BELL LABORATORIES RECORD

RADIO-TELEPHONE EXTENSIONS
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JOINING LINE WIRES
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TESTS OF TOLL CORD CIRCUITS
E. R. Smith

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In this Issue

the North Atlantic path.
A very important feature of

RECORD

New transmitting center for transpacific communication at Dixon, California

VOLUME TEN—NUMBER THREE

for

NOVEMBER

1931

New Overseas Radio-Telephone Extensions

By A. A. OSWALD
Radio Research

SINCE the establishment of the American Telephone and Telegraph Company's short-wave radio stations at Lawrenceville and Netcong for service to Europe* via London and to South America† via Buenos Aires, plans have been made and construction started for other overseas radio extensions. Among these are direct connections from New York to Rio de Janeiro, New York to Bermuda and San Francisco to Honolulu. While these systems will be similar in general to those already in service, they will incorporate the improvements resulting from continued research and development. To assist in embodying these developments, the Laboratories' engineers have actively participated in the station designs and are now engaged in technical supervision of various phases of installation and testing. For the same reason, much of the radio apparatus has been manufactured in the Laboratories' shops.

Fig. 1—*New radio links (shown in dotted lines) will considerably augment the overseas telephone service offered by the American Telephone and Telegraph Company*

From the economic point of view, the outstanding recent improvement is the introduction of a new type of antenna. This antenna, known as the double horizontal "V" or diamond-shaped type, was invented by Mr. E. Bruce and was first applied by him to receiving systems. It has since been adapted

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* Record, *July*, 1929, *p.* 435.
† Record, *May*, 1930, *pp.* 405 *and* 436.

Fig. 2—The apparatus for transmitting to Bermuda was built at West Street. B. G. Griffith is shown testing it before shipment to Lawrenceville

to transmitting purposes by Mr. E. J. Sterba.

In marked contrast to the Lawrenceville antennas* which consist of intricate conductor systems supported on high steel towers, the new type is a simple affair supported in a horizontal position by wooden poles from 40 to 70 feet in height, depending upon the frequencies to be transmitted. The gains realized with the new antennas range from 10 to 15 db, whereas some of the Lawrenceville antennas give gains as high as 20 db. The high gains of the Lawrenceville antennas are only required, however, where the transmission conditions are as unfavorable as those existing along the North Atlantic path.

A very important feature of the new type of antenna is that, when properly terminated, it can be used for several frequencies within a range of 2½ to 1. This covers the usual day, transition, and night frequencies for a given channel. The cost per antenna is about one-fourth of that for the Lawrenceville types, and the savings are further increased by using the same antenna for transmission on two or more frequencies.

Heretofore, each service from the United States has been established on the basis of making full-time use of the radio facilities between two fixed terminals. Plans for the new Rio de Janeiro connections involve sharing equipment already provided for connections to Buenos Aires. At Lawrenceville the transmitter operating with Buenos Aires has been equipped with an additional horizontal diamond-shaped antenna directed toward

Fig. 3—The transmitter (left) and power control equipment (right) for transmitting to Honolulu are similar to those at Lawrenceville

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* Record, *August*, 1929, *p.* 502.

Rio de Janeiro and adjusted for the daylight frequency used for transmission to Buenos Aires. At Netcong there has been installed a new receiver, and an antenna directed for reception from Rio de Janeiro. The transmitter at Rio de Janeiro operates on a different frequency from that used at Buenos Aires. Hence, with this additional receiving unit at Netcong, the New York control office can cover both the South American stations at all times and can direct the transmission from Lawrenceville to either Buenos Aires or Rio de Janeiro as required by traffic.

