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Textiles as Insulators

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THE insulation resistance of most solid dielectrics is greatly reduced if moisture is absorbed on their surfaces or penetrates into their internal structure. Gutta percha, the classical insulation of submarine cable, absorbs at most one or two per cent moisture when actually immersed in sea water, and the change in electrical properties is very slight. Rubber insulations absorb but a few per cent moisture under similar conditions, and when used in air are practically unaffected by atmospheric humidity. On the other hand textile insulations, largely because their threadlike structure gives a much greater ratio of surface to volume, absorb from twenty to thirty per cent of their weight when exposed to an atmosphere of very high relative humidity. With changes in humidity, their water contents change rapidly, and their dielectric properties reflect the influence of absorbed moisture.

Among the textiles, silk has been used for many years as an insulating material on electrical apparatus because of its recognized superiority in insulation resistance over cheaper fibrous materials such as cotton. This property of silk is rather surprising in light of the fact that the amount of moisture absorbed by it under given atmospheric conditions is greater than that absorbed by cotton.

Several years ago these observations suggested that a study of the effect of moisture on textiles, sufficiently thorough to explain this apparent contradiction, might discover means of treating the cheaper vegetable fibers so as to obtain superior insulating properties.

In determining the insulating properties of textile materials, experiment has shown that at least three factors are important. They are: the quantity and distribution of water in the fibrous structure; the amount and kind of water-soluble electrolytic impurities which are present, either naturally or as contaminants; and the kind of fiber—cellulose, protein, or other chemical species.

Between a textile and its surrounding atmosphere, moisture tends to pass until an equilibrium is reached between the moisture content of the textile and the relative humidity of the atmosphere. The moisture content of each sort of textile then depends directly upon the relative humidity of the atmosphere. Figure 1 shows this relation for several types of fibrous materials—cotton, silk, wool, and cellulous acetate. This orderly dependence of moisture content on relative humidity is similarly reflected in the relation between relative humidity and electrical characteristics. Figure 2 shows the insulation resistance of these materials plotted against per cent relative humidity over a limited range. It is impracticable to plot the resistance over the whole humidity range in this direct way, because of the wide variation of insulation resistance. The entirety of the data can, however, be shown by semi-logarithmic plot (Figure 3).

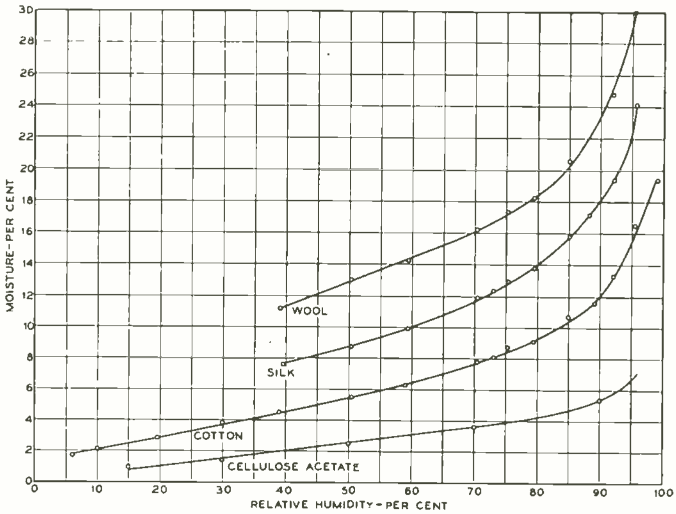


Fig. 1—Dependence of moisture of textiles upon relative humidity of atmosphere with which they are in equilibrium

Considered together, these three figures show that the insulation resistance of fibrous materials depend upon their moisture contents, and that these in turn depend upon the atmospheric relative humidity to which the materials are exposed. A misconception sometimes arises that the moisture contents, and therefore the electrical properties, of dielectrics depend upon the absolute humidity. In fact, however, the actual quantity of water vapor present in the air —the absolute humidity—bears

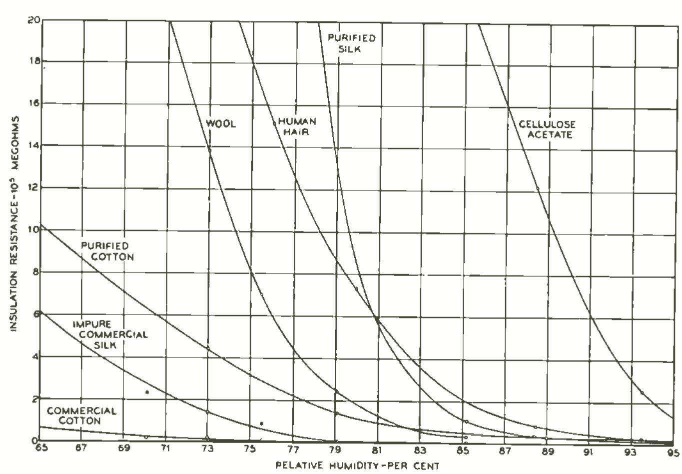


Fig. 2—Insulation resistance of one-half-inch lengths of textile threads as affected by relative humidity of atmosphere

little relation to the moisture content of textiles; it is the degree of saturation of the atmosphere with water vapor — the relative humidity — that bears the significant relation.

Polarization, another well-known phenomenon, is also found in the electrical behavior of textiles. If any dielectric be brought into contact with two electrodes of opposite polarity in the presence of atmospheric moisture, the electrical properties of the material undergo change with a rapidity dependent on the current and hence on the voltage, the length of the path, and the humidity. Such changes in the properties of insulating materials with continued applications of voltage have been considered accountable to the presence of electrolytic impurities in the materials. But the great magnitude of this change, from tenfold to a hundredfold increase in the insulation resistance of textiles exposed to ordinary humidities, has been very little appreciated.

The rise in resistance appears to be largely due to the partial removal of electrolytic impurities from some intermediate portion of the fiber to the vicinity of the electrodes. This can be strikingly shown by reducing polarized and unpolarized textile threads to ash. The ash of cotton, for example, is composed of salts largely of potassium, in some part of sodium, and to a less extent of calcium, magnesium, iron and aluminum. When organic materials containing small amounts of salts of the alkali metals, sodium and potassium, are ignited, the alkali salts melt at a relatively low temperature and protect the carbonized organic residue. This property is particularly advantageous in the study of the ash structure of polarized cotton threads, displaying the regions containing mineral constituents as those in which a black ash is preserved. If polarized cotton threads are ashed, the larger part of the mineral constituents are found in the neighborhood of the electrodes,

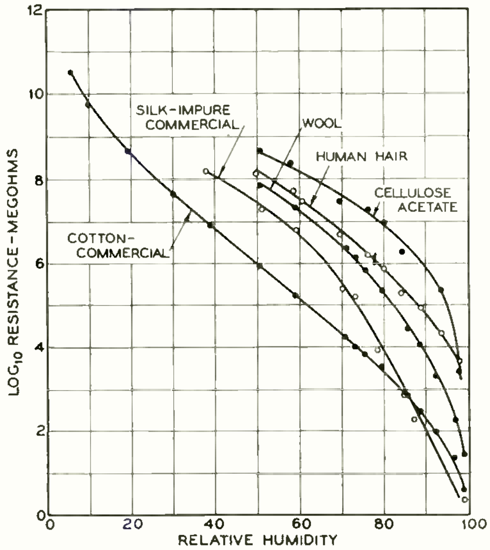


Fig. 3—Logarithmic plot of the data of Fig. 2

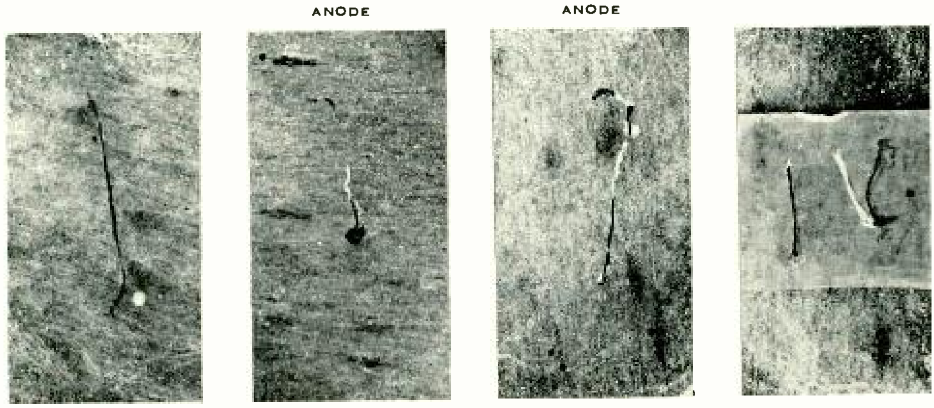
particularly the cathode. The cathode region is found to be alkaline, the anode region acidic.

Figure 4 shows the ash of a short piece of raw cotton thread. The blackened structure shows the presence of small amounts of alkali salts uniformly distributed throughout the fibrous structure. Figure 5 shows the ash of a similar length of cotton which was subjected to a polarizing potential of one hundred volts, and exposed to a relative humidity of ninety-eight per cent, for several days. A large part of the ash constituents have migrated to the negative electrode portion, leaving a short section entirely free of ash. The ash of Figure 6 is that of another similar length of the same polarized cotton thread which was permitted to remain at ninety-eight per cent relative humidity for several weeks after the polarizing potential was removed. The mineral constituents have to a considerable extent returned along the thread.

To verify the fact that the blackening effect could be due to the alkali salts, note in Figure 7 the ash structure of three different samples of cotton: the first of untreated raw cotton, the second of a well-washed thread of the same material, the third of a thread which was well washed, then dipped in a dilute solution of sodium hydroxide. The presence of alkali is clearly indicated in the first and third threads, but not in the second. This is to be expected, since it is well known that practically all of the alkali salts are easily removed by a simple washing treatment with water.

Perhaps the most significant evidence of the importance of electrolytic impurities in silk, wool, cotton, and to some extent other textiles, is the improvement of their electrical characteristics by thorough washing with water, without qualitative alteration of the general nature of the electro-conducting phenomena which characterize them. Figure 2 illustrates the result, on their insulation resistance, of washing cotton and silk threads. Fiftyfold to a hundredfold improvements in insulation resistance correspond, in the case of cotton, to diminutions in ash content, from about one per cent to a quarter or a twentieth of this value. Little or no reduction takes place, over the ordinary ranges of atmospheric humidity, in the moisture content at equilibrium. The sensitivity of purified cotton to the continued application of voltage is much less than that of the raw, but polarization still occurs. Commercial silks are similarly affected by washing. The differences in ash content and improvement factor are in some cases much greater than for cotton, because silks practically always contain acids, alkalis and soaps as residues from a degumming treatment to suit the silk for spinning. Cotton of the type generally used for electrical insulation receives no treatment by water or aqueous solutions from the time it is picked until it is transformed into finished thread.

If the mineral contents of washed cotton are quantitatively compared with the original contents, a decrease is observed, considerable in potassium and less in calcium and magnesium. Fairly complete removal of potas-



Figs. 4, 5, 6 *and* 7—*Photomicrographs of ashed threads* is apparently essential to good electrical characteristics, but electric improvement has been attended in some cases by an increase in the content of calcium and magnesium. This suggests that interchange of electrolytic impurities between the textile and the water takes place along with removal of electrolytes by the water.

