Bell Laboratories Record

Volume two July 1926 *Number five*

Photoelectric Cells

By Herbert E. Ives

WHEN the problem of transmitting pictures by telephone was undertaken in Bell Telephone Laboratories, one of the first problems to be solved was to find the best means for converting the various values of light and shade in a picture into variations in the strength of an electric current. Early investigators in this field had used the selenium cell, which consists of a resistance of metallic selenium which changes its value when light falls upon it, so that more or less current may be transmitted. For the high grade of picture service which would alone be satisfactory for the Bell System, the selenium cell is inadequate because its response is too sluggish to permit high speed of transmission and is moreover, not proportional to the light falling upon the cell.

The device which was selected for this particular purpose was the "photoelectric cell," a form of vacuum tube developed as a result of the fundamental discovery of the phenomenon of photoelectricity by Heinrich Hertz, who is commonly known as the father of radio. Hertz noted, while experimenting with sparks between various forms of spark gaps, that the ease of sparking appeared to depend on whether the experiments were performed in a dark or a light room. Following this apparently trivial observation, he was led to the definite conclusion that light falling upon the electrodes of his spark gap facilitated the discharge. Other investigators following in his footsteps found that the action of light is to release charges of negative electricity or electrons, as we would now say, from the illuminated surface. By placing the illuminated surface in an evacuated enclosure and by choosing metals which are most active in this respect, it has been possible to produce photoelectric cells which rival the human eye in their sensitiveness to light.

The kind of photoelectric cell used in picture transmission would be described scientifically as "an alkali metal photoelectric cell with gas filling." This means that the sensitive material is one of the alkali metals, such as sodium, potassium, rubidium or caesium, and that there is present in the cell a small amount of some gas, which is put in to amplify the effect.

E. D. Deery and H. W. Weinhart completing the glass work on a photoelectric cell for special research

A diagram of a typical photoelectric cell is shown in Figure 1. Here the sensitive material, the cathode, forms the inner coating of a glass bulb; the other electrode, the anode, is in the form of a ring of some insensitive metal, such as platinum or nickel, standing opposite the sensitive surface. Wires lead from the cathode and from the anode through the glass of the tube and to the auxiliary apparatus by which the current is measured or used.

The complete circuit, where the cell is used for measuring purposes, may be in the form shown in Figure 1. A battery is attached, with its negative terminal to the sensitive surface; and between the positive terminal of the battery and the other terminal of the cell is placed a galvanometer. When light falls on the sensitive surface of a cell, connected as shown, a current of a certain definite value starts flowing instantaneously. If the light is doubled, twice the current is obtained; if halved, half the current is obtained. In other words, the cell is instantaneous in its action, and the current of electrons is exactly proportional to the intensity of the light.

The process of manufacturing photoelectric cells is in some respects similar to that gone through in the manufacture of other vacuum tubes used in the telephone system. The shape and size of the cell is determined by the space into which it is ultimately to be inserted, and by the use to which it is to be put. A blank cell is first prepared as a glass bulb with sealed-in electrodes. This is placed on the vacuum pump and exhausted to a very low pressure, during which it is baked to get rid of all the gases in the electrodes. The next stage is the introduction of the alkali metal, which is usually potassium. This is intro-

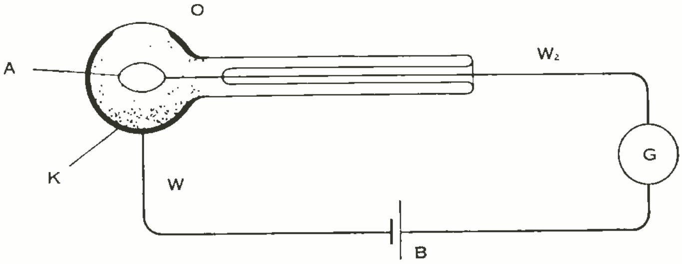
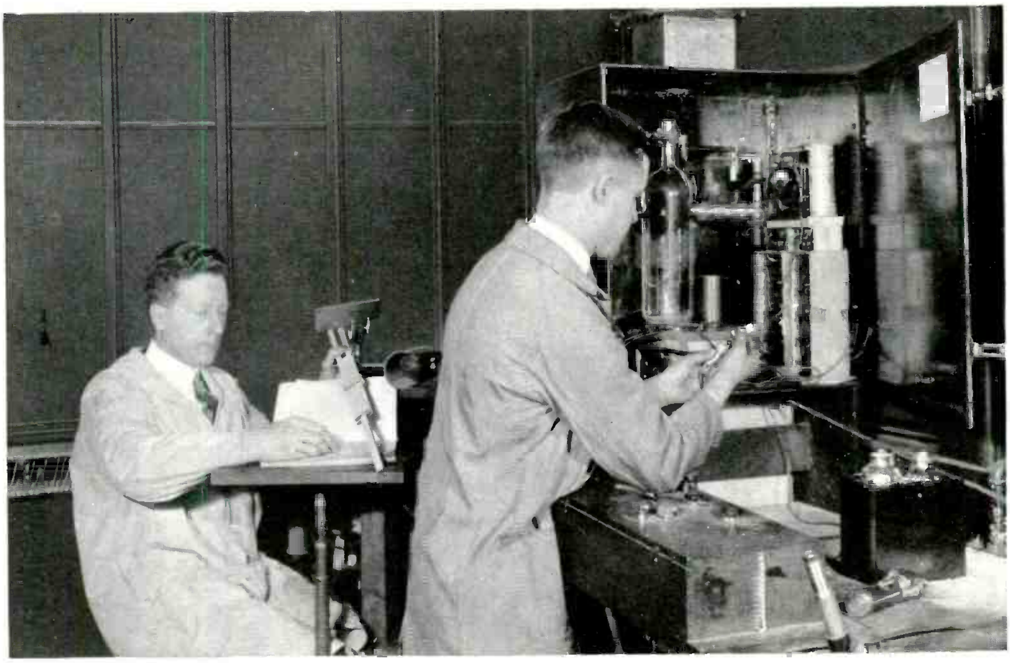
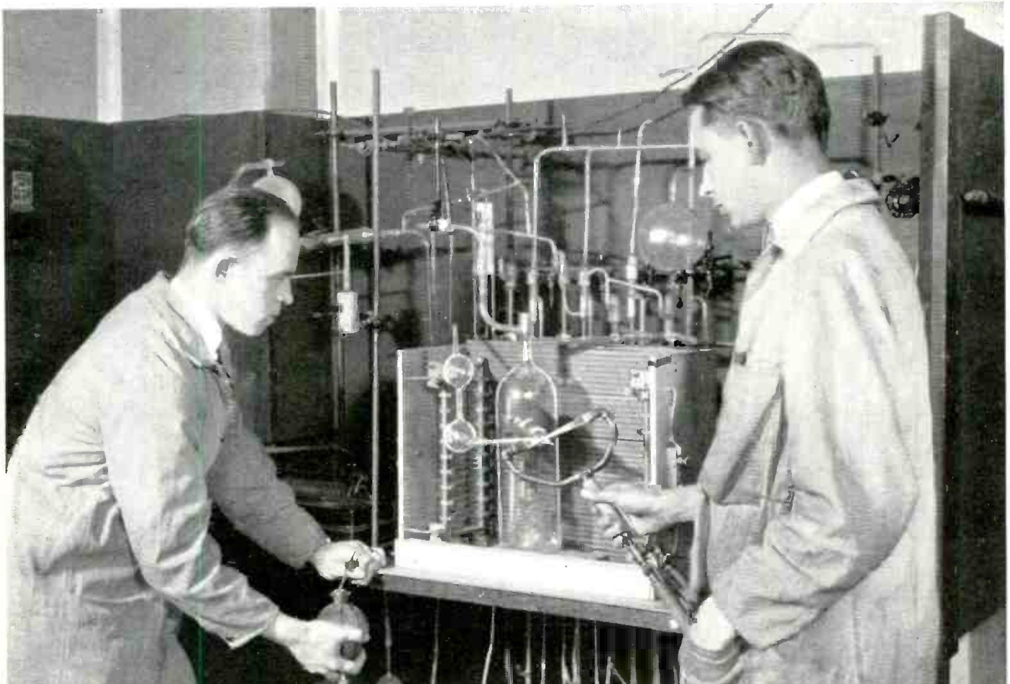


Fig. 1—Diagrammatic representation of a photoelectric cell: K—light-sensitive cathode; A—anode; O—window; B—battery; W and W_2—lead-in wires; G—galvanometer



A. L. Johnsrud and A. R. Olpin measuring the characteristics of a photoelectric cell



G. R. Stillwell and R. Rulison exhausting and filling photoelectric cells

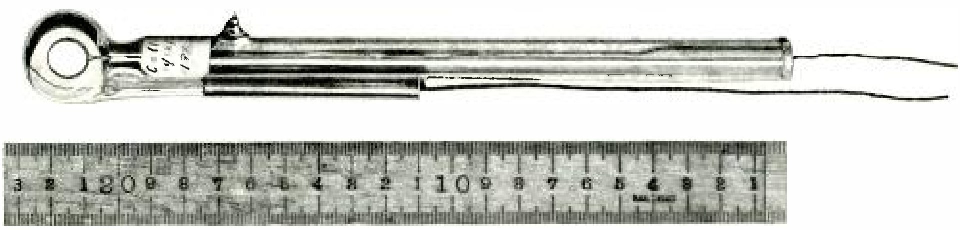


Fig. 2—Photoelectric cell of the type used in picture transmission by telephone

duced into a side tube on the pumping system, and is driven into the cell by distillation, the final stage being the condensation of the alkali metal in an even coating on the wall of the bulb. After a thin, uniform layer is deposited, a small window for the light to enter is made by playing a pointed flame on the part of the bulb which is to be cleared.

The cell may, if desired, be sealed off at this stage, but it has been found that the sensitiveness can be materially increased if the potassium surface is colored, as it is called, by letting in a little hydrogen and passing an electric discharge. It is further found that the current may be increased very materially if a little bit of gas is left in the cell. This remnant of gas, when traversed by the electrons which the light causes to be ejected from the sensitive surface, becomes ionized or electrically conducting and thus amplifies the current. The gases ordinarily used for this last remnant are the inert or noble gases, such as helium, argon or neon. These are used for two reasons. The first reason is to prevent the sensitive surface from changing its character by chemical reaction with the gas; the second is that these inert gases are ionized at much lower voltages than other gases, such as nitrogen and hydrogen, thus permitting the use of lower voltages on the apparatus in which they are used.

Figure 2 gives an excellent idea of the appearance of the photoelectric cells as prepared and used in the picture-transmission apparatus. The method of preparing these cells is largely standardized, and they are of very permanent and rugged character. Besides these cells, which are made up regularly for the picture-transmission apparatus now in field operation, cells of special design are made up from time to time for the purpose of studying the nature of photoelectric action. This study is carried on primarily because of the scientific interest which attaches to the question of electron emission under the action of light, from which we may expect to increase our knowledge of electronic phenomena of all sorts. It is carried on also with the expectation that it will in time lead to the production of cells of greater sensitiveness, of use not only in connection with picture transmission, but in other problems arising in communication work.

Making the Best Use of Experience

By Walter A. Shewhart

We have no way of judging the future save by the past, and so, throughout our lives we are constantly trying to find the best way of judging the future in terms of the past—trying to make the best use of the data of experience in meeting our individual problems and those of our business.

The data of experience fall into one or the other of two classes. One class contains those data, observations, and perceptions which can be explained in terms of the known laws of physics, chemistry, biology, or economics; for example, an eclipse of the sun, the growth of yeast, or the operation of a telephone relay. By a very slow and laborious method of observation, hypothesis, deduction and experimental verification, man has been attempting throughout the ages to reduce his experience to known laws which would relate the future to the past.