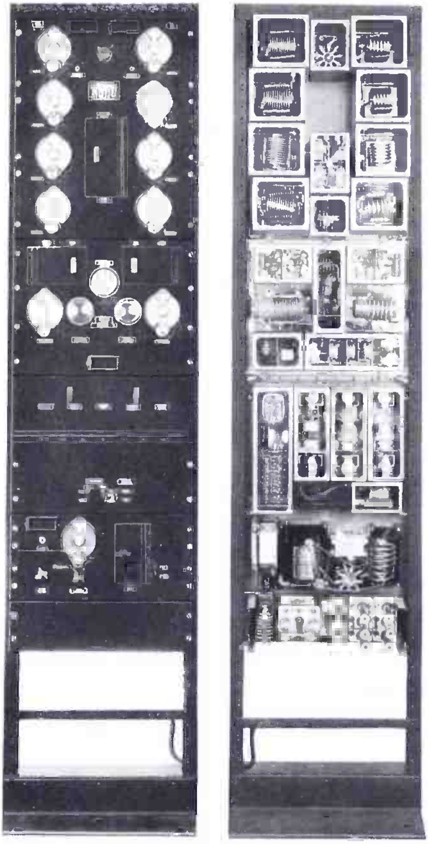


Fig. 4—Radio-receiving apparatus of the ship-to-shore type is used at Netcong for receiving from Bermuda

For the New York-Bermuda channel, as for the other transoceanic services, the American company will provide facilities only at the United States end. The distance from New York to Hamilton, Bermuda, being but 700 miles, the transmitter can be much smaller than for the 5,300 miles from New York to Buenos Aires, and frequencies about fifty per cent lower are used. For this project the Laboratories has designed and manufactured a 500-watt transmitter similar to that developed for ship-to-shore telephony on ships of the Leviathan class. The only important difference is that the Bermuda transmitter operates directly from the local three-phase power supply without rotating machinery, whereas the ship equipment includes motor-generators operated by the ship's general direct-current supply. The new transmitter is now being installed at Lawrenceville and will connect to a single diamond-shaped antenna which will be employed for transmission to Bermuda on a day frequency of 10,675 kilocycles and a night frequency of 6,755 kilocycles. Although the night frequency requires a higher vertical angle of transmission from the directive antenna than the day frequency, the one diamond-shaped antenna radiates at substantially the desired angles for the two frequencies, when spaced in proper relationship to the ground and otherwise correctly dimensioned.

The signals transmitted from Bermuda will be picked up at Netcong by one diamond-shaped antenna designed for reception at both the day and the night frequencies. This antenna and the associated radio receiver, of the type designed for use aboard trans-

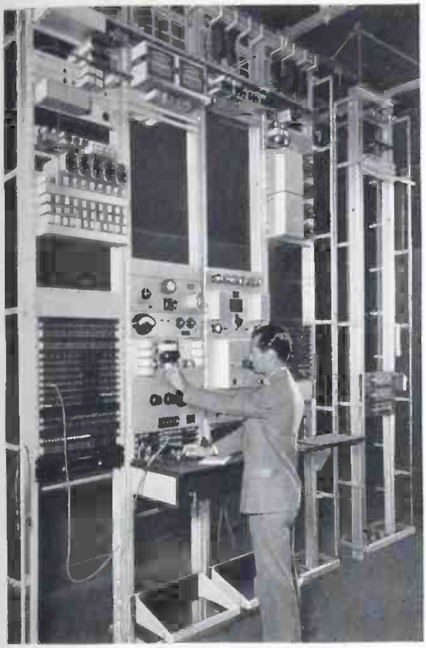


Fig. 5—The line-terminal equipment at Dixon is in a copper-shielded room

atlantic liners for ship-to-shore telephony, are now installed. The transmitter at Lawrenceville will soon be available for general system testing, and regular service will probably be initiated before the end of this year.

In the case of the San Francisco-Honolulu service, the Hawaiian end will be operated jointly by the Mutual Telephone Company of Honolulu and the Radio Corporation of America. The San Francisco end will be operated by the Transpacific Communication Company, Ltd., a newly organized subsidiary of the American Telephone and Telegraph Company. The terminal at San Francisco will connect with a receiving station at Point Reyes on the coast north of San Francisco and with a transmitting station in the Sacramento Valley near Dixon. In selecting these sites and planning the stations, careful consideration was given to the possibility of establishing other transpacific services such as to Australia, Japan, Philippine Islands and Alaska.