When tests were made on a commercial scale at Hawthorne, to determine appropriate means of improving cotton by washing, cotton washed with water from Lake Michigan had better insulating properties than had been obtained in the laboratory with distilled water. Later tests with distilled water duplicated the Hawthorne tests in one or two cases, but in general Lake Michigan water gave uniformly superior results. Experiments to determine the suitability of water in the Kearny plant for the same purpose gave much lower insulation resistances than those obtained at Hawthorne. Analyses of the two waters showed that the sodium and potassium contents were higher, and the calcium and magnesium contents much lower, in the Kearny than in the Hawthorne water. Sufficient magnesium carbonate to make a saturated solution of this salt was then used, with encouraging results, in a washing experiment at Kearny. The use of calcium sulphate, a more soluble salt, in numerous subsequent tests has produced cotton with insulation resistance as high as was obtained with Lake Michigan water.

Since textiles are composed of fibers, the resistance of a thread or the serving on a wire might be expected to depend largely on the resistance between fibers. The fibers themselves, furthermore, have superficial irregularities, suggesting that the resistances of different fibers of the same material might be widely dissimilar. That neither expectation is the case appears from many experi-

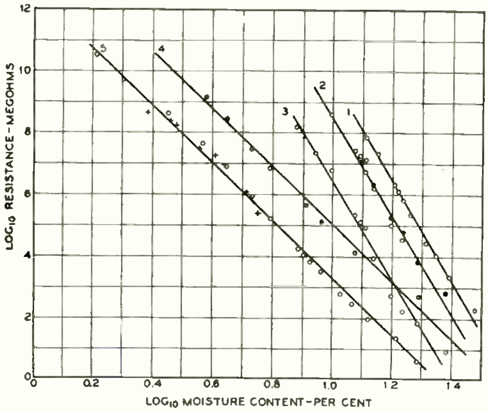


Fig. 8—Dependence of insulation resistance of textiles on moisture content 1—Wool yarn, 2—Washed silk thread, 3—Unwashed silk thread, 4—Washed cotton thread, 5—o Unwashed cotton thread; +cellulose acetate thread

ments with individual fibers and with threads.

Measured under controlled conditions of humidity and temperature, the insulation resistances of different single fibers are remarkably uniform. The insulation resistance of a thread, moreover, is practically that of all its component fibers in parallel, and contact resistances appear, therefore, to have negligible effect on the resistance of threads. This is true also for resistances measured transversely. Even when the length of a thread considerably exceeds the length of a single cotton fiber—about one inch—its resistance remains approximately proportional to its length. If interfiber resistance were large, the resistance per unit length would increase with the length of thread whose resistance was measured.

Thus for a given kind of fiber, the

more water and electrolytic matter present, the poorer are its insulating properties. But if these were the sole factors determining the electrical characteristics of all fibers, regardless of kind, animal fibers would be expected to be inferior to any of the species discussed. This is emphatically not the case; kind itself appears to be a factor. The vegetable fibers are inferior to the more hygroscopic animal fibers, and to the least hygroscopic synthetic fiber, cellulose acetate. To make clear the contrast, the logarithm of the insulation resistance is plotted against the logarithm of the moisture content in Figure 8; the values for each fiber fall approximately on straight lines throughout the range of measurement. The relative position of the curve for animal fibers, to the right and above that for cotton, means that the animal fibers have better insulating qualities in spite of their greater hygroscopicity.

The slopes of these lines have an even greater significance, for they indicate the sensitivity of the fibers to an increment of moisture. The steeper slope for the animal fibers indicates an electrical sensitivity to moisture greater than that of cotton. Under similar conditions they are not only wetter than cotton but more sensitive to further increments of moisture, yet they have a higher insulation resistance.

The differences in electrical behavior of the fiber species are believed accountable to differences in the spatial configurations according to which water is distributed within the individual fibers. The patterns are probably determined directly or indirectly by the chemical composition of the fibers and associated with the colloidal structure of the material.

As a result of our laboratory study cotton can now be improved in insulation resistance by simple washing operations to such an extent that it becomes an approved substitute in telephone cords* for all unwashed silk insulation. In this single respect a saving of several hundred thousand dollars per year is estimated, and the use of purified cotton in other places may materially increase this saving.

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* *The application of the results of these studies to the telephone plant is described by H. H. Glenn elsewhere in this issue of the* RECORD.

Washed Textile Insulation for Central-Office Wiring

By H. H. GLENN
Apparatus Development Department

SINCE the early days of telephone development work, silk and cotton have been the standard materials for insulating the wires in central office apparatus. In later years these materials have been supplemented by enamel. In general the insulation of the wires has been satisfactory, but breakdowns have occurred which could not be attributed to operating conditions or manufacture.

Studies made in these Laboratories revealed that impurities in the insulating textile—small quantities of water-soluble salts—were largely responsible for the observed irregularities. When moisture penetrates the textiles, as it always does in humid weather, these salts form weak aqueous solutions throughout the material, which by their conductivity reduce the insulation resistance of the textiles. Furthermore, the studies showed that passage of the leakage current through the solutions sets up a chemical reaction and the products of this reaction migrate to points of greatest current leakage. These products, themselves electrolytes, further increase leakage, and may ultimately lead to complete failure of the insulating textile, and even to serious corrosion of the metallic conductor itself.

The obvious procedure for improving the insulating properties of textiles is to remove the hazardous impurities. Since the contaminants are water-soluble, they can be abstracted by thoroughly washing the impure textiles with water. The process, however, purposes a substantially complete removal of salts already present in only small quantities, and must, therefore, use water of low saline content. The washing is best accomplished by a continual flow of water which, after one passage through the textile, is regarded as contaminated and is not used again. When the material is to be both dyed and washed, it can be washed, without intermediate drying, immediately after it has been dyed.

A comparison of the insulation resistances of cotton-insulated and silk-insulated wire at various relative humidities, ranging from sixty-five per cent upward to ninety per cent and down again to sixty-five per cent, before and after washing is shown in Figure 1. The improvement obtained in both silk and cotton by this process is seen to be marked.

A further requirement for the insulation is that the energy losses at speech and carrier-current frequencies be maintained at a minimum consistent with the space limitations applying to the conductors. The effect of purification of the textiles on this characteristic, expressed as loss in transmission units measured at 1000 cycles per second between the wires of twisted pairs, is shown in Figure 2. Use of a like thickness of insulation in all cases puts these graphs on a comparable basis.

The most important conclusion to be read from the graphs, from an economic viewpoint, is that cotton can be improved by washing to such an extent that it becomes a better insulator than the commercial insulating silk in general use. The cost of washing silk and cotton is nominal, usually less than five per cent of the cost of the material. The engineer given purified textiles may either take advantage of marked improvement in electrical characteristics by using washed silk, or substitute washed cotton for unwashed silk and realize substantial economies without degrading the product.

Incorporation of the improved textiles in Bell System apparatus is proceeding rapidly. Central-office distributing-frame wire, of which the annual requirements exceed four hundred million conductor feet, is now insulated with two coverings of silk instead of the three formerly required. The resultant wire is electrically superior to its predecessor, and about seventy thousand pounds of silk are saved annually. Telephone cords of various types have been reduced con-

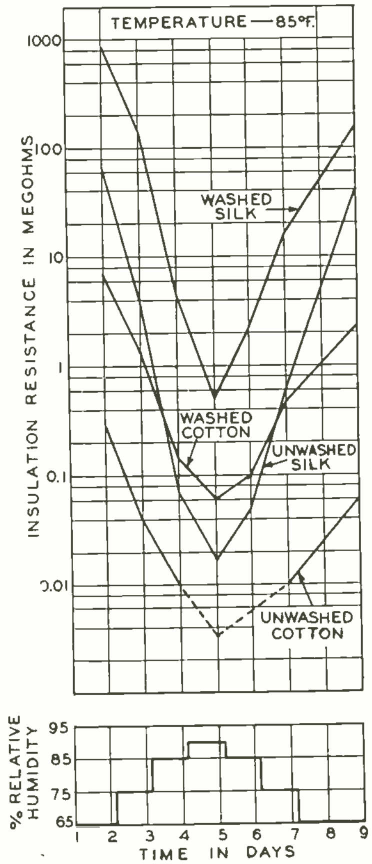

Fig. 1—D-c. insulation resistance of fifty feet of twisted pair wire insulated with double servings

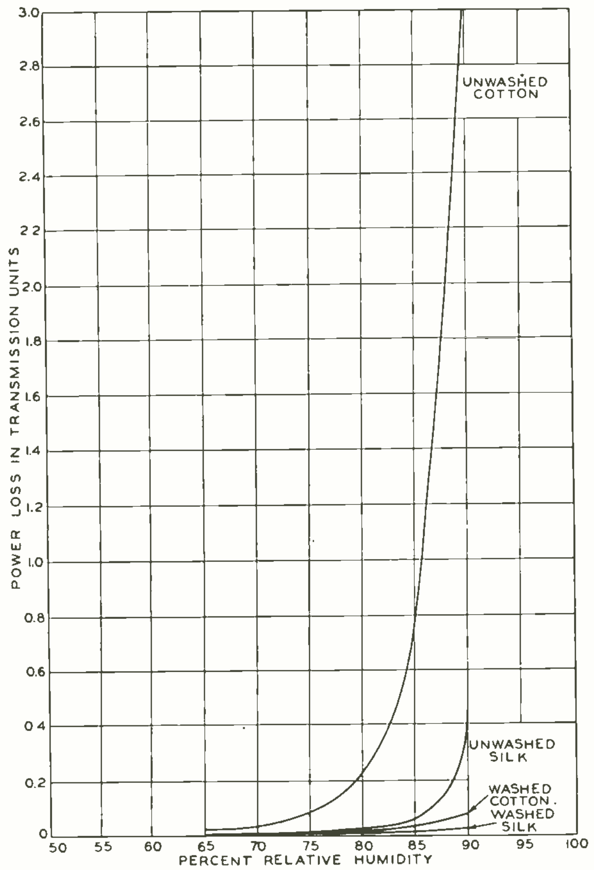

Fig. 2—Transmission loss in fifty feet of twisted pair wire insulated with double servings from measurements of a-c. conductance and capacitance

siderably in cost, without reduction in quality, by substituting two washed cotton braids for the cotton and silk braids formerly used. Corresponding economies in manufacturing cost or improvements in electrical properties

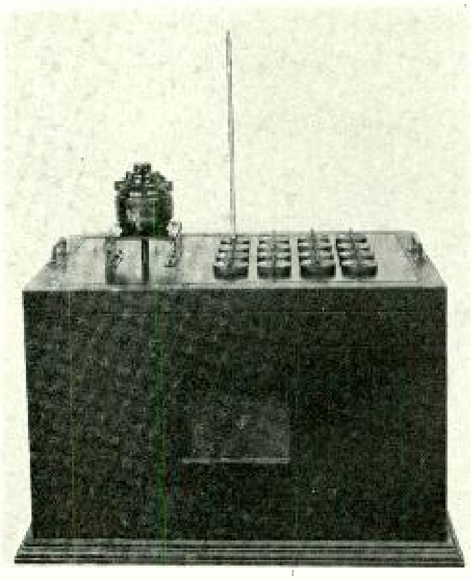

Fig. 3—Humidity cabinet for conditioning samples

will make the use of washed materials advantageous for various types of textile-insulated wire, exceeding two billion conductor feet in total annual requirements. Washed textiles are already incorporated in a large part of this output, and will be extended to the remainder as soon as possible.

To determine whether treated textiles have been washed sufficiently to meet established insulating requirements, their insulation resistance is tested in the factory before they are used. The development of apparatus sufficiently accurate for this purpose was a problem of considerable magnitude. Because the resistance of tetiles is quite high, delicate measuring instruments must be used, and the extreme sensitivity of textile resistance to changes in relative humidity requires that the humidity and temperature of the atmosphere enveloping the samples be closely controlled.