The other class of experiences contain the great mass of data or observed phenomena which either cannot be explained or cannot be predicted in terms of known laws, and therefore are attributed to chance. Throughout history we find the idea that chance results are those which do not happen according to any law, and we note the change of man's ideas of chance by the history of his superstitions and his religion. If a thing happened at the hands of chance it was once considered as the will of the gods, or as a run of luck. Witness, for example, one's state of health, the weather, the rise and fall of commodity prices, and practically all everyday experiences. Hence it was that no two individuals would interpret the bearing of a past experience upon the future in exactly the same way. How could they? for it was their belief that there was no particular universal law behind such experiences; that the future is not specifically foreshadowed by the experiences of the past.

Within the past three hundred years real progress has been made toward making use of experience which at the moment cannot be explained satisfactorily in terms of known laws. We have turned from the older unprofitable conception to a

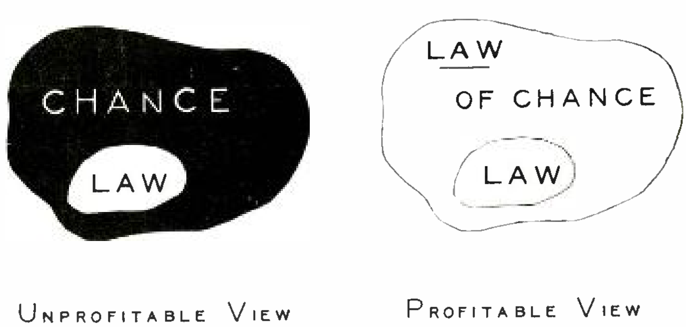


Fig. 1—How do things happen?

new and profitable conception that many of our experiences are in accord with the *laws of chance*. In other words, we have come to the view that chance results represent the effects of a complex system of causes and are the outward expression of numerous unknown but natural laws operating in a manner such that their resultant effects can be foretold, at least within certain limits.

The old and the new method of interpreting the major portion of our experiences are contrasted in Figure 1. On the left we see all experience divided into two parts—a small portion attributable to law and the rest to chance. On the right the cloud of ignorance and uncertainty has been somewhat removed from these same experiences by the process of looking at the data in terms of *laws of chance*. The modern viewpoint represents some experience as explainable in terms of assignable causes, and the remainder as due to a complex system of non-assignable causes, but susceptible to forecast at least within certain limits.

The distinction between assignable and non-assignable causes follows from a very simple example. Suppose each of two people fired one hundred shots at a target. The charts A and B of Figure 2 might represent their respective targets. Of the many possible reasons why the marksman cannot always be successful in hitting the bull's-eye, no definite reason or cause can be assigned for missing in any particular instance — the causes of missing are non-assignable. Suppose, however, that the targets were as indicated at A' and B' of Figure 2; there should be some discoverable cause for this general tendency to hit to the right; for example, the particular cause might have been wind blowing from the left.

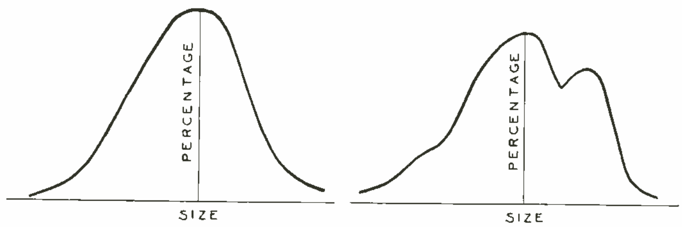


Fig. 3—Schematic of distribution: Left, chance distribution; right, chance modified by assignable causes

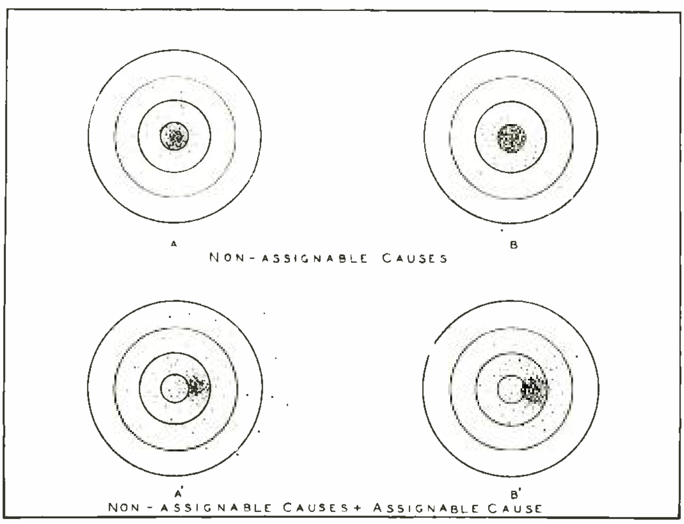


Fig. 2—Possible difference between the effects of assignable and those of non-assignable causes

Aiming for a bull's-eye and aiming for a standard and uniform product, as does a manufacturer, are similar in their liability to the law of chance. It is practically impossible to make two things which are identical; and one unit of apparatus will differ from another of the same type. This fact points to the existence of uncontrolled factors in the manufacturing process such possibly as temperature or humidity, the physiological and psychological conditions of the personnel, minute variations in raw materials, and those due to wear and tear on the machinery. Many of the minor causes of variation in product are non-assignable, and it would indeed be difficult to ferret out and control even a small fraction of them. It may be, however, that superimposed upon the minor effects of many causes are major effects assignable to individual causes of variation. Modifying such a major cause may effect an appreciable improvement in quality of product. But how is a manufacturer to know when the variations in his product from one month to another are those which may be attributed to chance, to a complex system of non-assignable causes which it would be exceedingly difficult to control, and when to one or more predominating and assignable causes of variation which it should be possible easily to discover.

Statistical theory helps to answer this question. If a plot were made showing for the targets A and B of Figure 2 the percentage of hits at various distances from the bull's-eye the form would be similar to the curve shown at the left of Figure 3. Similarly, if in respect to some measurable characteristic, for example, a given kind of product is distributed as on the left of Figure 3, it is likely that the lack of exact uniformity has been produced by a complex system of non-assignable causes whose effects would be difficult to separate. However, if the product is distributed in some other manner, for example that

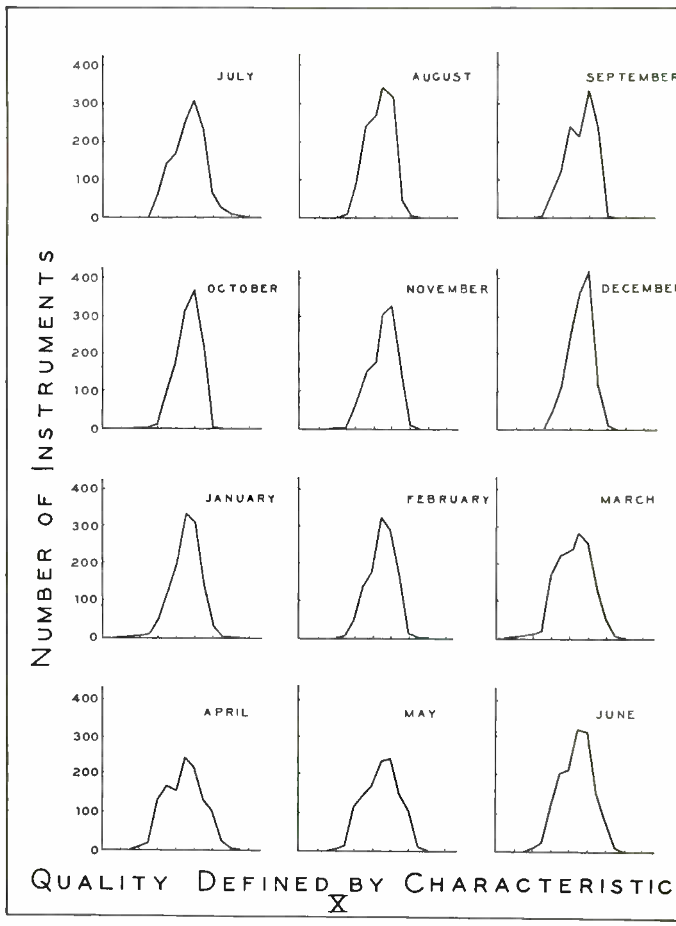


Fig. 4—Monthly frequency distributions in quality for samples of approximately 1250 *units of product*

indicated at the right, there probably are certain easily detectable causes of the differences.

These graphs must be interpreted as only a schematic representation of one of the fundamental ideas underlying the method of detecting the existence of other than chance causes. In the long run events happening according to a law of chance distribute themselves in respect to size, according to an approximately smooth distribution which persists essentially unchanged throughout all time; whereas events happening according to the law of chance superposed upon a few assignable causes distribute themselves in respect to size in an irregular manner which may or may not change with time. As used in the previous sentence, the phrases "approximately smooth" and "irregular" must be interpreted in a modern statistical sense for which Figure 3 is, as has already been said, a rough approximation.

To illustrate the theory, suppose 1250 instruments were selected each month from a product manufactured in quantities of approximately 2,000,000 per year. Suppose the quality,* as defined by some characteristic which is represented by the symbol X, was measured on each of the instruments in a month's sample, and that the results of such measurements were presented in the frequency polygons in Figure 4. The horizontal axes have a common scale in values of X.

Are we to conclude from the information given in this figure that the product was free from assignable

---

* *For example, if the product was a telephone transmitter the measure of its quality might be its transmission efficiency, compared to a transmitter adopted as a standard, and measured in transmission units. The symbol X then represents values in T U's.*

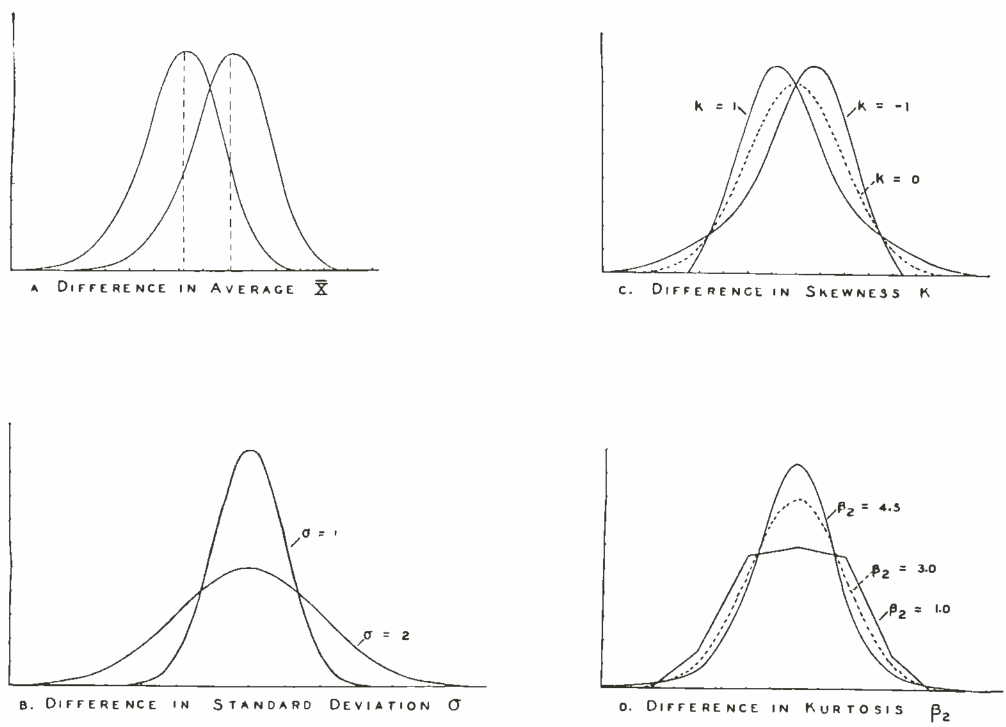


Fig. 5—Geometrical significance of commonly-used statistics

causes of variation throughout the year? Obviously no two polygons are the same. They differ in averages; that is, if the arithmetical mean is found each month for the 1250 measures of X, this mean, $\bar{X}$, will deviate slightly from month to month. In effect the manufacturer has bunched his hits sometimes a little to the right and other times a little to the left of the bull's-eye. That the arithmetical means are different is fairly obvious from the first of the curves. It is more obvious, however, that the range of values of X is wider in some than in others: that is, that the frequency polygons differ in "dispersion," as it is called. The dispersion is measured by what is known as the "standard deviation." This represents in effect a weighted average of the several amounts by which the various values of X differ from $\bar{X}$, the arithmetical mean of all of them.