For this reason the transmitter now being installed at Dixon has the same power capacity as those at Lawrenceville. In general it is the same, but it occupies less space, and a number of improvements have been introduced which give it greater stability in operating performance. Initially, one antenna of the horizontal diamond type will be used to transmit on the several assigned frequencies.

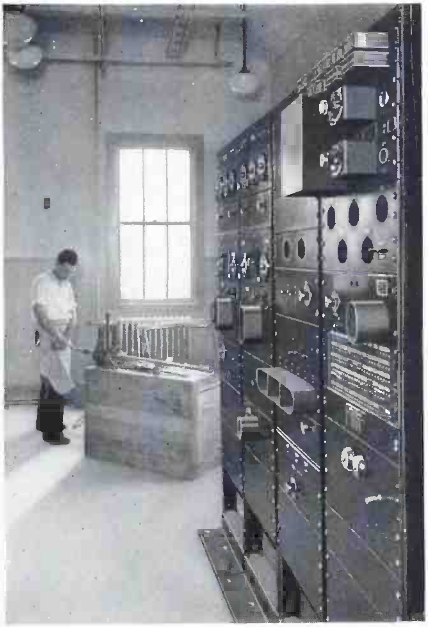
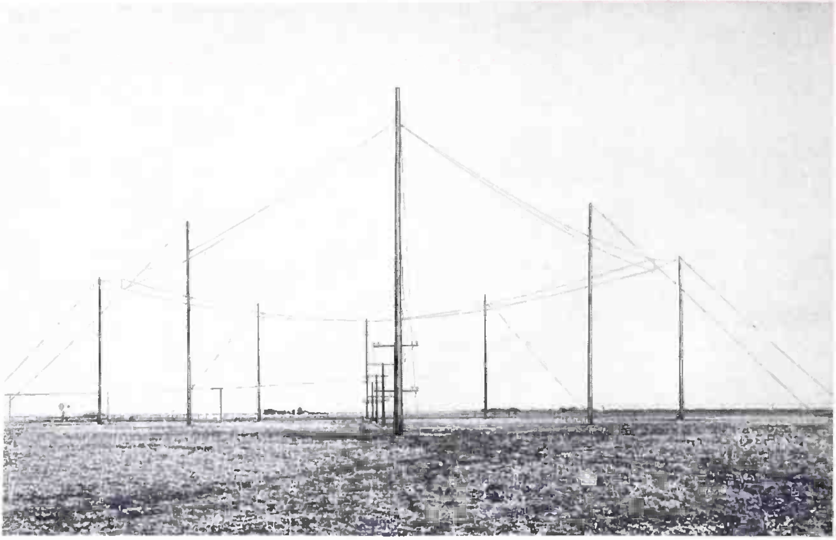


Fig. 6—Installing the receiver at Point Reyes for reception from Honolulu

At Point Reyes there will be two receiving antennas of the horizontal diamond type, connected to a receiving unit similar to the transatlantic



A single horizontal diamond-shaped antenna will transmit on different frequencies at different times of day from Dixon to Honolulu

type at Netcong. Heretofore the concentric-tube transmission lines connecting antennas to receiving apparatus have been supported above the ground on short stakes, and have followed a sinuous curve to allow for expansion.* At Point Reyes, the lines will be straight and will run underground.

The technique of connecting antennas and receivers by such transmission lines has advanced considerably. Lines 1⅜ inches in diameter having low losses have been developed for the long runs from antennas to receiving buildings, and ⅜-inch lines of the same impedance as the 1⅜-inch lines are used inside of the buildings. These ⅜-inch lines are sufficiently flexible to be installed like gasoline pipes on an automobile. They can be terminated at switching panels, where they can be interconnected as required. Special one-way repeaters designed for operation at frequencies of 10,000 to 20,000 kilocycles have been developed for use with these switching panels so that an entire receiving station can now be given great flexibility.

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* RECORD, *title page for March*, 1930.