The apparatus at present used for factory testing is pictured in Figures 3 and 4. The sample of thread to be tested is dried in a dessicator to bring all samples to a common condition of moisture content, then wound in a single layer around two electrodes which are inserted in a hard-rubber stopper. The stopper is placed in one of the holes in an insulating lid covering a heat-insulated glass tank of about one cubic foot capacity. In this

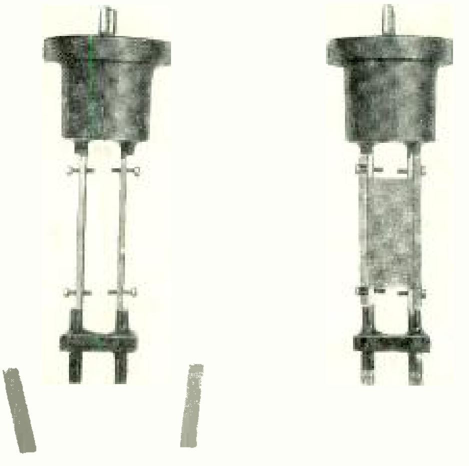

Fig. 4—Electrodes on which samples are wound for test

tank the humidity is accurately maintained, at seventy-five per cent for cotton testing and eighty-seven per cent for silk testing, by sulphuric acid or a saturated salt solution at the bottom of the tank,* and constant temperature is secured to within 0.05 degree F. by enclosing the assembly in a cabinet whose temperature is

* Bell Laboratories Record, *December,* 1927, page 108.

automatically controlled to within 0.1 degree Fahrenheit. The sample is equilibrated with the humidity over night, and its resistance is then measured. The separation of the electrodes and the number of turns of thread are such as to give readings of the order of 2000 megohms for washed silk and 1000 megohms for washed cotton and about one two-hundredth of these values for the respective unwashed textiles.

At high humidities there is still a wide margin between the insulating properties of washed silk and of washed cotton. Further study may reveal that this margin can be reduced. Laboratory experiments, in which cotton has occasionally shown improvement greatly exceeding the average, justify hope in the possibility of so processing cotton that its electrical properties will equal those of washed silk for many purposes.

Although there is still much to be learned about the electrical behavior of silk and cotton under various treatments and conditions, certain facts have been established beyond doubt. It is clear that the removal of the water-soluble salts which are present in both silk and cotton not only effects a decided improvement in their insulating properties but reduces the sensitivity of their alternating-current characteristics to changes in atmospheric relative humidity. The realizable improvement is great enough to permit the substitution of washed cotton for silk where commercial silk has been found to give satisfactory results. The use of purified textiles in switchboard cables carrying continuous direct potential will reduce electrolysis and thus prolong the useful life of the cables approximately in proportion to the extent to which the purifying process has been carried.

Laying A Foundation for Aircraft Communication

By D. K. MARTIN
Apparatus Development Department

AIR transportation requires for its fullest success a reliable and rapid means of communication with ground stations. The experience of air transport operators during the recent rapid expansion of the aviation industry has served to emphasize the necessity of such radio communication. With a deep appreciation of this need and a full realization of the difficulties of the task, Bell Telephone Laboratories has undertaken to develop equipment suitable for this service.

The first step in the development program was taken nearly two years ago when a thorough survey was made of the communication requirements of air transport. This was followed by the purchase of a Fairchild cabin monoplane with which extensive studies have been made under actual flying conditions. By the use of this plane, a better understanding has been obtained of the requirements of such a communication system, and a quantitative study has been made of transmitting conditions encountered in airplane operation.

Such transmission studies, including radio field-strength measurements, have been made for many years in

Fig. 1—The rod antenna and wind-driven generator may be seen in this photograph of the Laboratories' plane

connection with the engineering of broadcasting stations and of the transatlantic radio telephone circuits. In this work, however, data was required only of the transmission efficiency between two points on the earth's surface. For this new under-

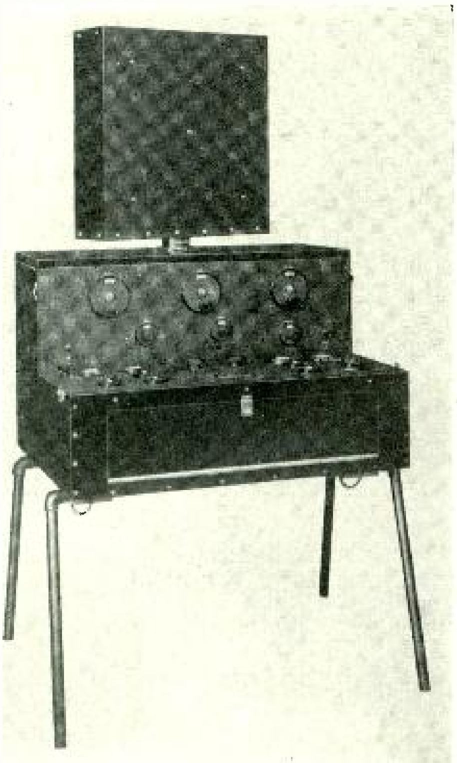

Fig. 2—Although the 44-A Test Set is designed for use with a loop, a rod antenna was used in the tests for reasons mentioned in the text

taking a third dimension, altitude, was involved and an additional difficulty was brought in due to the rapid change in position of the plane.

The first transmission measurements were made employing the Laboratories' plane, flying from Hadley Airport in New Jersey as a base. These tests were made in the frequency bands of from 285 to 315 and from 315 to 350 kilocycles which have been set aside for radio beacons and weather transmission service respectively. For measuring the signal received in the airplane, the Western Electric field-strength measuring set (44-A Test Set), of the type developed for use of the Department of Commerce, was employed. This instrument was adapted for use in the airplane by substituting a short vertical rod antenna for the loop usually employed. Similar tests were made on the Pacific coast by a field party in charge of R. S. Bair. The curve of Figure 4 is typical of the many obtained from these tests.

This particular curve is especially interesting as it shows the reduction in field strength encountered in mountainous country. From data of this kind, a determination has been made of the sensitivity necessary for an airplane radio receiver to make possible the dependable reception of beacon

Fig. 3—E. F. Brooke operating the 44-A Test Set in the Laboratories' plane

als and weather broadcast transmitted by radio telephone. In general it was found that at these frequencies transmission conditions between ground and an airplane were not greatly different from those existing between two points on the ground.

It has long been appreciated that although a one-way radio telephone and beacon service may provide all the communication required for many of the smaller planes, a two-way communication system is essential to the operation of the larger transport planes, particularly when carrying passengers. It is very generally agreed among air transport operators that radio telephony should be employed rather than telegraphy for this dispatch service. The reasons for this are rather obvious. With the telephone no special training in signalling is required to allow information to be passed between dispatcher and pilot, and there is the additional advantage of having an immediate and personal assurance that the information has been received and understood. Of no less importance is the rapidity with which information may be transmitted with the telephone. It is expected that the dispatch system for the more important American air lines will develop in a manner similar to that of the railway systems, where telephony has long been widely used for dispatching.

An accurate knowledge of the transmission characteristics of that portion of the frequency spectrum available for this two-way service is the foundation upon which a system must be built. The second step in our development program consisted, therefore, in a quantitative transmission study covering the frequency range of from 1500 to 6000 kilocycles, a preliminary consideration of the problem having indicated that this frequency range afforded the greatest possibility of any that could be employed without encroaching on other important radio services. In these tests transmission measurements were made both from plane to ground and from ground to plane—employing the field-strength measuring set in both cases. The curves of Figure 5 show graphically the results of one of these tests made at a fre-

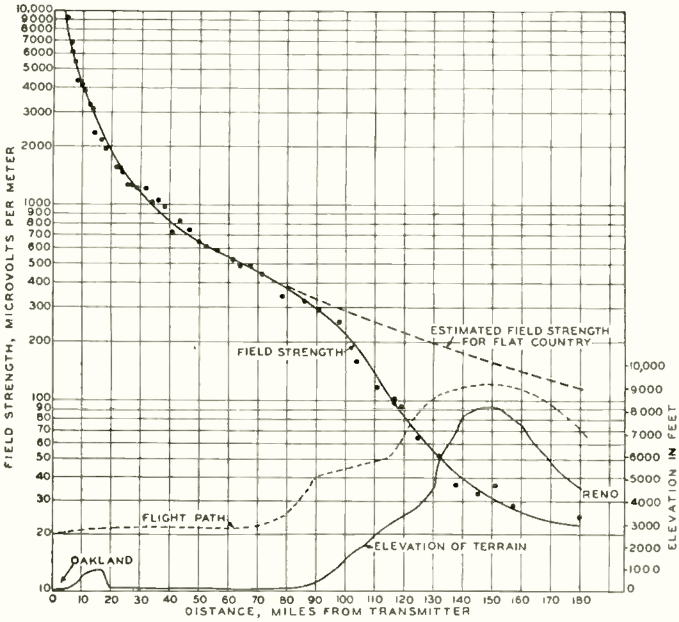

Fig. 4—Mountains decrease the intensity of signals received in a plane as they do those at land stations

quency of approximately 1600 kilocycles. These data were taken while transmitting from Bell Telephone

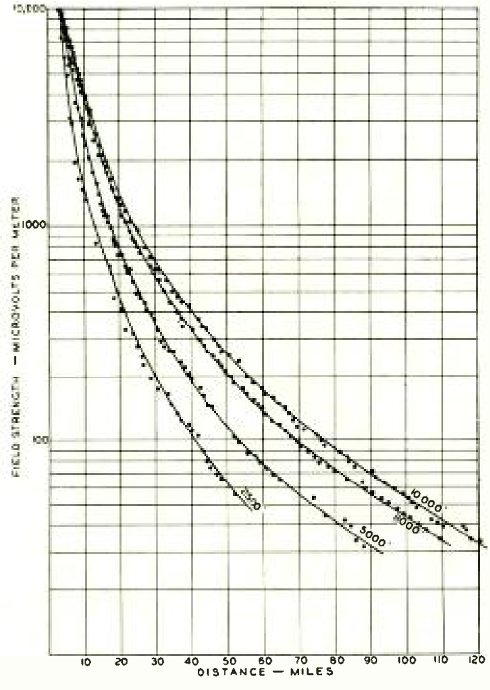

Fig. 5—Observations made indicate a considerable increase in signal strength as the altitude of the plane is increased. The altitude for each set of readings is indicated by the figures on the curves

Laboratories' experimental station at Whippany, New Jersey, and receiving in the airplane on a flight in the general direction of Baltimore.

These curves are typical of the large amount of data taken during flights in both the eastern and western experiments mentioned above. It will be noted that in contrast with the conditions found in the lower frequency band (285 to 350 kilocycles), the signal strength is a function of altitudes. Data taken at a frequency of approximately 5600 kilocycles at distances of from 30 to 40 miles showed the intensity of the signal to be approximately proportional to the elevation of the airplane, the signal increasing tenfold as the airplane height was increased from 1,000 to 10,000 feet. The field-strength measurements have been supplemented by quantitative intelligibility tests in which disconnected lists of words have been transmitted and a record kept of the accuracy of reception at the distant point.

The data obtained from these transmission tests have enabled the Laboratories to proceed with assurance to the design of a complete two-way radio telephone system for airplane dispatch service. The design of this apparatus has closely paralleled these transmission studies, and equipment is being designed for Western Electric manufacture which will adequately meet transmission requirements revealed by this survey. Regulatory requirements, such as that of the Federal Radio Commission decreeing that the transmitter be maintained to within .025 per cent of its assigned frequency, are also being fulfilled.