To find the standard deviation take the square root of the mean (average) square of all the several departures from the arithmetical mean.

The polygons of Figure 4 vary also in their lopsidedness, or more technically, in "skewness." To illustrate skewness Figure 5 shows at C in full lines smooth curves which have skewness of +1 and —1, respectively, and are obviously lopsided as compared to the dotted curve, averaging lower or higher values, respectively. Arithmetically the skewness is calculated by taking the ratio of the sum of the cubes of all the departures from the arithmetical mean to the cube of the standard deviation. When the measured value of X is less than $\bar{X}$ the deviation is negative, and the cube of it will also be negative. On the other hand, when the product is a value of X greater than this arithmetical mean the departure is positive and the cube is positive. The sum of the cubes will, therefore, be positive when, on the whole, the polygon is lopsided with too small values of X; and the sum will be negative whenever the values are too large.

Another measure of the frequency polygon is its shortness or, to use the Greek word of the mathematician, its "kurtosis." To calculate this the sum of the fourth powers of all the deviations from the arithmetical mean is

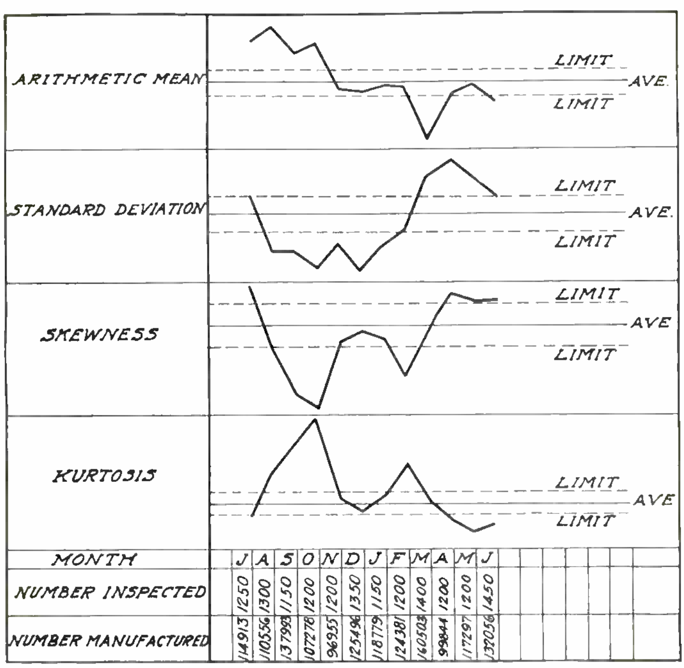


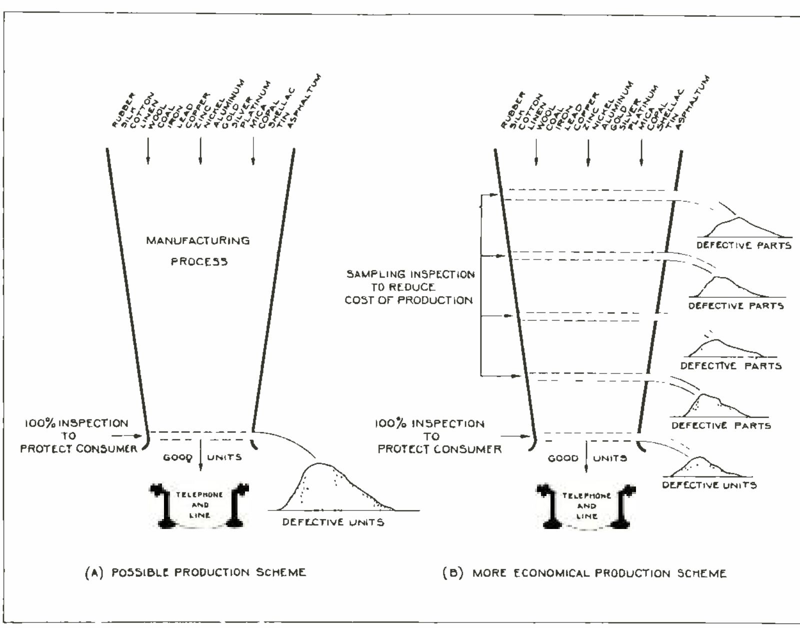
Fig. 6—This newly-developed control chart shows non-uniformity of product of Figure 4

divided by the fourth power of the standard deviation from the mean.

The value of these four measures of the frequency polygon are plotted month by month in Figure 6. Axial lines show the averages which the measures should have; and the dotted lines immediately above or below indicate limits within which these four characteristics should remain approximately 99.73 per cent. of the time, provided only minor chance causes affect the manufacturing process. The four heavy irregular lines follow the monthly fluctuations and indicate that the manufacturing process is subject to more than the ordinary random or chance causes.

Even though, as indicated by the arithmetical mean, the product is for many months within desirable limits the other curves, which are outside their limits for most of the months of the year, are danger signals to the engineer and to the manufacturer.

Ignorance of the existence of causes for a varying product is impossible when the inspection results are studied by this statistical method. Knowledge, however, of just what are the causes of the particular variations, month by month, must be the result of careful investigation by one who is familiar with the possible sources of varying product which might be effective. A statistical study of this sort can indicate the need of attention and assist investigations, but it cannot, of course, of itself solve a manufacturing problem. Prompt knowledge of impending danger is, however, available through the method, and that is its justification. Furthermore, it insures that no time will be lost in looking for causes of fluctuations which do not indicate impending trouble.



An illustration of the theory of inspection presented by W. A. Shewhart at the Bell System Educational Conference, June 21 to 25, 1926

Wider Responsibilities Claim Laboratories Men

Herbert E. Shreeve, formerly assistant to President Jewett, sailed last month for England, where he will reside as technical representative of the Bell System in Europe. In addition to acting as a point of contact with foreign technical administrations for the Departments of Operation and Engineering, and Development and Research of the American Telephone and Telegraph Company, and the Bell Telephone Laboratories, Mr. Shreeve's duties will include keeping the technical departments in the United States apprised of such matters of interest as may develop in the communication and scientific fields abroad.

Mr. Sheeve has been a member of the Bell System since May 1, 1895, when he went into the Engineering Department of the American Telephone and Telegraph Company. Later, in 1907, he went into the Development Branch of the Engineering Department of the Western Electric Company and still later—1911—into the Research Branch. During many years he contributed to the progress of long-distance telephony and to the repeater art. In 1915 Mr. Shreeve was sent to Paris, where he had charge of the reception of radio-telephone messages from Arlington.* During the war he was in charge of research and inspection for the Signal Corps in Paris; for his services he received the Distinguished Service Medal and was made a Chevalier of the Legion of Honor. At his discharge he held the rank of Lieutenant-Colonel. When Dr. Jewett became Vice-President of the Western Electric Company, in charge of the Telephone Department, Mr. Shreeve was made his assistant.

For his new work, Mr. Shreeve has been transferred to the American Telephone and Telegraph Company with the title of Assistant to the Vice-President in charge of the Department of Development and Research.

To Mr. Shreeve's post as Assistant to President Jewett comes P. Norton, formerly in charge of an analysis and testing group in the General Development Laboratory.* Mr. Norton holds the degrees of A.B., A.M. and E.E. from Princeton. Soon after completing his work there in 1910, he entered the then Physical Laboratory to work on problems connected with signalling. In 1914 he began his studies of apparatus for the protection of the telephone plant from harmful voltages and currents. After war-time work on submarine detection and in the manufacture of vacuum tubes Mr. Norton added apparatus analysis to his protection work. In connection with the latter activity he is concerned with high-voltage protection as a member of several joint committees of the Bell System and other electrical interests.

---

* Bell Laboratories Record, *Oct.*, 1925, *p.* 43.

* Bell Laboratories Record, *May*, 1926, *p.* 118.

New Cords and Cord Tips

By Howard H. Glenn

DID you ever shut the drawer of your desk on your telephone cord? This is only one of many things which contribute to the destruction of telephone cords. They become twisted and kinked, they come in contact with oil, water, ink and wet paint, all of which frequently damage either the flexible electrical conductors within the cords or the external appearance to such an extent that they have to be replaced long before any other part of the instrument needs attention. For this reason and for others as well a continuing study is made of possible improvements in cords.

Of the cords which were standard a few years ago each conductor had inside its insulation, eighteen tinsel threads twisted into a small three-strand rope. Each tinsel thread consisted of a cotton thread with a single continuous metal ribbon wound helically around it. An enlarged view of this conductor is shown in Figure 1. This old conductor was good, but an even better tinsel conductor has been developed and is now standard in the Bell System for both telephone and switchboard cords.

The new conductor employs a radically different construction in that each tinsel thread is made up of a relatively large cotton thread having two metal ribbons, also larger than the ribbons used in the old tinsel, wound helically around it, one on top of the other. The complete conductor is made by twisting six of these double ribbon tinsel threads around a central core of bare cotton thread. An enlarged view of this conductor is shown in Figure 2. It was invented by Albert Pruessman, who died several years ago. Its development to a commercial point and subsequent service trials leading to its adoption have been carried out by Laboratory engineers, largely under the direction of E. B. Wheeler, working in cooperation with the Manufacturing Department of the Western Electric and the American Telephone and Telegraph Company.

The new conductor has several advantages over the old conductor, such as longer life in service, greater ease in soldering to terminals, greater flexibility, and lower cost of manufacture. The longer life is probably due to the reduced abrasive action between tinsel threads when the conductor is flexed. The greater ease in soldering is due to the fact that the two relatively large ribbons more completely cover the cotton threads than the single ribbon of the old tinsel. The increased flexibility is due to the cushioning effect of the bare cotton core thread around which the six tinsel threads are wound, together with the novel way in which the conductor is twisted.

In the manufacture of the tinsel thread, the two ribbons are wound around the cotton thread about forty turns per inch of thread length. These ribbons, however, cause a torsional force to be set up in the completed thread due to their tendency to unwind if the end of the tinsel thread is released. Any twisted thread, cord, cable, or rope tends to unwind and to overcome this tendency, special rope-twisting machines incorporate a back-twist to resist the tension trying to ravel the ends. In the new conductor, however, the ribbon is wound around the cotton thread in one direction and the six tinsel threads twisted around the core of bare cotton in the opposite direction. Both processes are therefore straight winding operations and special rope-lay winding machines for cords are not required.

Evaluation of the gain from reduced cost of manufacture, increased cord life, greater ease of soldering and greater flexibility, has shown that the new conductor will not only result in substantial savings in first cost of cords to the Bell System, but also result in reduced maintenance expense.