A Versatile Nomogram for Circuit Problems

By T. SLONCZEWSKI
Telephone Apparatus Development

COMPUTATIONS most frequently made by communication engineers are probably those involving relationships between reactance, capacitance, inductance, and frequency. Although the formulas employed are comparatively simple, considerable labor is involved if a large number of computations must be made. In such cases labor saving devices are resorted to with good advantage. Electrically driven computing machines, for example, are employed for precise calculations in designing filters. For many other purposes a slide rule will give results with sufficient accuracy.

Frequently, however, not even slide-rule accuracy is required. When occupied in outlining a new design, when laying out an experimental procedure, when interpreting results, or when discussing approximate values in a technical conference, an engineer will often be satisfied with only one significant figure. Under these circumstances, however, it is desirable that the time and labor involved in obtaining the information be small enough not to divert his attention from his chief objective. The need for a device to make possible the rapid solution of simple reactance problems has been felt for a long time, and recently a nomogram has been devised which has very satisfactorily filled the requirements.

The two most frequently used relationships are those between inductive reactance, and frequency and inductance ($X_e = 2\pi fL$), and between capacitive reactance, and frequency and capacitance, ($X_c = 1 \div 2\pi fC$). Three parameters are involved in each, and when the values of any two of them are known, that of the third may readily be found. Either multiplication or division is required, depending on

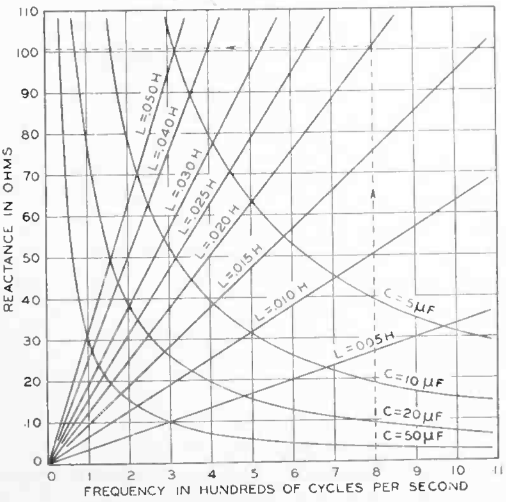

Fig. 1—A simple arithmetic nomogram for determining the reactance for various values of inductance or capacitance, and frequency

which of the three parameters is unknown, and 2π always enters as a factor. The principle involved in the construction of a nomogram for such calculations is simply illustrated by Figure 1, which would enable the inductive reactance to be determined when the frequency and inductance were known. By combining L and 2π as a single coefficient, X_e becomes a linear function of frequency (of the form $y = mx$) and may be read on the ordinate scale for any value of frequency and inductance. The value for 20 millihenrys at 800 cycles is indicated on the chart by dotted lines.

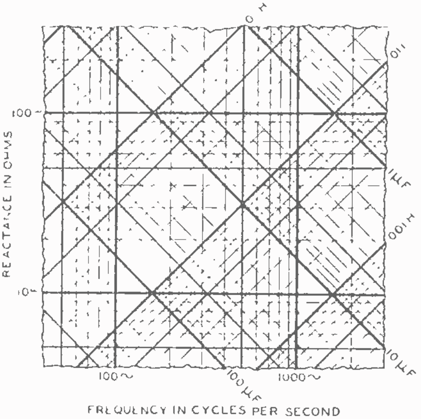

Fig. 2—A small section of the new logarithmic nomogram covering only a range of values comparable to Figure 1

Such a chart with simple arithmetical scales has several objectional features, however. In the first place the lines for capacitance would be curved instead of straight, because of the reciprocal relationship, and curved lines somewhat complicate the construction. Also the accuracy varies, depending on the values of the parameters. Perhaps the greatest disadvantage, however, is the comparatively small range of values that can be included on such an arithmetical chart.