A New Radio Receiver for Commercial Airplanes

By F. M. RYAN
Apparatus Development Department

GOVERNMENT aids to air navigation now include not only emergency landing fields and beacon lights along the established airways, but also radio telephone stations for the hourly broadcast of weather conditions, and radio beacon stations for guiding airplanes in flight. Bell Telephone Laboratories, actively engaged in airplane-radio developments during the war, has been continuously at work in the radio field in the intervening years, and now to meet the demands of commercial flying has developed a new and compact radio receiving outfit known as the 6008-A, to be manufactured by the Western Electric Company.

Radio beacons, used to guide planes over the various airways now rapidly extending their branches over the country, operate in the band of frequencies from 285 to 315 kilocycles. Weather information is transmitted hourly from government stations in the frequency band from 315 to 350 kilocycles; and the new receiver is designed to cover these two bands, making it possible to tune to any beacon or weather transmitting station along the airways.

Requirements for a radio receiver for aircraft are exceedingly rigorous. The apparatus, employing only a small vertical antenna, must be highly sensitive to receive signals at distances of from 100 to 200 miles from two-kilowatt ground stations; it must provide sufficient output level to make the signals audible over the tremendous noise of engine, propeller, and wind, which is experienced in most present day planes; and it must, of course, be simple and dependable in operation. Compactness and lightness are additional requirements that can never be overlooked. All these requirements have been adequately met in the development of the new receiver.

Throughout the receiver, tubes of the recently developed unipotential-cathode type have been employed. The cathode of these tubes is not heated directly by the passage of a current but indirectly by conduction and radiation from an auxiliary filament. By this arrangement the possible introduction of noise from the filament supply is entirely eliminated. Only four tubes are used altogether. Three are of the shield-grid type, two being employed in the receiver as radio frequency amplifiers, and the third as a detector. The fourth, which does not contain the shield-grid feature, is employed as an audio-frequency amplifier.

There are three tuned circuits, one for the antenna, and one for the output circuit of each of the stages of radio-frequency amplification. A special gang condenser is employed for simultaneously tuning these three circuits. In this way uni-control is provided with unusually compact and light equipment. The amplification of the receiver is controlled by a potentiometer which varies the shield po-

Figure 1—Simplicity of control, one of the many features built into the new airplane radio receiver, is evident from this photograph

tential of the two radio-frequency amplifier tubes. The only other control is a switch for turning the receiver on and off.

The receiver is mounted in a duralumin box about twelve inches long by eight high and a little over four inches deep. Complete with vacuum tubes it weighs less than thirteen pounds. The receiver is of high sensitivity; an antenna input of ten microvolts is sufficient to enable it to deliver an audio frequency output of six milliwatts. It is, however, capable of delivering output levels of as great as sixty milliwatts when required and, owing to the unusual detector characteristic, only twenty microvolts antenna input is required for this greater output.

Both filament and plate supplies are obtained from a small wind-driven generator with a stream-lined casing having a diameter of only a little over three inches. Complete with propeller it weighs less than seven pounds. This generator, driven at 6500 r.p.m. by a Deslauriers constant-speed propeller, is provided with a double winding, and supplies direct current at voltages of 9 and 220 for the filament and plate circuits. A filter for smoothing out the plate supply is included in the radio receiver. Due to the employment of vacuum tubes of the unipotential-cathode type, filtering of the filament or heater supply is unnecessary. The employment of this generator insures a dependable power supply at all times with a minimum amount of maintenance, and avoids entirely the use of dry batteries requiring frequent replacements. Mounting brackets and a connecting cable are provided with the outfit, which makes the installation of the generator in an airplane a relatively simple matter.

A stream-lined antenna pole about eight feet high is all the additional equipment that is required. The antenna may be either self-supporting or guyed, although the self-supporting type is preferred due to the smal-

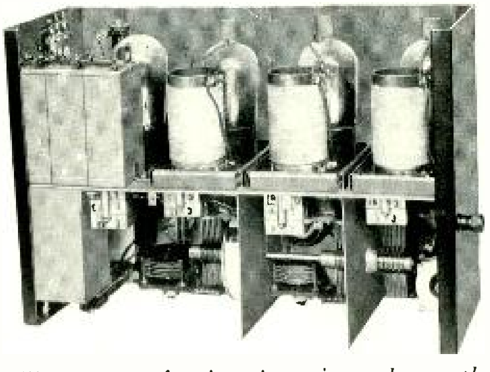

Figure 2—An interior view shows the compactness and relative simplicity of the apparatus

ler head resistance it offers. The only other special arrangements that are required to adapt the airplane for the use of this radio receiver is thorough elding of the ignition system. All t e conductors must be carried either in rigid metal tubes or flexible braided copper sleeving, bonded at frequent intervals to the frame of the fuselage. The magneto and spark plugs must also be completely shielded. Magneto and engine manufacturers are now prepared to supply such completely shielded systems and shielded spark plugs are also available.

A low-impedance head set, equipped with a weatherproof cord suitable for use with standard Spalding radio helmets, is supplied with this outfit. This head set may be used by the pilot to receive both the weather and beacon signals now being transmitted from stations of the Department of Commerce. In receiving these beacon signals the pilot may determine to which side of the airway he is deviating by the relative strength of two Morse characters; when flying on the airway these characters blend into one long dash of constant amplitude. The radio receiver has been designed, however, to be used also with the visual type of beacon indicator advocated by the United States Bureau of Standards. If this type of beacon transmitter is adopted by the Light House Bureau, visual indicators of the vibrating-reed type will be provided for use with the receiver.

The general employment of this radio receiving outfit by air transport operators will make available to them, at a minimum of cost, the valuable aids to navigation which have been provided by the government. In many of the smaller ships at least this will be the only radio apparatus employed. Most of the larger ships, however, particularly those carrying passengers, will require complete two-way radio communication, and equipment for this purpose will shortly be available from the Western Electric Company as the result of extensive studies by Bell Telephone Laboratories.

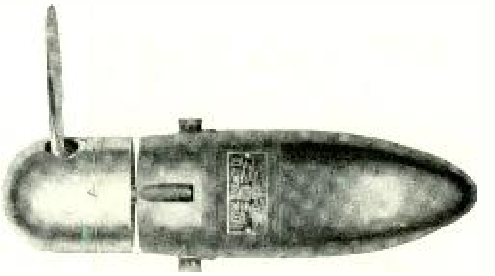

Figure 3—Only a single propellor blade is used with the wind-driven generator so as to simplify the adjustment of the blade angle to compensate for different velocities

Science in American

As long as the world at large was satisfied to leave the engineer and the scientist alone, they were content to communicate within their own ranks in their own language, and to bury within the volumes of their transactions their discoveries and deductions. But the day is past when it is right, or in fact possible, for the engineering story to lie hidden from the public. The sciences have entered so largely into business and into government that they have come directly into contact with millions of people who have no technical knowledge, but who still have the undisputed right to know at least something of what technical things mean. The people as a whole have signified their interest, too, and it is idle to continue to deny them information on the ground of their ignorance. Great stories lie hidden in science and engineering, and it is in line with the spirit of the times that these stories should become public property.

Because they lacked the time or because they felt it futile, technical men have never made an effort to explain themselves to their fellow human beings, and there has seldom been anyone else properly qualified to do it for them. The result has been unfortunate—bad for the public and bad for the profession, too. Great discoveries and inventions have lacked the public support; great projects have failed to interest those whom they were designed to serve; misunderstanding and misrepresentation, political corruption and large misuse of private power have grown out of the fogs that might have been dispelled by careful and enlightened publicity. In every profession there must be a certain number of people who are able to tell the story of the whole group to the outside world, and to promote within the group the exchange of thought and experience which helps to make the art progress.

—D. O. Woodbury in Tech Engineering News,
January, 1929.

Straightforward Trunking

By W. C. OAKES
Systems Development Department

A STRAIGHTFORWARD act is one in the accomplishment of which there is no retrograde action; it is one that advances orderly and progressively from beginning to end. So understood, the term straightforward is applicable to one method of operating trunks between telephone offices. While straightforward operation is practically as old as the scheme of trunking, having been employed on ring-down trunks or toll lines, and in isolated cases on automatic trunks, from the earliest days, yet it has not until recent years been developed so that it could be extensively applied.

Prior to the now general use of straightforward operation, the call-circuit method was commonly employed in establishing manual calls requiring trunking from one central-office district to another. Under this method, represented diagrammatically in Figure 1, the "A" operator, upon receiving a request for connection to a subscriber in another central-office district, depresses a call-circuit key bearing the designation of the called office. This operation connects her telephone circuit to a pair of conductors, known as a call circuit, which terminates at the called office in a "B" operator's telephone circuit, and over this call circuit she passes the number desired to the "B" operator. This operator in turn selects an idle trunk from the group running between the two central offices and assigns that trunk for the connection by passing its number to the "A" operator. The "A" operator then plugs the calling end of the cord used in answering the subscriber into the jack of the assigned trunk, while the "B" operator inserts the plug of the same trunk into the jack of the subscriber's line, thereby completing the connection.

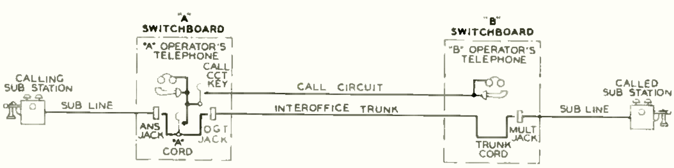

Fig. 1—Schematic of call-circuit interoffice connection

Under straightforward operation, shown diagrammatically in Figure 2, the "A" operator upon receiving a request for a similar connection, herself selects an idle trunk which is then either manually or automatically connected to a "B" operator's telephone circuit. Two tone-impulses are returned over the trunk to the "A" operator to indicate that the "B" operator is ready to receive the call. Upon the receipt of the tone, the "A" operator passes the called number over the trunk and the "B" operator thereupon disconnects her telephone from the circuit and plugs the trunk into the called subscriber's line.

With the call-circuit method the choice of a trunk, as may be seen from the description above, is made by the "B" operator, while with the straightforward method it is made by the "A" operator. For straightforward trunking, therefore, equipment and operating methods must be provided for the "A" operator which she did not require when using the call-circuit method. Three ways of trunk selection* by the "A" operator are possible. The first is by the usual individual busy test and this method, in general, is found economical for groups of not more than twenty trunks. For groups containing twenty to fifty trunks, however, it is usually economical to employ a second method in which a master busy tone is used. The complete group of trunks to each office is divided into sub-groups of five and the operator determines whether all the trunks of a sub-group are busy by testing only the first trunk, the busy condition of the sub-group being indicated by a tone superimposed on the usual busy click.