In order that tinsel cords may be connected to associated apparatus, they must be equipped with metal tips or lugs for clamping under binding screws. Heretofore, all of these terminals have been soldered to the tinsel conductors. While soldering of copper wires to terminals is a very simple and easy operation, the soldering of tinsel conductors is a very tedious operation, requiring skilled operators and careful methods to insure a reliable connection. In making a soldered connection to tinsel, it is necessary first to remove carefully the insulation for a short distance from the end of the conductor and then to secure the insulation where it ends by the application of a binding of either thread or wire to prevent fraying. The bared end of the tinsel conductor must be wrapped with wire because solder will not stick to tinsel alone. Having gone through these opera-

Fig. 1—Old cord conductor, showing construction of tinsel threads and method of stranding

Fig. 2—New conductor, showing double ribbon tinsel threads twisted around a central core of bare cotton thread

tions, the conductor is ready for the hot iron and solder. However, if the iron is too hot or is held in contact too long the tinsel will be burned and

Fig. 3—Old and new cord tips: Left, the old tip soldered to the conductor; center and right, the new tip, fastened to the cord by prongs

the joint a failure. On the other hand, if the iron is not hot enough to cause the solder to flow freely, proper contact will not be made between the tinsel and the binding of wire, with the result that a high resistance joint may develop or the terminal may later pull off in service.

A new cord tip, invented by W. V. Thompson and developed under the direction of the present author in cooperation with the Manufacturing Department of Western Electric, avoids soldering and also the necessity of removing the insulation from the conductor ends. The tip has two prongs projecting from the inside of the shank, which pierce the insulation and make contact with the tinsel inside. The tips are attached by a machine which presses the prongs through the insulation and then folds the shank of the tip around the cord, thus accomplishing the double purpose of holding the prongs tightly in place and binding the end of the insulation to prevent fraying. In Figure 3 are shown the old and new tips attached to conductors. Figure 4 is a sectional view of the new tip.

Service trials of cords equipped with the new tips have resulted favorably, and they are now in production for certain types of cords. The design of the solderless tip is such that it can be adapted for use on practically all present tinsel cord connections and its use is being extended rapidly.

The importance of this development is particularly noteworthy because the number of tips required per year for the brown-silk desk stand

Fig. 4—Enlarged view of the new cord tip

cords alone is about 20,000,000, and the saving reflected in price of cords to the Bell System will be almost one cent for each tip.

News Notes

OUR Directors have authorized the purchase of a tract of about forty-five acres at Whippany, New Jersey. Here will be established an experimental station exclusively for study of high-power radio transmission as an aid in the commercial development of broadcasting equipment. The tract is near the Whippany River, and is about twenty-five miles from New York.

Experimental work at this station will be conducted at times and under conditions which will prevent any interference with the reception in its neighborhood of regular programs from broadcasting stations.

More than fifty executives of Western Electric and Graybar were the guests of the Laboratories on Friday afternoon, May 28th. A buffet lunch was served in rooms 1203 and 1204. After this the guests were assembled in the auditorium, where they were welcomed by Mr. Craft, who also spoke on the trip through the building. Incidentaly, this was the first use of the auditorium. L. S. O'Roark then divided the guests into groups and detailed the guides.

Machine testing equipment for various types of transmitters and receivers, in use at Hawthorne

Loud speaker testing equipment for practically all types of speakers

Messrs. Glunt, Fondiller, Lowry, Matthies, Buckley, Hartley, Quarles, Williams, Frederick, Edwards and Snook escorted the guests to those exhibits, such as machine switching, cathode ray oscillograph, and liquid air plant, usually shown to visitors, and in addition, showed them a special set-up of transmitter testing apparatus, the radio transmitter development, and the acoustical laboratories now in construction. Messrs. Fowler, Farnell and Neave assisted in the details of the trip.

Two views of the special apparatus for testing transmission are shown on this page.

Russell M. Otis is co-author with Professor Robert A. Millikan of an article in the *Physical Review* for June, describing mountain-peak and aeroplane observations of high-frequency rays.

The Vitaphone—An Audible Motion Picture

By Joseph P. Maxfield

THERE has recently been announced to the public the existence of a contract whereby the Western Electric Company grants rights to the Vitaphone Corporation to exploit a system developed in our Bell Telephone Laboratories for the making and reproducing of moving pictures with an accompanying synchronous sound record. Our interest in this work was an outgrowth of our development of an electrical process of recording, the fundamental novelties of which were in turn obvious and logical applications of the theories and technique incidental to Bell System problems of transmission of speech and music. Having perfected this method of recording, its application to the motion picture field was more or less inevitable.

With a recording technique * available whereby sounds may be recorded a considerable distance from the pick-up mechanism, it became possible to take pictures with their accompanying sound record in such a manner as to produce the illusion of realism. The flexibility brought about by this possibility of recording at a distance has also made possible the use of methods of synchronizing the picture and sound record which were not available in the older art.

In order that the realism shall be produced, it is necessary to fulfil simultaneously a number of requirements. The most important of these are: accurate synchronism between the picture and the sound, complete freedom of action on the part of the actors, and a faithfulness of reproduction of the sound such that it might easily be mistaken for the music or speech of a real performance.

In connection with this illusion, several interesting details have arisen. It is customary in the phonograph art, which results in an audible performance only, to increase a solo part to a level of loudness somewhat greater in comparison with its musical accompaniment than would be the case in an actual stage performance. Similarly, in the moving picture field it has been the custom to hold the attention of the audience on the important features of the picture by keeping them in the foreground and considerably larger than life size.

The first audible motion picture was made in accordance with these two standard conventions, and the result was most disconcerting. The eye and the ear of the observer obtained, as to the relative location of the various artists, separate impressions which differed sufficiently to make it impossible for the observer to focus his attention on the performance. Also the fact that the artists were much enlarged, that is, appeared on the screen larger than life size, made the music accompanying them sound far too low in intensity.

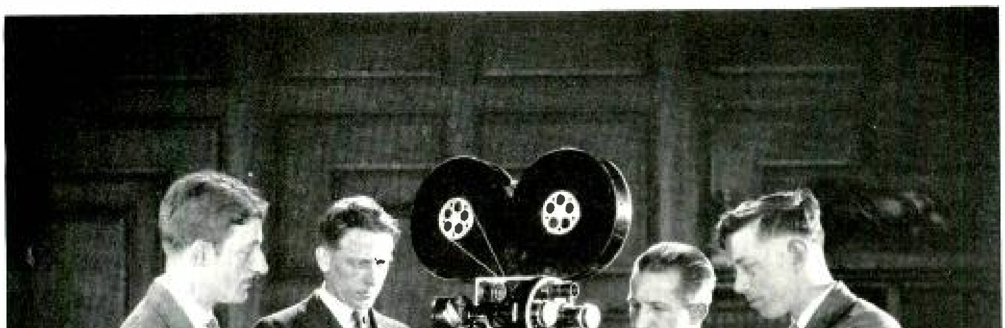
The later pictures, in which the sound was picked up as it would be by the ears of a listener to the original performance and in which the picture

* Bell Laboratories Record, *Nov.*, 1926, *p.* 95.

left the images in their natural sizes, removed these difficulties and produced an illusion so satisfactory that many of those observing it lost themselves in the performance and forgot that they were listening to an audible picture. The factors controlling the acoustic illusion which is produced by the new recording methods have been described in a previous article on "Sound Recording and Reproducing," which appeared in Bell Laboratories Record for November, 1925.

It may be interesting to sketch briefly the history of this development within the Bell Laboratories group. The very first attempts were the production of records containing a lecture to accompany the educational film called "The Audion." In this case, only approximate synchronism was maintained, and this was done by hand. This early attempt was so successful, however, and showed in so many ways the possibilities of the process that it was demonstrated in 1922 by Mr. Craft before the American Institute of Electrical Engineers at New Haven in connection with a paper which he presented.

From that time until the present, the work has been mainly along two



Four engineers concerned with development of this synchronous motion-picture camera: S. S. A. Watkins, H. C. Humphrey, C. R. Sawyer and A. C. Millard lines: first, the development of a method of synchronism both for the taking and reproducing parts of the system with mechanism which would be commercially operable under the conditions existing in the motion picture industry; and second, the development of the technique of taking and reproducing the audible pictures in such a manner that the realistic illusion would be produced upon an audience.

Any successful audible motion picture system must operate in both theatre and studio in a simple and reliable manner: that is, it must require very little more skill or technique than is required to operate ordinary motion picture equipment and phonograph apparatus. With this requirement in view, both the film and the record must be set in their respective reproducing machines with a given marker in the proper place and the two machines must then be speeded up from rest together. This has been accomplished by the simple device of having them coupled to the opposite ends of the same motor shaft.

The mechanism for taking the pictures with these markers on the original film and record can not be operated in quite so simple a manner, since the camera must be left free to be "pammed"—that is, moved about on its tripod to change the field of view. Therefore, two motors are used, one to drive the camera and the other to drive the recording machine. An ingenious electric gearing device has been developed whereby these two machines can be started from rest and maintained in synchronism, not only after they are up to speed, but during the period while they are starting up.

These motors are of the series commutator type interlocked electrically by tapping at three symmetrical points on each armature and by interconnecting the two rotors through slip rings. Thus the motor driving the sound-recording equipment and the motor driving the camera are independently supplied with electrical power, but through the slip-ring circuit there is a sufficient interchange in power between their armatures to produce synchronism during the starting period. Upon reaching the desired speed, the motors are converted into the synchronous type by putting a diametrical short-circuit between the commutator bars and disconnecting the interlock. The motors then continue to run as two independent synchronous motors, the speed of both being determined by the frequency of the power supply. It was found that the sixty-cycle supply in New York City was usually sufficiently constant for the purpose. In cases where such constant-frequency power supply is not available, a specially regulated source of alternating current must be employed.

In reproduction there is not the same necessity for having the sound reproducer and picture projector physically separate, and consequently the simplest method of obtaining synchronism consists in the use of a single motor with mechanical gearing. The speed of the motor is held constant by means of a vacuum-tube regulator. This regulator with certain modifications can be adapted for either direct or alternating current supply. It was essential that the mechanical gearing be so designed that mechanical vibrations and irregularities of load in the projector should not cause fluctuations in speed of the turntable for the phonograph record.

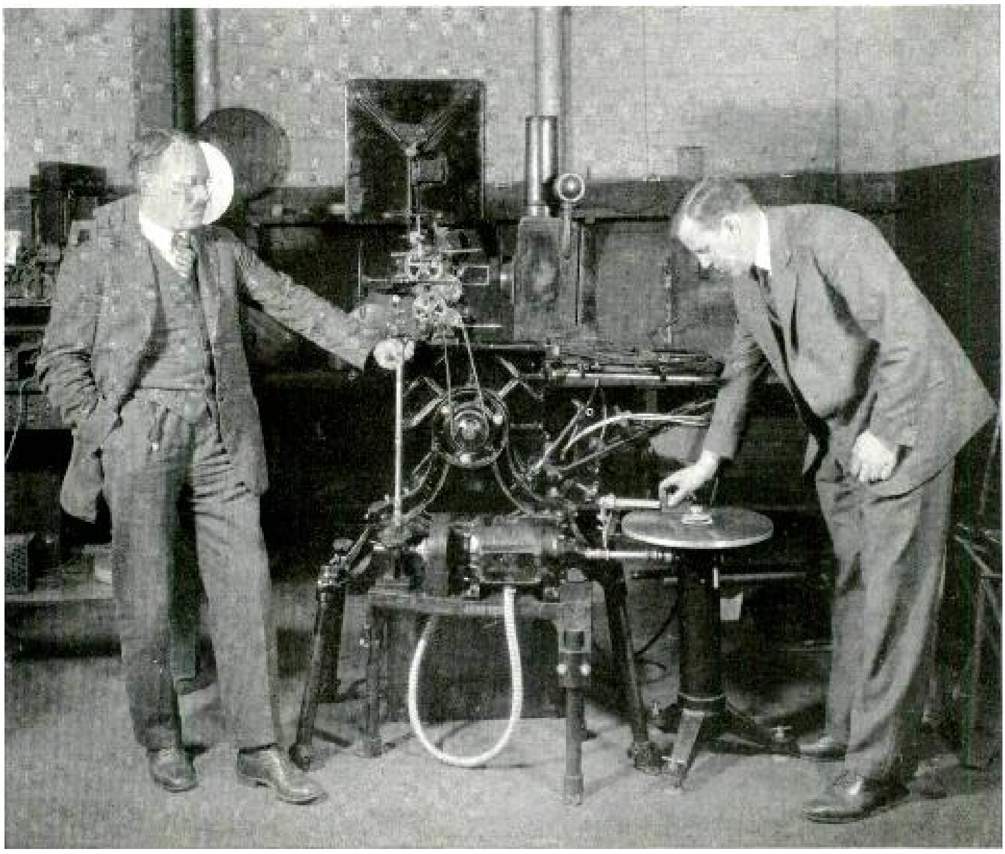
The removal of vibrations and of

small irregularities in turn-table speed proved a very difficult problem. It was finally solved by a rather ingenious device * of a low-pass mechanical filter-system which is situated between the last gear-driven shaft and the turn-table itself. This mechanical filter involved a fly-wheel and flexible connections. By properly proportioning the flexibility of the spring connections and the moment of inertia of the fly-wheel (including that of the turn-table), the "ripples" in speed were "ironed out" to a point where they are not detectable. To avoid surges in this filter system, it was necessary to apply frictional damping to the spring connections.

