dieffenbach		185.9
Class B	E. A. Whelan		170.9
Class C	W. P. Trottere		154.2
	Individual High Scores		
Class A	L. J. Burns		256
Class B	L. G. Hoyt		257
Class C	W. P. Trottere		224

Swimming

Tickets which entitle Club members to all privileges at the Brighton Beach Baths on Saturdays, Sundays and Holidays are now available. These tickets are one dollar each for Sundays and Holidays and fifty cents for Saturdays, which is a saving of one dollar on Sunday tickets and fifty cents on Saturday tickets. Tickets should be presented at the season ticket entrance to obtain a house check, thus eliminating all waiting in line. Club membership cards must be shown at time of presenting admission tickets.

During the past season, a large number of our members enjoyed the bathing at Brighton Beach, and it is hoped that an even greater number will take advantage of this opportunity during 1927. Department representatives and the Club Secretary, D. D. Haggerty, can supply any number of tickets.

Golf

On Saturday afternoon, June 4th, eighty golfers teed off at the Salisbury Country Club in the qualifying round of the fourth handicap tournament promoted by the Bell Laboratories Club. The players were handicapped for medal play from the scores made in previous tournaments or their three best scores, if they had not competed in other Laboratory tournaments.

First prize for gross score was won by E. H. Clark, whose count was 88. J. Hillier and G. E. Kellogg each tent to learn whether by means of positively-charged nuclei and electron-orbits we can construct an atom-model capable of imitating some at least of the properties of atoms, some at least of their influences upon the outer world. If so, the model of the electron-orbits is good, to a certain extent. If later some one conceives in another way an atom-model capable of imitating more of the properties of the atom, or of imitating the same properties more nearly perfectly, it will supersede the model with the electron-orbits; or perhaps the two will survive side by side.

Now there is a feature of atoms, to which the builders of atom-models pay much attention. Atoms are able to exist only in certain very definite, distinct, characteristic "stationary" states; the life of an atom is a succession of short sharp complete transitions from one of its states to another, as though the atom were a strange sort of railway-train able to jump instantaneously from any station along its line to any other and to sojourn at any station, yet never spending time between stations, passing from one to another so suddenly as never to be seen at any intermediate point. So passing from state to state, the atom emits light; and the frequency of the light is proportional to the energy-difference between the initial and final states, between the stations of departure and arrival.

The atom-model of the electron-orbits supplies a special orbit or orbit-group for each of these states of the atom; these orbits are interrelated by laws and they can be traced from certain formulae, and in many ways they provide a very convenient and pleasant picture of the atom. Yet the model provides no picture of the way in which the light is emitted when the transition between two states occurs, and in other ways as well it is defective.

There is another field of mechanics which offers a most profitable model; this is acoustics, the mechanics of vibrating systems and sound. The major and most strikingly evident feature of a vibrating object such as a stretched violin-string, or a telephone membrane, or a drumhead, or a boxful of air enclosed in solid walls, is its system of *resonances.* Incited to vibrate by a stimulus varying with its own natural rhythm, such a resonator oscillates very powerfully and sonorously; incited by a stimulus of a different rhythm, it responds indeed with the frequency enforced upon it, but much less willingly; incited by a sudden blow or stroke, it vibrates for a time with its own natural frequency, and would so vibrate forever were it not for internal or external friction. Could one devise for an atom an *acoustic model,* of which the diverse resonances would correspond to the diverse states of the atom? Could one assign to each state a natural frequency of vibration proportional to its energy, so that the frequency of the light emitted when the atom passes from one state to another would be the beat-frequency, the heterodyne-frequency as one says in radio, between the mode of vibration which the atom is abandoning and that which it is adopting?

This is a part of the programme of wave-mechanics. The acoustic atom-model—if it may be roughly so termed, to distinguish it in a word from the model with the electron-orbits—is to be visualized as a fluid pervading space and vibrating in a resonance. It is an odd sort of fluid indeed, not to be completely identified with any known material substance; for if a gas were to develop a spot of excessive density it would strive to regain uniformity and evenness once more, while the imaginary fluid in some regions has this and in some just the opposite quality. Furthermore, the different modes of vibration corresponding to the different states of (say) the hydrogen atom are not to be considered as the fundamental and the various overtones of one and the same vibrating fluid; the elasticity of this symbolical substance changes, when the atom passes from one state to another. Yet in many ways the quaintly-designed symbolic fluid is an admirable atom-model; modes-of-vibraton and electron-orbits turn out to be interchangeable ways of picturing the diverse states of the hydrogen atom, either practically as good as the other in this respect, and the method of wave-mechanics remains secure in the advantage of its own superb interpretation of the light-frequency as the beat-frequency between the modes of vibration.

Could a perfectly free electron be considered a fluid with a resonance-frequency? That is indeed a difficult idea to receive; and yet the same general equation of wave-mechanics which describes the resonance-frequencies of that imaginary fluid which is a model for the atom, implies also that a free electron is attended by a wave-train proceeding in the direction in which the electron is advancing, with a wave-length depending on the speed of the electron. By recent experiments in our Laboratories, Davisson and Germer revealed the amazing and portentous fact that free electrons are attended by such wave-trains, which are diffracted by crystals and carry their electrons with them wherever the diffraction sends them. Wave-mechanics thus emerges from the inaccessible interiors of the atoms, and submits itself to trial by observation.

The outcome cannot yet be foreseen. It is not, however, injudicious to reflect that twenty years ago we all supposed that light possesses only the qualities of wave-motion; and then experiment was piled upon experiment to show that in addition it behaves in many situations as though it were a stream of corpuscles, a dilemma not yet resolved. Perhaps the experiment of Davisson and Germer is but the first of an equally imposing series, which will shortly establish that matter with equal inconsistency partakes of the qualities of corpuscles and qualities of waves.