For the third method, the trunk group is divided into sub-groups, as for the master busy tone, and a lamp is associated with each trunk. In operation, the lamp associated with the first idle trunk of a sub-group is

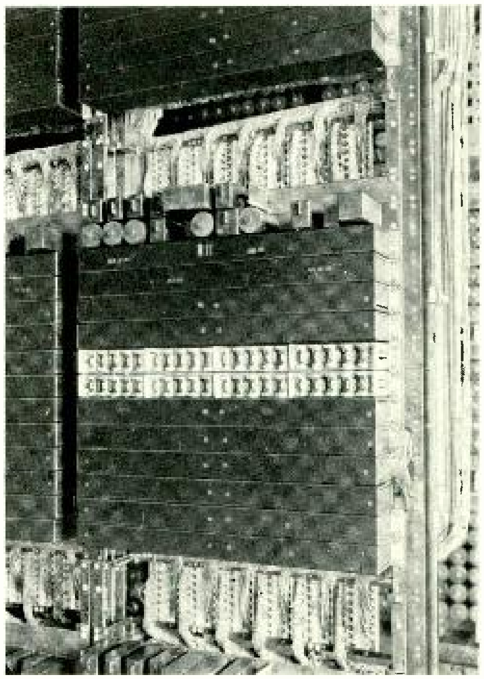

Fig. 3—An applique unit is a compact group of relays and equipment that contains the heart of the automatic listening system

lighted to indicate to the "A" operator the trunk which should be used. To permit the use of this scheme without sacrificing multiple space in the section of a switchboard, a combination lamp and designation strip has been developed which can be mounted in the space required for the usual designation strip alone. This method, known as "idle trunk indicating," is usually economical for groups of more than fifty trunks, but in some situations, such as with the "AB"

* *A fourth method, used only for exceptional cases, was described in* BELL LABORATORIES RECORD, *Vol. VII, No. 4, pp. 157-160, December, 1928.*

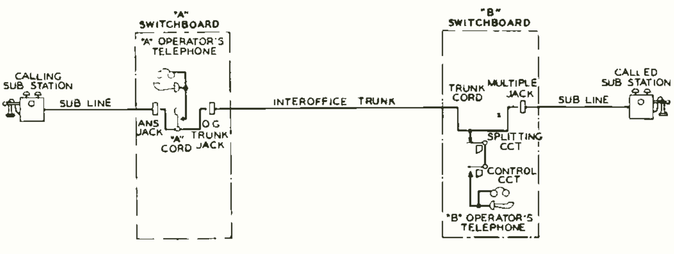

Fig. 2—Schematic of straightforward interoffice connection

tandem board, it is found desirable to use it with smaller groups.

As the "A" operator is responsible for selecting a trunk it is necessary to provide a means of indicating the selection to the "B" operator. The straightforward trunk has been arranged, therefore, so that the guard lamp at the "B" board will indicate when a call is waiting. Furthermore, in order that the "A" operator may pass the called number to the "B" operator under straightforward operation, provision must be made at the "B" board to connect the selected trunk to the "B" operator's telephone circuit. Three methods are possible, and they are known, in accordance with the practice employed, as jack-listening, key-listening, and automatic-listening operation. Automatic-listening operation is used in machine-ringing "B" boards and also in new tandem switchboards. Key listening, in general, is used in manual-ringing switchboards, while jack listening is employed in switchboards of which the expected life is too short or the trunks too few to justify the expense of either of the other methods.

With the jack-listening method the "B" operator plugs the trunk on which a signal appears, into the jack of a listening circuit at her position. The function of this circuit is to trip ringing in case machine ringing is employed, return the two-impulse order tone commonly known as a "zip" tone to the "A" operator, and immediately connect the trunk to the "B" operator's telephone circuit. As mentioned above, the tone informs the "A" operator that the "B" operator is ready to receive the call.

The key-listening method requires a key which is individual to a trunk, the "B" operator connecting her telephone circuit to a trunk by depressing the associated key. As with the other methods, the order tone is returned to the "A" operator to indicate that she should pass the call.

It will be noted that with both jack listening and key listening, the operation of connecting a trunk to the telephone circuit is under the manual control of the "B" operator. With automatic-listening operation, however, selected trunks are automatically connected to the "B" operator's telephone circuit one at a time, in a predetermined order advancing from left to right, as calls come in over them. The order tone is sent not only to the "A" operator but, on account of the automatic connection of the trunks to the telephone circuit, it is also returned to the "B" operator to inform her that a call is about to be passed.

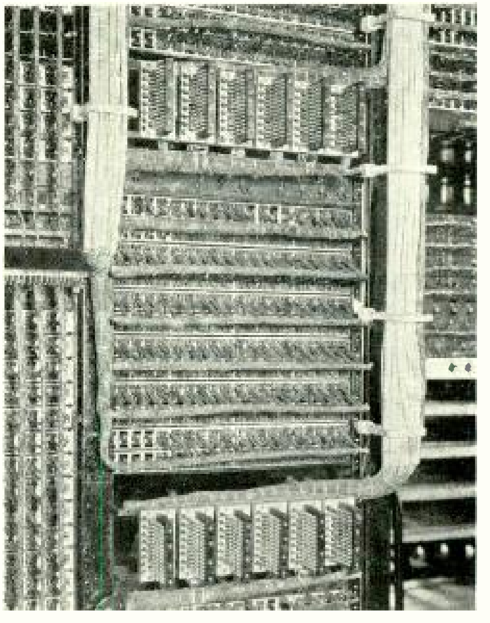

Fig. 4—A rear view of the applique unit emphasizes the compactness of the unit and the readiness with which it may be installed

The release of the trunk, however, is under the manual control of the "B" operator, and is accomplished by the depression of a release key or the plugging of the trunk into the line called. As the release of one trunk permits another trunk to seize the telephone circuit automatically, the release key is provided to permit the "B" operator to accept another call while the previous one is being plugged into a line jack. This overlapping operation speeds up service by filling the interval during which the operator is reaching for the jack.

Due to shortening the "B" operator's work-time the use of automatic listening has enabled the operators to handle a number of calls considerably in excess of those handled with the call-circuit method.* The key-listening method, although somewhat slower than that of automatic listening, also shows economies resulting from higher loads. Although the economies of jack listening over call-circuit operation are somewhat questionable, it is advisable, nevertheless, in a district which is being converted to straightforward operation to provide jack listening at the "B" boards of the few offices which can not be economically converted to key-listening or automatic-listening operation, in order to maintain a uniform operation on the part of the "A" operators.

The application of straightforward operation has been mainly to existing offices where the call-circuit method was in use. It was desirable, therefore, to engineer the requirements for the conversion so that a minimum of changes would be necessary in the existing equipment either on the relay racks or switchboards. The conversion required from one additional relay per trunk, for jack-listening operation, to four per trunk, for automatic-listening operation, with a further addition of from ten to fifty relays per position.

For automatic listening it was found that the most economical way of providing the extra equipment for the conversion was by supplying position units which included the extra relays for the trunks of a position as well as the relays for the positional circuits. This unit, shown in Figure 3, and known as the "applique" unit, is made up in the factory with all apparatus mounted and all wiring local to the unit permanently made. By proper cabling between the applique unit and both the existing relay racks and switchboards, the apparatus of the unit functions properly with the existing equipment to provide the traffic features of the straightforward method.

** With large groups this statement does not always hold but, considering areas as a whole, economies have always resulted, and uniformity of method warrants the change to straightforward trunking even in these exceptional situations.*

The Electromagnetic Oscillograph in the Circuit Laboratory

By L. J. STACY
Systems Development Department

OSCILLOGRAPHIC analyses as applied to problems of the Circuit Development Laboratory may be conveniently divided into three different types: measurements of time, including frequency and phase angle; investigations of wave shapes; and measurements of magnitudes of such quantities as current, voltage, power, resistance, inductance or capacity. So far it has been the practice to use the ordinary form of electromagnetic vibrating-mirror oscillograph modified to employ a special timing system, and a roll of recording photographic paper instead of a film and drum.

Time, in many cases, is the controlling factor in a telephone circuit. In a panel-type sender circuit, for instance, the relay which operates at each closure of the subscriber's dial contacts must operate within .025 second. Although it is possible to determine whether or not the relay operates properly by testing with a subscriber's dial or pulse machine, the oscillograph has been used to determine the margin of safety between the actual operating time of the relay and the minimum time allowed for operation in the circuit. At present, oscillograms are taken to measure operating and releasing times of relays; open and closed periods of interrupters; and many other allied conditions.

The timing system is controlled by an electrically driven tuning fork, adjusted to vibrate at the proper frequency, and carrying contacts which interrupt the direct current that operates a small impulse motor. A disk on the motor shaft has ten evenly spaced slits. Pulses of light admitted through these slits at regular intervals are directed by a suitable optical system to

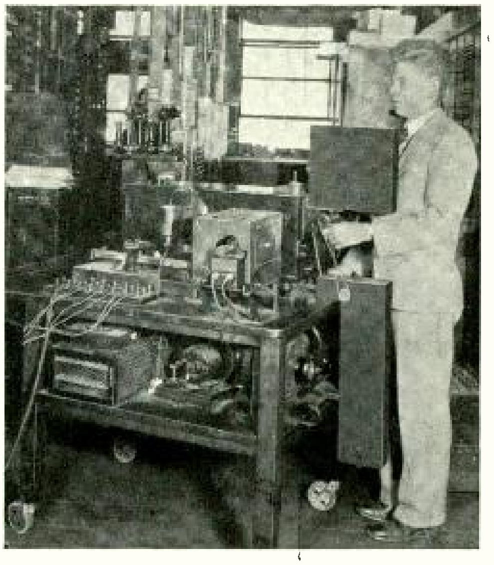

Fig. 1—Using the oscillograph to measure the operating times of relays

the edge of the film, where they form reference timing lines.

There are many factors to be taken into consideration, however, when measuring time with this instrument.

Among them are inherent limits of accuracy of the timing mechanism itself, such as small variations in the frequency of the timing fork and hunting of the timing motor; variations due to slipping of the paper; variation in the speed of the motor which, from a large roll, continuously draws the paper past the aperture; uneven shrinking of the paper during developing and drying; temperature variations causing changes in damping due to changes in the viscosity of the oil in the vibrator cell; and personal errors in reading the oscillograms. Fortunately most of these are not necessarily cumulative; some can be evaluated; and most of them can be kept small. The overall accuracy of the timing mechanism, checked by a thousand-cycle wave applied to one of the vibrators, is usually maintained to at least one-half of one per cent, and when necessary a much greater accuracy can be obtained.

Inaccuracies resulting from unequal separation of timer lines have been observed to introduce an error in certain cases of from two to three per cent. Personal errors are difficult to evaluate but it has been demonstrated quite conclusively that individuals may vary in their readings of the same oscillogram by as much as five ten-thousandths of a second while readings made by the same individual will vary from day to day and even at different times of the same day.

In comparing wave shapes, oscillographs with vibrators having the highest natural period and critical damping are most satisfactory. Ringing and tone studies frequently require examination of the wave shapes from various machines, as changes in the shape of the current wave result in differences in the range and quality of the ring. So, too, the number and magnitude of the harmonics have considerable effect on the characteristic sound of a tone. Although the oscillograph gives no determinable quantitative measure of these harmonics it is frequently used to compare two waves with regard to general form.

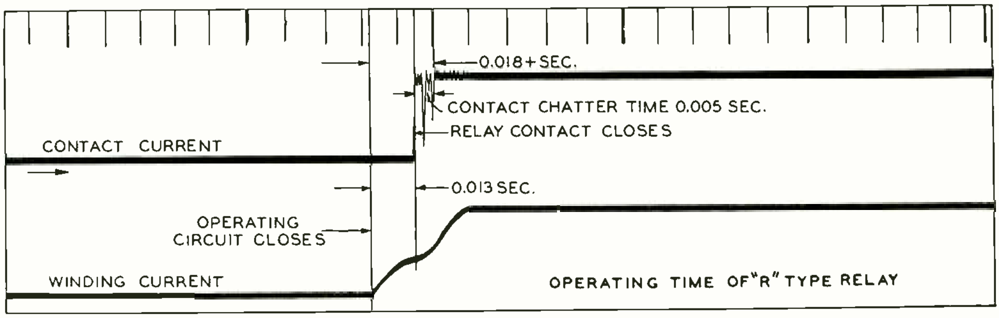

Fig. 2—Oscillogram illustrating the method of determining relay operating times

In studies of clicks and other noises which may be produced in the receiver by various causes, wave shape is also examined by means of the oscillograph. Disturbances with wave fronts corresponding in steepness to those of a thousand-cycle sine wave will be much more objectionable than those with higher energy contents dissipated over longer periods, because both the receiver and the ear are most sensitive in the vicinity of a thousand cycles. With decreasrequencies the same energy becomes steadily less audible.