* *Due to H. C. Harrison.*

The driving mechanism is arranged so that it can be coupled to a standard motion picture projector without modifying in any way the internal arrangement of the projector. It is necessary only to remove the driving mechanism which normally comes with the projector and to substitute the new. This new driving unit, which has been made small, can be used for both silent and audible pictures and, therefore, it may permanently replace the original driving mechanism of the motion picture projector.

In connection with audible pictures



A complete projecton equipment: H. M. Stoller and H. Pfannenstiehl, who with their groups were responsible, respectively, for the motor and its control and for mechanical design of the turntable gears and other parts there is one question that naturally arises, and that is as to a possible loss of synchronism due to breakage and subsequent patching of a film. It is the experience of the motion picture industry that in the higher grade theatres known as "first run" and "second run" houses there are seldom more than three or four breaks during a year. The percentage of breakage, of course, increases materially in "third run" houses. Of the breaks which occur, well over ninety per cent. take place at splices in the original film, and can be avoided by a careful inspection of the film previous to each showing. In the case of the audible picture, each reel of film will consist of one piece only, having no splices, and it is, therefore, expected that the breakage will thereby be negligible. If, however, a break should occur it will be necessary to insure that the length of the picture is not altered, and any pictures removed will be replaced by an equal length of film.

While the audible picture recording words of the actors is probably the most interesting from a technical point of view, the largest commercial use of the system, at least at the start, will probably be to furnish a high quality of musical accompaniment for the usual or "silent" pictures in theatres where cost prohibits accompaniment by a high-grade orchestra.

Bell System Educational Conference

An invitation conference of educators interested in economics was held during the week of June 21-26 under the auspices of the American Telephone and Telegraph Company. Deans and heads of economics departments from sixty-one universities attended and discussed papers on economic problems of the telephone industry. The first day was devoted to the organization and history of the System, and to the scientific, social, and economic significance of its research and development work. Addresses on the latter subject were made by Mr. Jewett and Mr. Craft. On the first afternoon, the conferees assembled in the auditorium of the Laboratories where papers were presented by Messrs. Fondiller, Wilson, Lowry, and Shewhart. John Mills acted as chairman, and L. S. O'Roark guided a short trip through the buildings. The electrical stethoscope was described by H. C. Snook and demonstrated by H. F. Hopkins. The session closed with a demonstration of talking motion pictures conducted by Messrs. Glunt, Mather, and Maxfield.

Inventions and Patents

By J. G. Roberts
General Patent Attorney

In the May, 1926, issue of the Record appears an illustration of the cover page of the first patent issued to Bell Telephone Laboratories. There are many more such patents to come. Some of these are pending. Others will issue on inventions not yet conceived.

The patent laws are a condition to be dealt with, not a problem to be solved. We, for our own protection and that of the Bell System which we serve, must operate under and be guided in our actions by them. We have valuable rights securable under these laws. We must be on our guard to respect the patent rights of others.

Inventions are creations of the mind, often useful designs, mechanisms or processes involving new and ingenious constructions or modes of operation, somtimes brilliant discoveries following persistent investigation and research, not infrequently the result of mathematical analysis induced by intellectual curiosity and occasionally the spontaneous conception of a practical idea springing out of an environment of known phenomena.

Why are patents valuable, and how much? The first part of this dual inquiry is readily answerable and explainable. A patent is of value to the owner chiefly because it protects him from those who would otherwise follow in the wake of his development work and, without cost or fear of prosecution for infringement, take full advantage of it in their own business. The invention covered by patent is of value to the world at large because after the seventeen-year period of its protection it becomes public property.

Some of the factors which enter into patent evaluation are so indefinite and variable that the net values fluctuate widely from year to year. It is not at all uncommon, when substantial progress has been made in the development or commercial use of an invention, to find suddenly looming large in value an old patent or pending application filed because of its remote and future importance in the art. On the other hand, patents frequently diminish in value to the vanishing point. This unavoidably occurs when development drifts away in some other direction.

Foresight, while inferior to hindsight, is often our only guide. In this respect we in the Patent Department are handicapped. Patent laws are technical and time limits for action are fixed. Delay in filing is hazardous and sometimes fatal to the securing of patent rights. We must carry on our work, more often than otherwise, in the early stages of development and take our chances on looking backward and thinking forward.

It is fortunate that we have in the Laboratories that fine spirit of cooperation so essential to the accomplishment of big things. Here are engineers, inventors, supervisors and patent attorneys working side by side and all helping to create desirable new devices for manufacture and use in the Bell System, and valuable patents that protect expensive development work from unlawful appropriation by others.

While ours is one of the greatest of research organizations, we do not claim a monopoly of ingenious minds even in our own special field. Competition in invention is keen, especially here where the most generous of patent laws prevail. It behooves us to keep going, not feverishly, but carefully and persistently, always striving to keep at least a step or two in advance. Others certainly have the right to, and will, if they can, edge in here and there and thus impede our progress in the art or collect tribute for being smarter or quicker than ourselves.

Until we shall have finished the job of creating perfect communication equipment; until all the technical problems that may arise in the manufacture and use of that equipment shall have been solved; until our very last patent shall have been secured, and even until the last inventor anywhere has passed out of the picture of American telephone progress, Bell Telephone Laboratories must not fail to take full advantage of the protection which the patent laws of the United States afford.

A Recognition of Engineering Achievement

On Commencement Day, June eighteenth, Worcester Polytechnic Institute conferred the degree of Doctor of Engineering upon

> *EDWARD BEECH CRAFT, Engineer, Inventor and Organizer of Research; whose inventions take part daily in each of more than fifty million telephone conversations; whose genius, initial conception of the practicability of panel systems for machine switching, and continued supervision of its development have contributed largely to the present system of telephony; whose technical experience devoted to the service of his country during the World War hastened advances in radio-communication with aircraft; whose organizing ability continuously applied for a quarter of a century to engineering development and industrial research has increased the social and economic significance of research*

The Patent Department

By Francis J. Hallenbeck
Bureau of Publication

To develop an idea from its initial conception to its ultimate commercial form of apparatus or system requires organized collaboration. How the creative efforts of many minds, diverse in types of training and experience, are effectively co-ordinated has been told in previous articles descriptive of the Systems, Apparatus, and Research Departments of our Laboratories. In the course of every important investigation and developmental study many special problems arise and many novel ideas and theories are evolved. To protect the Laboratories from undesired appropriation of inventions growing out of such studies and to insure to the Bell System unimpeded progress in the utilization of the better equipment thus developed, patent protection must be secured. Negotiations to this end are carried on under the leadership of John G. Roberts,* General Patent Attorney, by a group of men not only skilled in the law, but also of wide acquaintance with the telephone art, in touch with the commercial situation, and in sympathy with the viewpoint of scientists and engineers.

All phases of the process, from preliminary analysis to final grant of a patent, are handled by our Patent Department. It keeps in touch, so far as it can practically, with Laboratory developments, and investigates ideas submitted as novel by engineers themselves, selecting such inventions as may seem at the time to warrant protection. After a device or process is deemed patentable a report is written describing it, indicating its features of patentable novelty, citing any other inventions related to it in general character, and the outlook for commercial use. This report is then expanded into appropriate form for filing at Washington. The entire prosecution of applications before the Patent Office is in the care of this Department. It also scrutinizes all new equipment and processes proposed for manufacture or use to make sure that these do not infringe the rights of

Joel C. R. Palmer

* *Admitted to the bar of the State of New York.*

others, and considers the advisability of acquiring patents held outside the Bell System.

More than one hundred people form the Department's personnel. They are organized in five groups, two of which are designated as attorney divisions. At the head of the division concerned with equipment is Joel C. R. Palmer, a member of the New York bar, who entered the New York Telephone Company in 1903 after graduation from Harvard. Transmission problems were his first interest. After coming to the Laboratories in 1908, he had charge of the Transmission branch. In 1914 he entered the Patent Department. A part of the work of his group is the preliminary analysis of patent material and the preparation of reports. After an application is filed the prosecution of the case is in his hands. As to detailed responsibilities, John A. Hall* has charge of manual telephone systems and related problems. Machine switching matters are handled by George H. Heydt*; and vacuum tubes and telephones, including microphones and loud speakers, by Walter C. Kiesel.* Other kinds of equipment —picture transmission, public address systems and acoustic systems — are dealt with by Guy M. Campbell.*

Elmer V. Griggs

The other division, which looks after transmission systems, is in charge of Elmer V. Griggs, a member of the bar of New York and of the District of Columbia, and a graduate of the University of Iowa and George Washington University Law School. Before entering the Patent Department in 1917, Mr. Griggs served as an Examiner in the Patent Office. To outline the operations of his group would be to repeat the description of the attorney division dealing with

Clarence A. Sprague

* *Admitted to the bar of the State of New York.*

equipment, for the essential difference is in subject matter. In Mr. Griggs' division Harry A. Burgess * is in charge of general transmission problems, including questions concerning repeaters and carrier currents. Thomas P. Neville ** has as his chief activities radio transmission, filters, modulators and oscillators. James W. Schmied * handles submarine cables and alloys, and Bennett H. Jackson * specializes in foreign patents.

When an attorney division has completed its preliminary report a group comprising the Application Division continues the work by writing patent applications in form appropriate for filing. Directing this group is Clarence A. Sprague, a Syracuse graduate and a member of the bar of the District of Columbia. After some teaching experience and after serving as an examiner in the Patent Office, Mr. Sprague studied law at Georgetown and George Washington and entered the Department in 1917. In his organization, Maurice R. McKenney * is concerned with telephone, telegraph

* *Admitted to the bar of the State of New York.*
** *Registered Patent Attorney.*

Top row: T. P. Neville, J. A. Hall, G. M. Campbell; second row: H. A. Burgess, B. H. Jackson, G. H. Heydt, S. A. Milne; seated: H. G. Bandfield, W. C. Kiesel, M. R. McKenney, J. W. Schmied, S. B. Kent and radio systems; Harold G. Bandfield * prepares the applications on magnetic alloys, general apparatus and acoustic systems. Stanley B. Kent handles general transmission, loading, filters, submarine signalling and telegraphy. The drafting work is Samuel A. Milne's responsibility.

Many European patents are owned by the Western Electric Company; the prosecution and maintenance of these cases is in the hands of a representative of our Patent Department located in London. This position is now held by Edgar W. Adams,** a graduate of Armour Institute, National University and George Washington University. Mr. Adams is a member of the bar of New York and of the District of Columbia. Before coming to the Department in 1912 he was an Examiner in the Patent Office.

Harry P. Franz

File, stenographic and office service, the devising and operating of various routines concerned with the filing and maintenance of applications and patents, and the discharging of certain contractual obligations are the chief functions of the Clerical Division in charge of the Office Manager, Harry P. Franz. Mr. Franz entered the Laboratories in 1918 and the Patent Department in 1922. An important part of the Clerical Division's work is the maintenance of a file of patents relating to arts in which the Bell System is interested. The collection now comprises some half million copies of patents, and is being added to constantly at the rate of 25,000 a year.

This in brief is our Patent Department. It aims to assure to the development groups the full fruits of their labors. From idea to patent its work entails technical knowledge and legal skill of high order.

---

* *Registered Patent Attorney.*

** *On account of Mr. Adams' absence the* RECORD *was unable to obtain his portrait.*

Transforming Our Power Supply

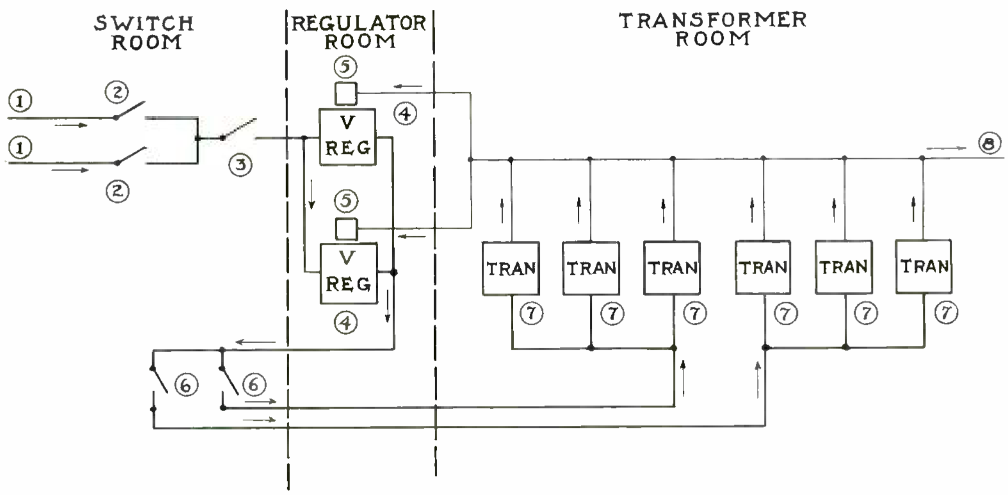
By S. H. Willard

HOW do we obtain the electrical power vital to our laboratories, which gives light, runs elevators and a thousand and one other things?

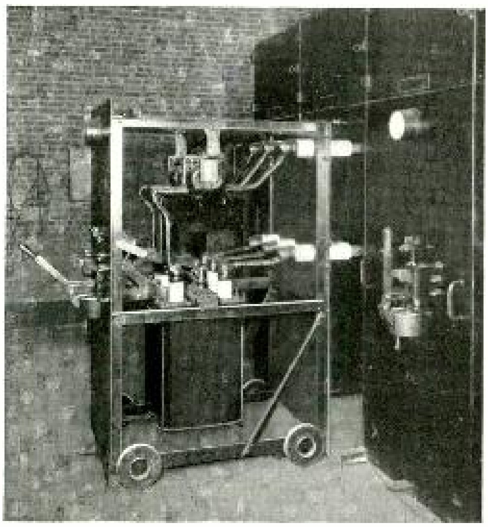
In the first quarter-century of the building's history service was rendered by our own power plant. The passing years, however, saw changes which made central-station service more economical and the year 1923 witnessed the closing down of our isolated system with its array of boilers, engines, and generators.* After this, power at low-voltage was purchased — direct current from New York Edison and alternating current from United Electric — and distributed directly to the building. With the room available in Section H for a transformer station, advantage was taken of the economies of high-voltage alternating-current supply. This station was recently completed and power at 13,200 volts, three phase, is purchased from United Electric Light and Power Company. At present, Section H is deriving all of its power from this source, and as soon as certain necessary alterations can be made in the circuits of the older sections, this supply will be available to the entire building for lighting, power and other purposes.

A low-voltage direct-current supply

* *This was related on page 65 of the* Record, *October*, 1925.



Simplified circuit of our building-supply transformer system. High-voltage leads are indicated by heavy lines, low-voltage leads by light, and partitions between rooms by broken lines. 1—13,200-*volt, three-phase feeder loop;* 2—*United Electric switches;* 3—*Main switch;* 4—130 *kv-a. voltage regulator;* 5—*Control Relay;* 6—*Transformer switches;* 7—250 *kv-a. transformers;* 8—*Building-supply bus bars*



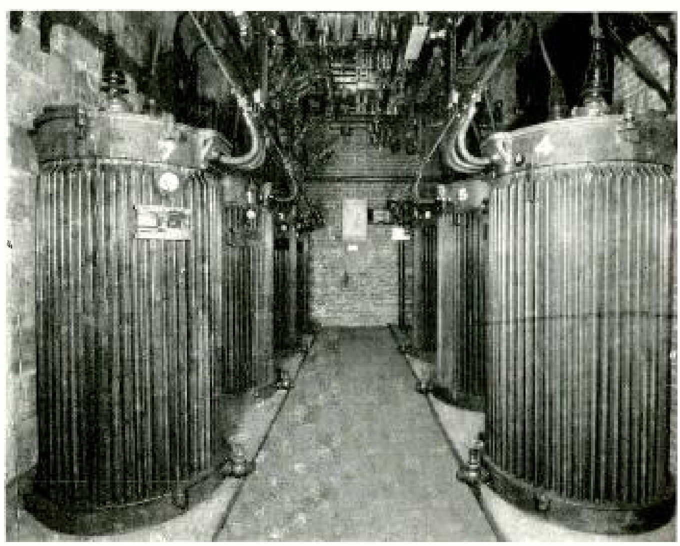
Switch room, showing truck switch rolled out from its case

will also be maintained for special purposes.

A trip through our transformer station might properly begin at Abingdon Square, where our conduit line is connected to the high voltage loop that supplies a number of buildings in the vicinity. Most of us remember the building of this line with its multiple ducts, much like a telephone subway. In some of these ducts are high-tension lead - covered cables, which end in switch and meter-boxes of the power company in the first room of our station.

Lined up beside these boxes are three others equally massive; these are the main switch and two transformer switches. The installation resembles a group of bank vaults rather than our telephonic conception of switching mechanism with its delicate springs and small contacts. Instead of lifting a keyshelf or small panel to make repairs or inspection, the entire inside portion of these switches is rolled out. This action, which exposes the working parts, cannot take place until the lever on the face is in the "off" position. This prevents arcing across the air gap between the terminals on the movable portion and the feeder contacts at the rear of the encasement. The actual switching operation is performed in oil. Such protected switches and other devices give the system a maximum of safety for operation or for repair.

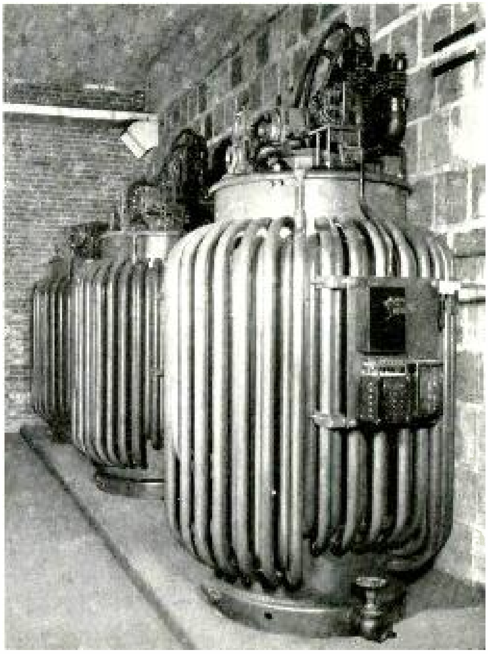
From the main switch the power then passes to the next room, where voltage regulation is effected. In this room are three large cylinders, each encased in a network of oil ducts for cooling. These are automatic voltage-



Transformer room. On each side is a bank of three transformers connected in delta. The one in the left foreground is a spare for emergency use regulators of the induction type, big brothers to the variometer so familiar to radio fans. Indeed, the only difference, irrespective of size, is in the material of the core; the regulator using iron, and the variometer, air. Two of the regulators are continually in circuit; the third serves as a spare. Attached to each unit is a control relay which is connected to the low-voltage side of the transformers. This relay operates as the voltage supplied by the transformers to the building fluctuates, due to changes in load within or without the building. Operation of the relay starts a motor on top of the regulator. A coil within the regulator moves in step with the motor and varies the inductive relation between the revolving coil and a fixed winding. Depending upon the direction of rotation, the feeder voltage is "boosted" or "bucked" and the low voltage supply is maintained within plus or minus two per cent. of the rated value. From the regulators the lines lead through transformer switches to the primaries of the transformers which are located in the last room, or more exactly, vault.

Here are grouped seven transformers, in two banks of three each connected in delta; the seventh transformer is a spare. All are oil cooled in a manner somewhat similar to the regulators, and are rated at 250 kv.-a. The secondary of each transformer is controlled by a circuit breaker which is operated manually, but can be opened by a switching device on the control panel. The high voltage is impressed on the primaries, and is stepped down to the voltages which are distributed to the building.

The low-voltage supply delivered from the transformer plant is regulated to give 230-volt, 3-phase, 60-cycle alternating current at the various points of use. The system is grounded at the geometrical center of the 3-phase triangle. Each phase of this



Voltage-regulator room. On the side of the regulator are the control relays; on top is the motor for turning the inductance coil

system is also subdivided into a 3-wire system, giving us a total of three 115-volt/230-volt single-phase sources. The middle point of each phase is approximately 66 volts above ground, and the outside points of each phase are approximately 132 volts above ground.

From the transformers the supply of power is delivered through bus bars to the distributing switchboard located on the floor above the vault, from which point it is distributed through 3-wire cables to the terminal boxes on the various floors.

From this brief description we can gain an idea of the care and thought applied to the system which so satisfactorily supplies our electrical power.

A Simplified Announcing System

By O. H. Danielson

SINCE their inception, the Public Address Systems have been rendering noteworthy service in projecting a speaker's voice to everyone in his audience, regardless of the size of audience or auditorium. Lately a need has been felt for a smaller and less expensive system, which might be used where high power is not a factor. To serve this field, a loud-speaking outfit has been developed which has been given the descriptive title "AC-Operated Announcing System."

As the name implies, this system was designed to draw its operating power entirely from a 110-volt, 60-cycle source. In its simplest form it is intended to furnish a means of one-way, loud-speaking telephone communication between a transmitting station and one or more outlying points. As such, it consists broadly of a two-stage amplifier, a transmitter, loud-speaking receivers as required, and the necessary control apparatus.

The applications of this system cover a wide range of possibilities, two of which are already being tried out in our own building. A trial installation for secretarial work is now in use by Mr. Craft. On his desk is a transmitter mounted in a mahogany case which also contains two small signal lamps. In an anteroom is installed the amplifier. On Miss McMahon's desk stands a cone loud speaker. When Mr. Craft wishes to talk to her, he signals by a buzzer. She closes a key which operates a relay completing the 110-volt circuit through the amplifier. As soon as the amplifier circuit is closed the signal lamps in the transmitter mounting light up, indicating that the system is energized and ready for use. This cycle of operations is practically instantaneous. Dictation or instructions in a conversational tone may then be given over this sys-

L. S. O'Roark demonstrates the "talking end" of the new announcing system as used for dictation and instructions to the secretary tem, and be heard distinctly by the secretary. When the speaker has finished, the secretary opens the key, shutting off the amplifier and extinguishing the signal lights. That these lights are out is a definite indication that the system is not in operation, and conversation in Mr. Craft's office is not being transmitted beyond its walls.