The most serious errors affecting the study of wave shapes are those caused by incorrect damping. Damping is controlled by the viscosity of the liquid—a mixture of oil and turpentine—in the vibrator cell. As viscosity is a function of the temperature, vibrators will be over-damped when cold and under-damped when hot. Wherever the wave form is at all important it is necessary to heat the field coils—the chief source of temperature rise—to such a point that the temperature remains substantially constant. The amount of damping can be adjusted by changing the proportions of oil and turpentine in the cells. Although there is a critical point at which vibrators show neither a lag nor an overthrow it cannot be maintained in practice. Fortunately damping does not require particular attention for the measurement of time intervals but as the vibrators are maintained just slightly underdamped when the fields are hot, there is a tendency to accentuate any contact chatter or similar conditions which may exist.

When quantitative measurements of current, voltage, or other quantities are to be made the vibrators are adjusted either to give known deflection for a predetermined circuit condition, or else to give satisfactory deflections for the unknown condition. In the latter case an additional calibrating picture would be taken with the same adjustment and a known current flowing. Under these conditions the oscillograph serves to record at each instant the value of current, voltage, power, or whatever circuit variable is being measured.

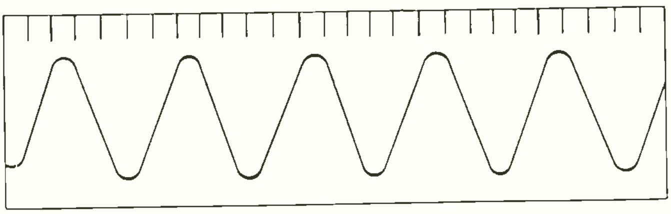

Fig. 3—Oscillogram showing the wave form of standard ringing machines

One of the interesting uses of the oscillograph for problems of this group is a method* of measuring the quantity of electricity required for any circuit operation. Oscillograms are taken of the current flowing in the

"Saving Days and Dollars with Shears" by S. W. Allison, BELL LABORATORIES RECORD, *January*, 1928.

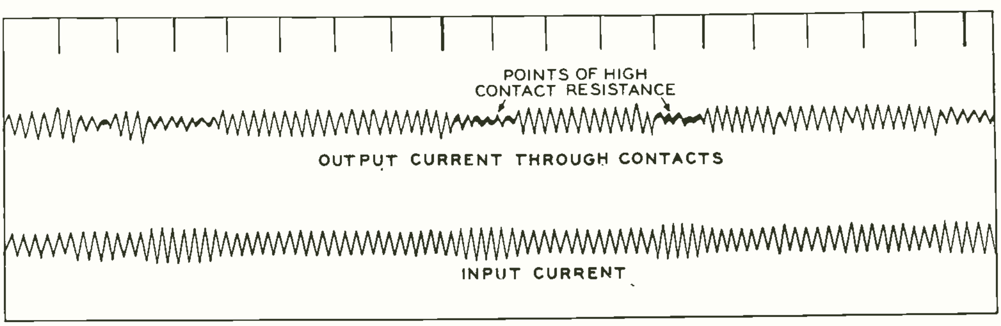

Fig. 4—Oscillogram showing the varying resistance of contacts

circuit for the period of operation. As the area under the current curve represents the energy consumed the area can be evaluated in ampere-seconds, and later translated into ampere-hour requirements of central-office batteries.

Another interesting use is measuring change in contact resistance in talking circuits with no direct current flowing. Oscillograms taken in the laboratory under these conditions show that the contact resistance varies over a wide range — becoming infinite and reducing the tone to zero in extreme cases. Special precautions must be taken to guard against such conditions in commercial circuits.

Errors in measuring magnitudes may be introduced by the causes already mentioned but more particularly by improperly damped vibrators. An over-damped vibrator is sluggish and the slope of the curve it traces— unless it be a steady-state value — is always less than the slope of the true curve. Under-damped vibrators overthrow and oscillate at their own natural period. True instantaneous values are not obtained unless the vibrator damping is critical.

The oscillograph may be applied to this great variety of circuit problems, but the engineer must recognize that like all measuring instruments it has limits of accuracy beyond which it is useless to go and that data obtained when these are ignored lead to results not always truly representative of what is occurring in the circuit.

"*Elementary Differential Equations*"

"Elementary Differential Equations," by T. C. Fry, has just been published by D. Van Nostrand Company. It becomes the most recent member of the Bell Telephone Laboratories series of books, of which the titles which have previously appeared are recapitulated on page 220 of the February RECORD. *Like its predecessors, the book is derived from out-of-hour courses given in the Laboratories by its author. It deals with the solution of ordinary differential equations and of systems of such equations, especially those linear equations commonly encountered in physics. The fundamental notions of differential equations are given geometrical interpretations which permit a ready visual grasp of their purport. Written primarily for engineers, the book avoids existence theorems and other topics of purely mathematical interest, and uses the space thus released for practical applications and illustrative examples.*

A New Cordless Switchboard

By W. O. FULLERTON
Systems Development Department

FOR small business establishments, even a complete and comprehensive telephone service may require comparatively few central-office lines and extension telephones. Except in the smallest organizations, a private branch exchange is generally desirable, however, to make any incoming call conveniently available to any of the employees, and to facilitate calls between the local telephones. It is especially necessary that switchboards for such installations take up a minimum of office space. Since the telephone calls seldom occupy the attendant's full time, the board should be arranged to allow her to carry on clerical or other work as well. Cordless switchboards, which occupy only a small part of the top of a desk or table, have therefore been made for many years, to provide the necessary switching facilities with the utmost compactness. As the name indicates, no switching cords are used; interconnections between extension telephones, and connection of these telephones to central-office lines for incoming and outgoing calls, are made by keys on the face of the switchboard.

At these boards there are terminated as many as three trunks from a central office and seven extension lines, in addition to the attendant's telephone. Each line, whether from the central office or from one of the extensions, terminates at a lever-type key made with three key handles. The handles can be operated both up and down, so that there are six positions available for each line. Five of these are used for connecting paths, so called—circuits within the switchboard, which join all the keys. Interconnection is secured by operating the keys of any two lines, to join them to the same connecting path. On a board fitted with the full number of lines, five conversations can be carried on at once—three to the outside, and the other two between extensions. Should the attendant not be involved in any of these calls, all seven of the extensions can be used simultaneously. The sixth key position is used for ringing, on the extension keys, and on the trunk keys for holding incoming calls until the desired line is free.

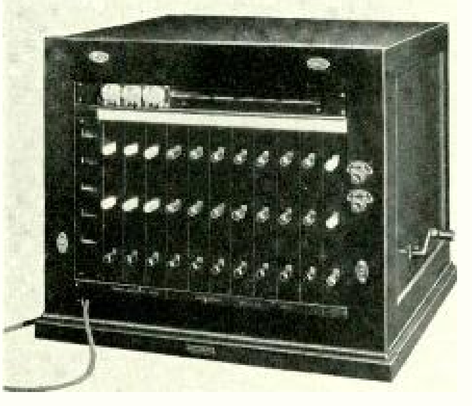

Fig. 1—Outer view of the 506-A switchboard. The other three pictures also show this switchboard

Since the necessary direct current

for talking and signalling is obtained through cable conductors running to the central office, it is desirable that current requirements be kept as low as possible. For this reason, and because the small number of lines makes simplification possible, electromechanical signals requiring little current are used for attracting the operator's attention in place of the signal lamps customary in switchboard practice. Above the key for each trunk circuit is a drop* operated by ringing current from the central office and restored by hand. Station line signals and supervisory signals are of the magnetic target type. Those for the extension lines are located above their respective keys; when a receiver is taken from the hook, the target of the corresponding signal appears, and it restores when the attendant answers. Supervisory signals are at the left of the key bank and opposite their respective connecting paths. They are displayed at the end of each conversation, after the extensions have hung up, and are restored when the attendant restores the keys to normal.

For ringing any of the extensions, pressing down the lowest handle of the appropriate key connects ringing current to the extension line. This current ordinarily comes from the central office, but when central-office ringing current is not available, a magneto generator built into the board is used.

On an incoming call from a central office, the drop associated with one of the trunks operates, and a buzzer gives audible notice that a call is waiting unless the buzzer is shut off at its control key. The attendant, choosing an idle path, connects it to the trunk and to her own telephone set by the appropriate key handles. On learning which station is wanted, she completes the call by connecting and ringing the desired station line. She disconnects her own telephone by restoring the key to its normal position, and when the call is finished restores both trunk key and extension key. Calls from one extension to another, or from one extension to the outside, are completed in practically the same manner.

When the switchboard is to be unattended, at night or at other times, three of the lines may be left connected to the trunks by operating keys just as for calls during the day. Calls may then be made and received directly at the

* *Drops, the first visual telephone signals, have been made in many forms. As here used, they carry a shutter hinged at the bottom and held vertical by a latch at the top. Ringing current raises the latch, allowing the shutter to fall forward.*

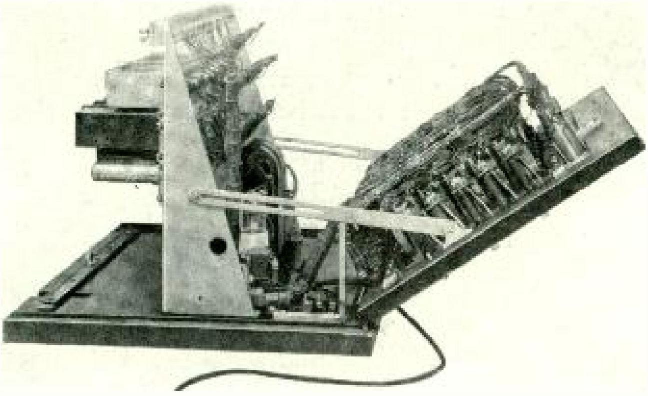

Fig. 2—When the cover is removed and the front swung down, ready access is given to all the apparatus

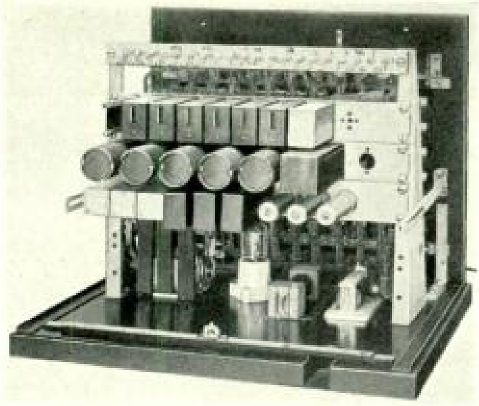

Fig. 3—The mounting-plate assembly is in the foreground, in this picture taken from the rear

extensions. The night service key is provided for use when these permanent night connections are set up. Its operation disconnects the battery from the supervisory signal circuits and opens the connection between the buzzer and the trunk drops, to prevent unnecessary battery drain.

Direct current for talking is supplied to local conversations through a retardation coil in each connecting path. To eliminate the transmission loss of these coils on outside calls, direct current in those cases is supplied from the central office over the talking circuit, and the retardation coils are cut out. This arrangement gives the local station the benefit of standard transmission on all central-office connections.