A system of somewhat different nature has been set up to connect an office with another office and with a laboratory. A transmitter mounted in a deskstand with a push button is located in room 839. Cone loud speakers are placed in Room 835, an office, and 836, a laboratory. Pressing the button on the transmitter stand energizes the system in a manner similar to that described above and permits speech simultaneously to Rooms 835 and 836.

The heart of both systems is the amplifier, which is somewhat similar electrically to a 25-B amplifier preceded by a single stage of audio-frequency amplification. Within the amplifier is a current-supply circuit which, drawing energy from alternating-current mains, furnishes filament currents of the proper values to all of the vacuum tubes, rectified currents to the plates of these tubes, and current (rectified, of course) for the transmitter. The circuit is so designed also that correct potentials are impressed upon the grids. For volume control, the secondary winding of the first input transformer is tapped and connected to a multipoint switch. The entire equipment is compactly arranged in a rectangular metal box.

The two previously described applications for such an equipment, as well as many uses which will develop in the future, require that the system as a whole be flexible. The amount and arrangement of apparatus in addition to the amplifier depend upon the use to which the system is put.

Besides the two installations in the Laboratories, other applications readily suggest themselves. If at some time in the future you should happen into a restaurant, give your order, and then notice the waiter go to one of several telephones installed around the walls of the room, press a button and apparently engage in a low conversation, do not be misled; if you could transfer yourself to the kitchen at that instant you would hear your order for "ham and—" emanating with considerable volume from the throat of a loud speaker.

Miss McMahon at the "receiving end" of the announcing system

A moment's thought will reveal many ways in which this device may be used; in the future, trips about town promise to be rewarded by glimpses of interesting adaptations of this new product of our Laboratories.

Speech Sounds

By Joseph B. Kelly

Nature has endowed us in many ways with the ability to adapt ourselves to the conditions which we are likely to encounter. A bright light causes the fibres of the iris to contract and the pupil of the eye is made smaller; in the dark these fibres relax and the pupil dilates. By these adjustments there is permitted to enter the eye only that quantity of luminous rays which is necessary for vision. Our ears do not have any such governor to accommodate them to the conditions which they experience, but they have the ability to endure sounds of a remarkably wide range of intensity.

Sound, as we sense it, is the result of the propagation to the ear, usually through the air, of a disturbance produced by a sounding body. A sound travels in all directions, from the point at which it originated, when there are no solid bodies to cause reflections; and its intensity at any point varies inversely as the square of the distance of the point from the source.

If someone were to speak directly into your ear at a distance of one-half of an inch this speech would, of course, be loud, but not unbearably so. Sounds of approximately this intensity are not unusual in conversation in the subway. If, with this loudness, the speaker were to pronounce numbers, but in a large quiet place where there would be no reflections, you could interpret about one-half the numbers, even though you were a mile away.

That gives an idea of the sort of mechanism which we have for our hearing sense. It is a sound detector or meter which will respond to and interpret sounds of such different intensities that one may be only one ten-billionth as loud as the other. These and many other interesting facts are data derived by research workers in our Laboratories who have been investigating for years the mysteries of speech and hearing, the two terminal elements in a telephone conversation.

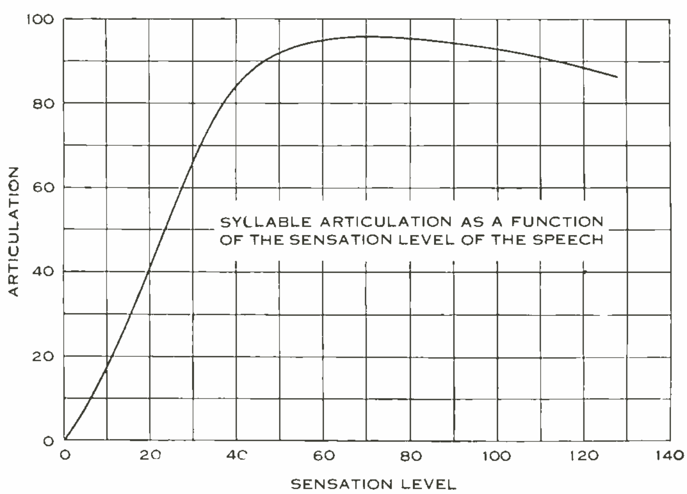


Fig. 1—In this curve, loudness (sensation level) increases left to right

Continuing this analogy of ear and meter we know that in choosing a meter for a specific purpose we endeavor to obtain one such that the readings which we wish to make will be at the middle and not the extremes of its range. So it is with ears. Although they respond to and interpret sounds of an enormously wide range of intensity, they are none the less best adapted to the middle range.

This is shown graphically in Figure 1, in which the interpretation of speech is represented by syllable articulation. Tests were conducted in which meaningless syllables were pronounced and the listeners required to record the syllables as they heard them. No context of sentences or words guided the listeners. They were asked to recognize discrete and elementary sounds which, however, enter into the formation of words. The percentage of these syllabic sounds which they were able to recognize correctly is called the articulation. The curve shows how the articulation varies with the intensity of the sound.

The intensity of the sound to which the auditors were subjected — in technical terms, the "sensation level"—is measured in transmission units above the so-called "threshold of audibility" of the speech. The threshold of audibility is the sensation level at which the sound is just recognized as a sound.

As the sensation level is increased and the speech is correspondingly above the threshold of audibility, there is a range of intensity in which the sounds are so weak that they register in only an indecisive fashion, and the articulation is low. As the speech is made louder, the articulation keeps increasing until a sensation level of seventy is reached. At this point the articulation reaches a maximum. Even at this point the human ears have become slightly overloaded. Hence, when the sensation level is raised still higher one experiences an effect very similar to that of overloading a vacuum tube. Distortion becomes prominent and the ability to interpret is lessened.

It is interesting to note that the sensation level necessary for maximum interpretation is one which is usually encountered in conversing at a distance of from four to eight feet in a room of average noise. This makes it appear that our ability to interpret is to a large extent a matter of education. Even though our ears

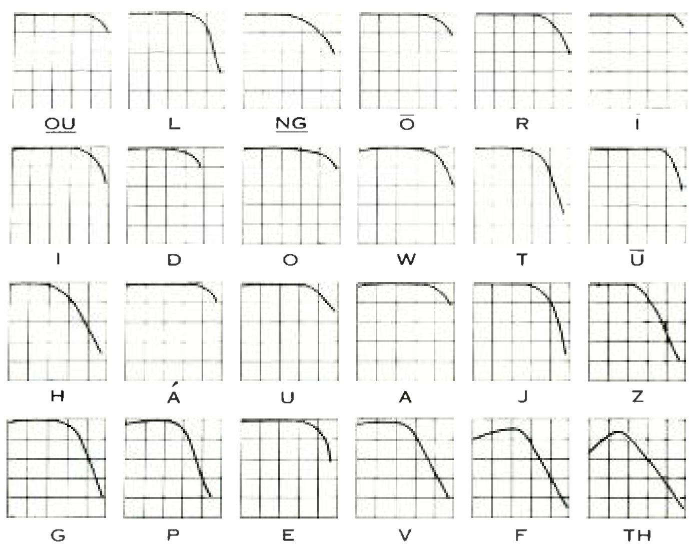


Fig. 2—Here, as loudness decreases (left to right), articulation usually decreases (vertically)

are slightly overloaded we are accustomed to the condition and ultimately find it the best. It is likely that people who are continually submerged in loud noise become accustomed to this noise, and are educated to interpret best at loud speech-levels, even though the ear is very greatly overloaded.

The curves of Figure 2 relate articulation of specific but fundamental sounds of speech with the sensation level of speech as a whole. In most cases these curves appear to belong to one family, and are governed by the same causes as the curves for speech as a whole. There are, however, several departures which are worthy of interest.

The behavior of the individual sounds is due to several causes. The occurrence of the vowels and semivowels at the top of the list is explained by the fact that these sounds have most of the energy in speech. They are really the factors which determine the threshold, and as the loudness is decreased towards its threshold value they are the last to be heard and are readily distinguished. Yet they are not essential sounds for the interpretation of speech. Stenographic systems dispense with the vowels and concern themselves only with the consonants.

Another cause of the differences in individual speech-sounds lies in the manner of their formation, which produces for us pure vowels, combinational and transitional vowels, semivowels, stop consonants and fricative consonants. The pressure waves thus brought into being are exceedingly complicated, containing different harmonic components for each of the fundamental speech sounds involved.

If the distribution of the harmonic components of the pressure waves of two sounds is similar, the sounds are apt to be misinterpreted one for the other. This action takes place to a large extent among the consonant groups. For example, the sounds of the "stop consonants," *p*, *k* and *t* (so-called because in the production of these sounds there is in the mouth a stop which must be broken before the sound can be terminated), are often misinterpreted, one for the other. Sounds in the other groups are similarly misinterpreted. In consequence the articulation is lowered.

Since the articulation takes into account not only the sensation level of a specific sound, but also the likelihood of its being misinterpreted for a similar sound, it is really a measure of the difficulty of the sound. Figure 2 may be considered therefore as an arrangement of the sounds of speech in the order of increasing difficulty.

The vowels are seen to be the easiest of the sounds of speech. In general the dipthongs and vowels are more easily heard and understood than the consonants. The stop consonants are heard with fewer mistakes than the fricative. The latter group, containing v, z, f, s and th, is an extremely difficult one. Were it possible for one of the national organizations which concern themselves with simplifying our language, realizing the difficulties of this group of consonants, to wipe it out of existence at one swoop it would not only simplify matters for the phoneticians, but would bestow a boon on the telephone engineer who deals with speech as a commodity.

In the Month's News

FOLLOWING the formal opening of the Sesqui-Centennial Exhibition at Philadelphia, the *Public Ledger* made this editorial comment:

> The complete success of the amplifying apparatus insures for the stadium itself a usefulness far beyond what its creators could have imagined. Every word spoken from the rostrum was clearly heard at the extreme limits of the vast horseshoe.

The reference is to a Western Electric 1-A public address system installed in the Municipal Stadium and operated by the Bell Telephone Company of Pennsylvania. A novel feature of the installation is the mounting of twelve six-foot horns in a group suspended from a cable 800 feet long stretched across the Stadium. Circuits have been permanently placed so that microphones can be plugged in at many points. A telephone circuit allows observers at various parts of the seating area to talk with the operator in the control room underneath the stands. An appreciative letter from the Telephone Company to Mr. Craft says in part:

> We feel grateful to Messrs. Glunt, Gilson, Santee, Kuhn and Martin for the design and production of new horns, receivers and projectoliers. The system will undoubtedly be used very extensively throughout the period of the Sesqui-Centennial, and consequently will be much observed by the public.

EDWIN H. COLPITTS, Assistant Vice-President of the American Telephone and Telegraph Company, recently was honored by receiving the honorary degree of Doctor of Laws from his Alma Mater, Mount Allison University.

Mr. Colpitts entered the American Bell Telephone Company in 1899, after graduate study and an instructorship at Harvard. In 1907 he came to Western Electric, becoming Assistant Chief Engineer in 1917. He held this position until 1924, when he took up his present work in the Department of Development and Research.

H. CLYDE SNOOK has received the degree of Doctor of Science from his Alma Mater, Ohio Wesleyan.

DURING THE MONTH of May, patents were issued to the following Bell Laboratories men:

C. R. Moore (2)	H. Whittle
W. G. Housekeeper (2)	C. L. Goodrum
H. M. Stoller	R. D. Conway
H. Pfannestiehl	J. L. Fearing
J. C. Schelleng	B. W. Kendall
W. L. Casper	J. C. R. Palmer

MAURICE B. LONG spoke on "The Electrical Transmission of Pictures" at the June 5th meeting of the Physics Club of New York.