In the course of switchboard development the circuit features described had been provided a number of years ago. Now a new board of this type is being made, known as Number 506-A*. It is the same in circuits and in functioning as its predecessor, but in arrangement and mounting of the apparatus it has been revised completely to simplify manufacturing and to give maximum accessibility for maintenance. A salient feature of the new design, whereby the changed construction first becomes evident, is the type of cover, which includes roof, back, and two sides. When it is taken off, and the hinged front swung down as in Figure 2, the apparatus can be reached from all sides. The front itself has not been changed, but the apparatus mounted on the side walls of the older switchboard has been transferred to mounting plates on the interior, supported by two gusset plates of heavy sheet metal. Four pieces of apparatus — hand generator, resistance lamp, induction coil, and buzzer — are fastened to the wooden base, but everything else has been transferred to the

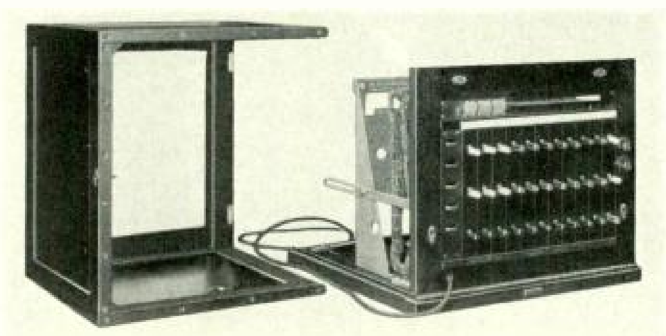

Fig. 4—The switchboard with cover removed, showing how readily the interior is made accessible

**Another new cordless switchboard, 506-B, gives switching facilities for five trunks and twelve extensions. In method of operation and circuit essentials it is the same as the smaller cordless P.B.X. Construction and arrangement of the apparatus are similar, but certain pieces of apparatus are mounted differently.*

mounting plates, except of course the apparatus mounted on the key front. At the top of the mounting-plate supports, where it is handiest, is a terminal strip for making connections to the central-office trunks and the extension lines.

Even removal and replacement of the cover have been simplified. It is open on the bottom and the front, and is arranged to fit against the back of the key front. A lock screw at the back, and two at the front, hold it in place. Steel runners at either side of the base, turned up at their outer edges, provide a surface on which the cover may slide, and prevent it from moving sidewise. A projecting strip at the bottom of the cover hooks under a metal strip running across the back edge of the base. As a result of this construction, removal or replacement of the cover, including unscrewing or replacing the three lock screws, is a matter only of seconds.

From the viewpoint of users and attendants, the distinguishing colors of the various groups of key handles facilitate operation by showing at a glance the grouping of the keys. At the same time identifying the keys has been made easier by an additional designation strip provided near the bottom, but otherwise the new switchboard has the same general appearance as that previously supplied. From the standpoint of installation and maintenance, however, it marks a prominent advance, giving greater speed for any necessary work as a result of the much greater convenience. Likewise the new construction, with everything so open and so readily accessible, facilitates manufacture.

It is with regret that we record the death of a valued member of our Technical Staff:

George Oliver Bassett

chemical engineer

August 24, 1870—March 21, 1929

Alumnus of Massachusetts Institute of Technology; member of the American Chemical Society; a member of the Bell System chemical staff since 1894, and in charge of the analytical laboratory since 1907; active in developing methods of analysis for paints and pigments, and in investigating means of wood preservation

News Notes

Mr. Charlesworth attended the Cincinnati Regional Meeting of the A. I. E. E. on March 20 and 21.

At the meeting of the Colloquium on March 4, K. K. Darrow discussed the "Fermi-Sommerfeld Theory of Electrons in Metals." R. L. Wegel spoke before the Colloquium on March 18 on the "Internal Viscosity of Metals."

The New York Chapter of the American Society for Steel Treating held its March 11 meeting in the Auditorium of the Laboratories. The guests, numbering about four hundred, were welcomed by G. F. Fowler, who introduced a showing of sound pictures. Following a talk by Dr. Ives, the television system was demonstrated. A tour of inspection was made of the Microscopical Laboratories directed by F. F. Lucas, who as Chairman of the Chapter arranged the meeting.

Research

H. D. Arnold addressed the faculty and senior students of the departments of physics and chemistry of Wesleyan University at Middletown, Connecticut, on training for engineering and research.

H. A. Frederick, W. C. Jones and H. A. Larlee attended a meeting of the Telephone Instrument Survey Committee at Hawthorne from February 24 to March 2, discussing matters pertaining to handsets.

L. H. Campbell and F. F. Farnsworth visited the Southern New England Telephone Company at New Haven from January 28 to February 1 to note the results of various types of finishes on automobiles used by the associated companies of the Bell System.

G. O. Bassett and R. E. Waterman made a general inspection of experimental tests on wood preservatives at Gulfport, Mississippi, from January 20 to February 16.

H. H. Lowry visited certain properties of the Lehigh Coal Company at Wilkes-Barre and Hazleton, Pennsylvania on February 5 and 6, and again on February 11, to investigate a new supply of coal for the manufacture of transmitter granules.

J. E. Harris and J. H. White were at Hawthorne from February 24 to March 3 to observe recent developments in copper refining.

Herbert E. Ives received the honorary degree of Doctor of Science from the University of Pennsylvania on February 22.

Harvey Fletcher recently gave a series of demonstration lectures on "How and What We Hear," speaking before the University Club of Chicago on March 9, at the University of Minnesota on March 11, and the Mayo Clinic, Rochester, Minnesota, on March 12.

General Staff

S. P. Grace spoke before the University Club of Albany on March 6 on recent developments of these Laboratories. The following day he addressed the executive and supervisory staffs of the New York Telephone

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Children" before the Maxwell Training School Annex in Brooklyn on March 12.

Company in Albany. On March 15 he addressed the Detroit Engineering Society and on the sixteenth, the executive and supervisory staffs of the Michigan Bell Telephone Company at Detroit. Mr. Grace also spoke before the College of Engineering at the University of Michigan on March 19. His engagements for March concluded with a speech at the Alumni Dinner of Massachusetts Institute of Technology at the Waldorf-Astoria, New York, on March 26. On each occasion, R. M. Pease demonstrated certain Laboratories apparatus in conjunction with Mr. Grace's talks.

John Mills addressed the Eastern Association of Physics Teachers at Boston on March 2, on the photoelectric cell and its use in communication. G. F. Fowler was also present, giving a demonstration of apparatus.

P. B. Findley spoke on "Speech and Hearing with Reference to Deafened School

M. I. T. Students

Two groups of Massachusetts Institute of Technology cooperative students left the Laboratories to return to the Institute on February 1, 1929. One group will be graduated with the degree of master of science in electrical engineering in June of this year. They will have had five terms' experience in the Bell System in addition to completing all the courses required at the Massachusetts Institute of Technology for the master's degree. They are, left to right: standing, C. H. Rumpel, D. Y. Bradshaw, J. C. Edgar; seated, N. C. Olmstead, J. L. Barnes, J. E. Tully, C. T. Prendergast. This is part of the first group to be graduated under the Bell System option of the electrical engineering cooperative course.

The other group is a year behind the first. They are scheduled to re-

1930 *Group of M. I. T. Students*

ceive their master's degrees from the Institute in June, 1930. They are, left to right: standing, W. C. G. Swift, O. R. Garfield, G. L. McKenna; seated, D. T. Osgood, R. D. Fracassi, L. R. Moses, A. E. Fribance.

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M. B. Long visited the state universities of Iowa, Nebraska, and Michigan, and Massachusetts Institute of Technology, during March to interview those of the 1929 engineering graduates interested in employment in the Bell System. During the month R. A. Deller went to Case, Purdue, and Virginia P. I. for the same purpose; M. L. Wilson, to Columbia; L. S. O'Roark, to Illinois and Kentucky; D. A. Quarles, to Union and Yale; E. L. Nelson, to Bradley; T. E. Shea, to Stevens, Syracuse, and Johns Hopkins; T. C. Fry, to Wisconsin and Harvard; W. Wilson, to Cornell and Princeton; E. J. Johnson, to Rutgers and Rensselaer; H. S. Shope, to Texas A. & M., Texas U., Rice, Oklahoma A. & M., and Oklahoma U.; and J. O. Perrine, to Pennsylvania State, Vanderbilt, Kansas U., Kansas State, Missouri, and Washington University.

Apparatus Development

R. L. Jones and W. Fondiller were recent visitors at Hawthorne, where they observed improved manufacturing processes now in use in the Manufacturing Department.

N. Bishop inspected the five-kilowatt broadcasting equipment owned by the City of Atlantic City. With A. B. Bailey, he also supervised the conversion to crystal control of the five-kilowatt equipment at Station WABC of the Columbia Broadcasting System. Previously, Mr. Bishop had supervised the crystal-control conversion of the one-kilowatt broadcasting equipments at Miami Beach, Florida, owned by the Miami Beach Bay Shore Company and at Clay Center, Nebraska, owned by M. M. Johnson and Company. He installed a five-kilowatt broadcasting equipment at Tulsa, Oklahoma, recently purchased by the Southwestern Sales Corporation of that city. He also inspected the five-kilowatt equipment owned by the Bankers Life Insurance Company of Des Moines, Iowa, and the five-kilowatt equipment at Winnipeg owned by the Manitoba Telephone Systems.

W. L. Tierney supervised the conversion to crystal control of a one-kilowatt broadcasting equipment for Warner Brothers, Los Angeles, and a similar equipment owned by L. Wasmer, Inc., Spokane, Washington. In addition he directed the installation of a one-kilowatt broadcasting equipment for the Puget Sound Radio Broadcasting Company of Seattle. Mr. Tierney also directed the installation of the five-kilowatt broadcasting equipment for Hale Brothers, of San Francisco, California.

B. R. Cole made a survey for a one-kilowatt broadcasting equipment for the Matheson Radio Company, Inc. of Gloucester, Massachusetts.

J. C. Herber directed the installation of five-kilowatt broadcasting equipments for the Alabama Polytechnic Institute and the State Government of Alabama. He also installed the associated speech-input equipment at Birmingham and Montgomery. He inspected the 500-watt broadcasting station WSMB of the Saenger Amusement Company of New Orleans, and the one-kilowatt broadcasting equipment owned by the City of Camden, New Jersey. Mr.

Herber subsequently made a survey for the one-kilowatt broadcasting equipment purchased by the Shepard Stores, Boston, Massachusetts. He also made an inspection of the 100-watt equipment owned by the Tremont Temple Baptist Church of Boston.

O. W. Towner supervised the conversion to crystal control of the five-kilowatt broadcasting equipments of the Peoples Pulpit Association, and the Chicago Daily News, Chicago; the Palmer School of Chiropractic of Davenport, Iowa; and the Zion Industries of Zion, Illinois. He also made a survey for a one-kilowatt broadcasting equipment for the Hotel Lassen of Wichita, Kansas. Previous to this, he had supervised the conversion to crystal control of the five-kilowatt broadcasting equipment owned by the City of Atlantic City, New Jersey, and the five-kilowatt equipment owned by the Radiophone Broadcasting Company of Chicago, and took part in the survey for the Shepard Stores of Boston, Massachusetts.

H. S. Price addressed the Graybar Convention of Specialists on February 14 on broadcasting equipment and surveys for installation.

R. V. Terry visited Washington and Rochester to inspect recording lenses for newsreel cameras.

G. Puller visited several motion-picture theatres in Philadelphia to inspect sound-picture apparatus.

R. Nordenswan spent several days at Hawthorne in connection with the manufacture of phonograph reproducers used with sound pictures.

E. G. D. Paterson, C. S. Gordon and A. F. Gilson visited the Chesebоro-Whitman Company in Newark Valley, New York, on March 4, and Mr. Paterson and Mr. Gordon visited the Babcock Company in Bath, New York, on March 5 to discuss the manufacture of ladders.

B. Freile visited Hawthorne and the Automatic Electric Company plant at Chicago during the week of February 25 to confer on step-by-step apparatus.

J. T. Butterfield has been elected President of the Passaic County Planning Commission, charged with coordinating the future growth of municipalities and suburban territories in his district.

A. F. Gilson visited the Stromberg-Carlson Manufacturing Company in Rochester and the Highway Trailer Company in Edgerton, Wisconsin, during the last week in February in connection with inspection engineering work.

Mr. Gilson was elected to membership in Edward J. Hall Chapter, Telephone Pioneers of America.

P. S. Olmstead attended a survey conference on handsets at Hawthorne and W. A. Boyd and R. M. Moody attended a similar conference on keys at Kearny during the last week in February.

R. J. Nossaman visited Field Engineering Headquarters in St. Louis, Cleveland, Detroit and Chicago and attended Field Review Conferences in Fargo, North Dakota, Minneapolis and Omaha during the latter part of February.

J. M. Hardesty attended the meetings of the American Concrete Institute at Detroit from February 12 to 14.

C. R. Moore visited Philadelphia on February 1 with H. D. Bender of the A. T. & T. Company to confer with the engineer in charge of standards of the Pennsylvania Railroad on the standardization of outside-plant tools. They also visited the plant of North Brothers in Philadelphia to observe the manufacture of wood-bit braces.

S. C. MILLER was in Georgia and Florida during the latter part of February on matters pertaining to timber preservation.

E. H. COLLEY AND G. Q. LUMSDEN inspected the experimental test grounds of the Bell System at Gulfport, Mississippi, to compare the effects of various preservative treatments on telephone poles.

PATENT

I. MACDONALD, M. R. MCKENNEY AND P. C. SMITH were recent visitors to Washington in connection with the prosecution of patents.

SYSTEMS DEVELOPMENT

A. F. DIXON visited Hawthorne, where he observed many of the improved processes now in use in the Manufacturing Department.

R. S. WILBUR, J. R. STONE AND G. A. BENSON inspected the new No. 3 Toll Board at Chicago. Mr. Benson and L. F. Porter will remain during the test period and be present at the cutover.

W. J. LACERTE is spending several weeks at Denver, Colorado, in connection with the introduction of dial equipment in that city.

F. A. KORN, L. M. ALLEN AND H. A. MILOCHE visited the new Marine Office at Atlantic City and the new unattended exchange at Somers Point, New Jersey.

J. W. WOODARD discussed the new Akron toll project with engineers of the Ohio Bell Telephone Company at Cleveland and Columbus.

J. H. SOLE recently tested a new automatic voltage regulator at the A. T. & T. repeater station in Boston.

A. A. BURGESS supervised the installation of a new switched telephone typewriter service in the toll office at Chicago.

E. J. JOHNSON spent several days at the Hawthorne Plant during the latter part of February.

Bell Laboratories Club

Members of the Bridge Clubs and guests attended a lecture on the game by Mr. Wilbur Whitehead, given in the Auditorium on February 25. Twenty tables were arranged about the platform, at which most of the audience took their places. At each table identical hands were dealt, bid and played. The same hands were again dealt, face up, and the bidding was discussed in great detail by Mr. Whitehead. His questions as to the

correct procedure were searching, and many of his comments provoked a laugh. During the playing of several games, Mr. Whitehead walked about observing, commenting and answering questions. Well-known commuters were seen to struggle feebly as each train-time approached—but so great was their interest that they stayed to learn all they could. The big laugh of the evening followed Mr. Whitehead's winning of a "plugged nickel" from D. A. Quarles after a dispute on one of the finer points of strategy.

Swimming and Gymnasium Class for Men

Each year the Club adds new activities to its social and athletic program. During the past year golf and bowling were organized for women and tennis for men. The Club now offers swimming and gymnasium classes for men at the Kittredge School of Sports. The first class started on Thursday evening, March 14, and will be held each Thursday evening for a period of ten weeks. The fee is $7.50 per person for the course of ten lessons, which consist of one-half hour swimming instruction and one-half hour gymnasium work at each meeting. If the membership so desire, the course will be extended to fifteen weeks.

When the formation of this class was first announced it was hoped that twenty-five men would be interested enough to enroll. Instead, the Club Secretary was swamped with applications and was obliged to increase the membership to thirty, making arrangements with the Kittredge School to start a second class on Tuesday evening, April 2.

D. D. Haggerty, Room 164, will furnish further details regarding these classes, and if enough men are interested a new class will be started on the completion of the present one.

Baseball

Reading the National and American League training camp news reminds one that it is time to get out the old uniform, oil up the pet glove and report to Manager Wood at Farmer's Oval, where tryouts will be held for places on the team which will represent the Laboratories in the

Bell System Baseball League. West Street athletes have reigned supreme for a number of years in all branches of sports except baseball. In 1926, the first year that the Bell System League was organized, West Street men won the league championship, but in 1927 and 1928 the New York Telephone Company team has pushed us into second place. Is there any reason why our team should not finish on top in 1929? None whatever if the ball players in West Street will report for practice and help Manager Wood organize what should be the crack team in the League.

Of the 1928 first string, Trottere, Christ, Koch, Lohmeyer, Drenkard and Gardner remain as a nucleus. We want to hear from college players, men who have played on high school teams and those semi-pro players who may play twilight ball without interference with their Saturday and Sunday contracts. Pitchers are particularly wanted. Tryouts and practice sessions will be held at Farmer's Oval, Fresh Pond Road, Brooklyn, on Saturdays, April 13, 20 and 27. The opening game in the league will be played on Monday evening, April 29, at Erasmus Field, Brooklyn, and will be followed by games on each evening of the week during May, June and July.

Outside of big league ball parks, Erasmus Field is the finest athletic field in the metropolitan district. The park has a grass infield, excellent club house, and locker facilities with hot and cold showers. The Club also provides transportation to the field on nights that the team is scheduled to play. D. D. Haggerty, Room 164, or H. O. Wood, 5A, will be pleased to give full information.

Again this year the Club will have an interdepartmental baseball league. These games will be played at Erasmus Field on Saturday afternoons during May, June and July. Two games will be played each Saturday.

Indoor Golf Tournament

Sixty-six players teed up in the seventh indoor golf tournament of Bell Laboratories Club. A surprise was in store for them; H. L. Edlind, youngest player of them all, walked away with a low gross of 79, two strokes less than par for the thirty-six holes of the qualifying round. Then followed round after round of match play, enlivened by the plop of balls into the water hazards and a near-fire when Tom Rice laid his cigarette on a "property" rock. The players were divided into eight groups according to their qualifying scores. Final matches resulted as follows: J. A. Burwell defeated J. R. Kidd 1 up; "Jack" Hillier defeated H. W. Wood 2 up and 1 to play; L. G. Hoyt defeated N. Thorn 4 up and 3 to play; G. E. Kellogg defeated W. L. Kidde 3 up and 1 to play; E. G. D. Patterson defeated W. F. Johnson 4 up and 3 to play; A. L. Johnsrud defeated P. B. Fairlamb 2 up and 1 to play; F. Canavan defeated E. K. Eberhardt 2 up and 1 to play; J. J. Hart defeated C. A. Sprague 1 up. The prizes were clubs, balls, and golf

accessories. Taking home a prize was an old story for most of the winners; L. G. Hoyt for the fifth time finished "inside the money."

Several of the matches were hotly contested; Sprague took his match away from Crews on the twentieth hole; Patterson beat Hall on the twenty-first; while it took five extra holes for Kidd to establish his superiority over Heydt.

L. P. Bartheld, chairman of the Club's athletic committee, officiated as starter, with J. C. Kennelty, newly elected chairman of the golf committee, assisting.

Women's Interests

Basketball

It is a matter of a great deal of pride to announce that the Bell Laboratories Women's Basketball Team has achieved first place in the Bell System League. Eight games were played and won by our team, five of them League games and the other three, outside games. Throughout these games the teams have met with a spirit of sportsmanlike competition and enthusiasm which probably began with the track meet and seems to be growing in all activities of the Club.

The prizes given by the League to the winning team were awarded to Ann Barioni, Marie Boman, Helen Fritschi, Marianne Grimm, Lillian Kaempffe, Marie O'Neill and Natalie Skinner.

Bowling

Perhaps it was the added incentive of a prize offered by A. F. Gilson coupled with a growing enthusiasm for the game; at any rate, Friday evening, March 1, at Dwyer's was the scene of much keen competition among the women bowlers. Antoinette Kelly was awarded the fountain pen and pencil for the greatest improvement over her season's average. Miss Kelly also leads with a season's high average of 104.3, followed closely by Natalie Skinner whose average is 99.5. Third place is held by Margaret Horne, average 94.1. The season's high scores, thus far, have been made by Lee Melita, 162, Antoinette Kelly 154, Natalie Skinner 152.

Dancing

Judging from the enthusiastic response made by the women of the Laboratories, the new class in rhythm is launched on what promises to be a very successful season under the direction of the Noyes School of Rhythm.

These evening classes are specially designed for business women to afford complete relaxation and to assist in acquiring graceful, rhythmic movement and correct posture.

The first class started Tuesday, March 12, and will continue every Tuesday till May 14.

Bridge

The Women's Bridge Club of Western Electric "GHQ" entertained the women of the Bell Telephone Laboratories at a tournament for the women's trophy on March 8. The evening's play ended very nicely for the visitors, who kept the trophy for the Laboratories with a plus score of 4562.

The leaders in the tournament were:

Catherine Maull and
Katherine Munn 1963
Allegra Rodgers and
Elizabeth Pritzkow 1180
Thelma Taylor and
Edna Haunfelder 1170

These inter-club meetings are proving very popular and will undoubtedly be arranged more frequently in the future.

Hiking

Hiking season is here again.

Our Saturday walks are easy although the mileage may seem large. There is always a camp fire supper at the end of the hike.

On Sunday we go farther and harder. Hikers bring their own food on these long hikes; empty knapsacks may mean hungry mouths.

Weekday campfire suppers are heaps of fun. We leave the building at five sharp and cross the Hudson at Dyckman Street. Everyone pitches in and helps so that by seven o'clock we are all having a race to see who can make the clubbiest sandwich. We sit around the fire and after apologies to the moon and stars, we try to sing. A final cup of coffee and the last of the cookies and we start for the ferry. We always miss a boat because we have to stop at the kiddies' playground and "go up in the air so high." The hostess attends to the food supply and camp equipment for these suppers.

You can get a printed program from the hostess of the hiking activity, Phyllis Barton, Room 749-B.

Indoor Golf

A most successful indoor tournament was held at the Miniature Golf Course of America on Thursday evening, February 28.

In the qualifying round of medal play, thirty women teed off, of whom Miss I. H. Benedict had the low score, one hundred and six strokes. She was awarded an eight-dollar order on Peck and Peck. In the finals Miss Benedict was entered at scratch, and each of the others was given a handicap equal to three-quarters of the difference between her own score and that of Miss Benedict.

Marie Boman's net forty-eight in the finals was low enough to win the first prize, also an eight-dollar order on Peck and Peck; and Helen Cruger won a vanity box by turning in a net forty-nine for second place. Helen Norton finished in third with a net fifty and was awarded a scarf, and Amada Mancinelli received a compact for finishing in fourth place with a net score of fifty-one. Miss Menig's fifty-two was just one stroke too many to enter the charmed circle of prize winners. Miss Benedict's card for the final totalled fifty-seven.

The next tournament is scheduled for March 27. Marion Kane, who can be reached on 774, will furnish particulars.