FRANK B. JEWETT addressed graduate engineers and undergraduates on Engineers' Day at the University of Colorado.

JOHN J. GILBERT is in Newfoundland in connection with a cable project.

A PLANT AND ENGINEERING Conference of the American Telephone and Telegraph Company was held from June 2nd to 11th at Buckwood Inn, Shawnee-on-Delaware. Mr. Craft spoke on matters relative to the research and development work of the Laboratories. Messrs. Dixon, Jones and Lyng also attended the meeting.

SERGIUS P. GRACE addressed the Upstate Telephone Convention at Rochester, New York, on "Science and Research in Telephone Development."

ON MAY 28th, E. M. Honan of the Inspection Department, spoke before a meeting of the American Chemical Society at Madison, Wisconsin. The subject of Mr. Honan's talk was "A Rapid Test for Evaluating Baked Japan Finishes."

DURING MAY, B. A. Merrick was in Chicago discussing with a number of manufacturers possible changes in design and production methods which may be expected to result in quality improvements in certain types of telephone supplies. R. M. Moody, E. G. D. Paterson, H. F. Kortheuer and O. S. Markuson were in Hawthorne in connection with regular Inspection Survey Conference Work.

A. I. RIVENES, who has been one of the Inspection Department's Field Engineers in the Central Territory, with headquarters at Hawthorne, has been transferred to duty in the Complaint Bureau at New York. E. G. D. Paterson and R. C. Kamphausen recently visited St. Louis, Missouri, and Tulsa, Oklahoma, in connection with a number of matters affecting the quality, maintenance and operation of gas engines. G. Q. Lumsden accompanied several Associated Telephone Company engineers to Natural Bridge, Virginia, for the purpose of observing plant practices in the butt treatment and inspection of chestnut poles.

POWER MACHINERY used in the telephone plant was discussed at a conference at the Lynn Works of General Electric on May 24th and 25th. Bell System engineers interested in this phase of the work were present. The group from the Laboratories included A. E. Petrie, S. H. Anderson, F. F. Seibert, R. D. DeKay, F. T. Forster, J. F. Stone and C. W. Van Duyne, of the Systems Development Department, and D. A. Quarles and E. G. D. Paterson, of the Inspection Department.

RAYMOND L. WEGEL attended meetings of the American Laryngological, Rhinological and Otological Society, Inc., the American Otological Society, the American Laryngological Association, and the American Bronchoscopic Society at Montreal.

"TYPES OF ENGINEERING WORK," was the subject of an address delivered on May 21 by John Mills to sophomores in Course VI at Massachusetts Institute of Technology.

FROM THE APPARATUS DEVELOPMENT DEPARTMENT several engineers have made short trips during the month. Harold T. Martin visited the Victor plant at Camden to discuss large horns for public address systems. B. O. Templeton and G. C. Porter visited three public schools in New Jersey to inspect phonograph public-address systems. They secured photographs for a future article for BELL LABORATORIES RECORD. J. F. Baldwin, with C. H. Amadon of Inspection and two A. T. & T. engineers visited a supplier's plant for further study of a carbon-dioxide fire extinguisher for central office use as a supplement to the present chemical extinguishers. N. H. Slaughter was in Chicago on radio broadcasting matters on June 16 and June 17. David H. Newman has just returned from a two and one-half months' trip to the city of Caracas, Venezuela, where he engineered the installation of a one-kilowatt broadcasting equipment for Empresa Venegoland de Radiotelefonia.

Bell Laboratories Club

On Saturday Afternoon, June 5, at the Salisbury Country Club, seventy-four of our golfers teed off in the qualifying round of the second Golf Tournament of the Bell Laboratories Club. The players were handicapped for medal play in accordance with standard rules from their three best scores turned in to the Golf Committee, of which E. J. Johnson is chairman.

Prizes were offered for the two best gross scores and the two best net scores in the qualifying round. These were won by J. Hillier, having low gross score of 88, with G. T. Lewis's 90 second. A. A. Reading came home with a low net score of 73, and A. W. Lawrence, J. A. Lee, K. B. Lambert, and J. W. Hayward tied for second low net with 74's. The other twenty-seven who qualified, with their scores were:

	Gross	*Handicap*	*Net*
W. L. Kidde	91	15	76
E. H. Clark	92	11	81
J. G. Roberts	92	11	81
G. E. Kellogg	93	11	82
J. A. Burwell	95	17	78
H. A. Pattison	98	18	80
H. D. Arnold	99	22	77
C. W. Warner	100	22	78
A. L. Thuras	101	21	80
W. C. Miller	101	25	76
L. G. Hoyt	102	18	84
J. Mills	103	26	77
A. J. Boesch	105	22	83
J. Hall	105	26	79
S. P. Grace	105	26	79
A. J. Johnsrud	107	27	80
T. C. Rice	109	25	84
M. R. McKenny	109	26	83
E. C. Mueller	110	28	82
J. B. Retallack	110	29	81
O. H. Williford	113	29	84
J. C. Kennelty	113	30	83
G. Degenring	114	31	83
O. Cesareo	115	31	84
W. E. Viol	117	34	83
J. Mallon	117	34	83
C. R. McConnell	119	35	84

The finals were played at Salisbury on Saturday, June 12, which for a short time promised to be ideal day for golf. However, shortly after the last man had teed off, it started to rain, and continued throughout the entire afternon. Needless to say, the scores of a number of players who had a good start were spoiled.

All of the players who qualified on June 5 were out for the finals. J. M. Hayward and A. L. Johnsrud, finishing ahead of the other players, were tied with net scores of 69. Mr. Johnsrud had a gross 96, with a handicap of 27, and Mr. Hayward a gross 100, with a handicap of 31. The winners of the other six prizes in this final round with their scores were:

	Gross	*Handicap*	*Net*
J. C. Kennelty	101	30	71
J. A. Burwell	89	17	72
J. A. Lee	104	32	72
T. C. Rice	100	25	75
G. E. Kellogg	87	11	76
A. W. Lawrence	95	19	76

A silver cigarette box was given by the Club for low net score in the finals in addition to graded prizes of golf material for the eight leaders. It was necessary for Messrs. Hayward and Johnsrud to play off their tie. The other ties in the final rounds were settled by totaling the prize given for the two positions and dividing this money between the two players whose scores were the same.

The play-off for the trophy and the first and second prizes was held on Wednesday, June 16, over the

Number 3 Course at the Salisbury Country Club. Mr. Hayward won with a gross 108, net 77, over Mr. Johnsrud, who had a gross 113, net 86.

The Golf Committee has planned two tournaments for 1926 and has made arrangements with the Salisbury Country Club to hold the second one on Saturdays, September 11 and 18.

T. C. Rice, K. B. Lambert, J. M. Hayward and J. A. Boesch

THE ANNUAL BOWLING DINNER, which was held on Tuesday evening, May 18, at the Fraternity Club, brought to a close a most successful bowling season. One hundred and twenty-three bowlers attended and enjoyed an excellent dinner while listening to music by our own Jazz Orchestra under S. J. Zammataro's leadership. Immediately following the dinner, Chairman Bostater made a short speech in which he gave a brief outline of what the Club had done during the past season, and thanked the bowlers for their cooperation in making his term in office a successful one. Mr. Craft, who was then introduced, distributed the prizes. The remainder of the evening's entertainment was a party at the Shubert Theatre, where the Greenwich Village Follies is playing.

O. Cesareo, A. H. Williford and A. L. Johnsrud

The averages of the bowlers were substantially better than those of last year, and our men made a very creditable showing in the Metropolitan Bowling Championship of the New York Bowling Association at Dwyer's Alleys. Men were entered in the singles, doubles, and five-men events of all classes, and one of the Laboratories teams finished

A. W. Lawrence, E. C. Mueller, J. C. Kennelty and L. G. Hoyt

were so enjoyable that the hikers have expressed the wish that another supper party be planned.

The hiking scheduled for July should bring out some new hikers to join the old-timers. Surely these trips will be interesting if you like to walk at all. On July 10, try walking from Heathcote to White Plains; July 18, climb High Tor, starting at Haverstraw, and you will find there is a wonderful view from the top; July 24 the hike will start at Nepperhan, taking the road along the Catskill Aqueduct to Greenville, and returning by way of Grassy Sprain Reservoir Trails at Nepperhan; August 1, off to Jersey to start

second in the "Amateur Five" events. Entries in this event were limited to bowlers of averages of 180 or less. Our team made scores of 941, 1026, and 915 for a total of 2883 pins, only 12 pins below the winner of this class. Each member of the team, which consisted of R. J. Miller, I. MacDonald, T. C. Rice, A. W. Dring, and F. H. Behrens received a solid gold medal and a cash prize.

THE SUPPER HIKE to Alpine was the most popular which has been held. Those who went along know what a good time they had cooking steak and bacon over an open fire while the coffee steamed away over another fire. The stunts which followed and the trip home again

Our entry in the "Amateur Five" tournament. Standing: T. C. Rice, R. J. Miller; seated: A. W. Dring, F. H. Behrens, I. MacDonald over the Mine Trails from Ringwood to Little Cedar Pond, and then back by way of Sterling Furnace to Ringwood again. This is old mining country in the Ramapo Hills.

ALTHOUGH THE RIDING at Van Cortlandt Park has been discontinued until about September 15, there will still be riding at the Unity Academy all through the summer, and Miss Gilmartin will be very glad to let you have tickets.

ALTHOUGH IN THE EARLY SUMMER the weather did not encourage bathing, the month of July with its warm Saturdays and Sundays should tempt many club members and their friends to take advantage of the arrangements which have been made for bathing at Brighton Beach. Brighton is the most convenient beach for the greatest number, and you are sure at Brighton to see some of the other members of the Bell Laboratories. Here also are many facilities not usually found at the other beaches, such as handball, tennis, pool and swimming pool for the kiddies. The club is fortunate in being able to obtain tickets at one-half the regular rate.

OUR INTERDEPARTMENTAL BASEBALL LEAGUE got away to a flying start, but bad weather has put us considerably behind with our schedule and piled up a number of unplayed games.

At the present time the Apparatus Development team is leading the league and is playing a brand of baseball which should give them the club championship. Both of their victories have been registered over teams which were considered the two strongest in the league.

Interdepartmental League Standing

	Won	*Lost*	*Tied*	*Pct.*
Apparatus	2	0	..	1000
Toll and Circuit	1	0	..	1000
Tube Shop	1	1	..	500
Commercial	0	0	1	000
Equipment	0	1	1	000
Research	0	1	..	000

Two games are played every Saturday at Erasmus Field, weather permitting.

Bell Systems Baseball League Standing

	Won	*Lost*	*Tied*	*Pct.*
Bell Laboratories Club	3	1	..	750
W. E. Installation Dept.	3	1	..	750
N. Y. Tel. Co., Long Island	3	1	..	750
W. E. Co., Hudson Street	2	1	1	666
N. Y. Tel. Co., So. Man.	2	1	1	666
A. T. & T. Co.	1	3	..	250
N. Y. Tel. Co., No. Man.	1	3	..	250
W. E. Co., 195 Broadway	0	4	..	000

Baseball, as we all know, is a game of unexpected upsets, and on Monday evening, June 14, we had our share of trouble. After winning three games without losing one, we dropped a hard-fought contest to the team representing New York Telephone Co., Long Island Division, which puts our club in a triple tie for first place.

The baseball committee is most grateful for the loyal support given by the three hundred rooters who attended this game and stayed to the finish, although it rained during the last three innings of play.

The crowd was the best that has ever attended our games; five large buses and a number of private cars were needed to carry the spectators.