By employing logarithmic scales all these objections are overcome. The relationship may still be expressed by a linear function but of the form $y = x \pm b$ where x represents either log $2\pi L$ or log $(1 \div 2\pi C)$ and b, the log f. For both capacitance and inductance y represents the log of the reactance. For inductive reactance the "b" term is positive and the line slopes up to the right and for capacitive reactance it is negative and the line slopes down to the right. The nomogram devised thus has four logarithmic scales. The abscissas are frequency, the ordinates ohms reactance, and the two sets of parametric curves are straight lines, plotted on a logarithmic scale and running at right angles to each other diagonally across the sheet. A portion of such a logarithmic nomogram covering approximately the same range of values as Figure 1 is shown in Figure 2.

The advantage of using a logarithmic scale is that the per cent accuracy is the same for all values of the parameters, and that a large range of values may be included on a chart of moderate size. The chart has the advantage over the slide rule that it gives the decimal point of the result directly, and over an alignment chart that it does not require the use of a straight edge.

Its use is quite simple. To determine the reactance of a coil of .02 henrys inductance at 800 cycles, for example, one merely enters the abscissa scale at a frequency of 800 and runs up to the intersection with the line for .02 henrys. The reactance in ohms is then found to be approximately 100 ohms from the ordinate scale at the left. By a similar procedure the reactance of a condenser of 10 microfarads at 800 cycles would be found to be 20 ohms. The converse problems are solved with equal facility. If a coil was found to have a reactance of 100 ohms at 800 cycles, its inductance would be found by running horizontally from 100 ohms on the ordinate scale to the vertical line for 800 cycles and then following diagonally up to the scale of inductance, where the value of .02 henrys would be found.

Other relationships involving the same parameters may also be readily determined such as resonance frequency, and—by the use of a few additional scales—either Q values of coils and condensers, or phase angles of resistance. The resonance frequency is that at which the inductive reactance of a piece of apparatus equals the capacity reactance. Where a capacitance and an inductance line on the chart intersect they have the same reactance, and the resonance frequency is found by following down from the intersection to the abscissa scale. Thus .05 henrys and 3 microfarads intersect at a reactance of a little over 100 ohms, and the resonance frequency, vertically downward, is found to be 400 cycles. The Q value of a coil is equal to $2\pi fL \div R$ and the phase angle of a resistance, for the ordinary range of values, is given by the same expression. Both, therefore, are of the same type of expression as that for reactance, and may be found by merely adding a different set of scale values on the sides of the chart.

Other extensions of the chart's usefulness also are possible by a substitution of scales. Susceptance problems, for example, may be solved by mentally substituting micromhos for ohms, microfarads for henrys, and henrys for microfarads. Still another use of the chart lies in the fact that it represents a field of values involved in communication problems which may be surveyed at a glance. Significant areas may thus be blocked out on it. The methods, for example, by which inductances are measured depend both on the value of the inductance and on the frequency employed, and are described in master testing specifications. The new chart offers a convenient method of blocking out the field of values over which the various methods apply.

To extend the use of the chart in this manner it has been printed by Keuffel & Esser on transparent graph paper 8½x11 and is stocked (Form E-1707) as part of our standard stationery. The range of values covered is from 10 to 5 million cycles, from 0.01 to a million ohms, from 0.001μH to 1000 H, and from 1μμF to 0.1 F. It may also be printed on heavier paper and used under a desk glass or pasted on bulletin boards convenient for general use.

Rolling Joints

By C. R. MOORE
Outside Plant Development

When telegraphy began its rapid rise about a century ago it uncovered a wide field of new problems to be solved. For the first time it was necessary to install long continuous lines of wire, and since the length of any one piece is restricted by manufacturing limitations many joints had to be made in a line traversing even a moderate distance. At first the wires were simply twisted together without much attention to the method, but it was soon found that something more was needed. As a result there was evolved the Western Union joint, shown in Figure 1, which has been satisfactorily used for many years.

Fig. 1—The Western Union joint is easily made and for many years was standard for open-wire telegraph construction

For telegraph service in its early form the union had to be mechanically substantial and in tight enough contact electrically not to open the circuit as the wire moved in the wind. Slight changes in pressure at the contact, resulting in variations of resistance, would not ordinarily be serious. Subsequent developments in telegraphy and the advent of telephony, however, placed more stringent demands on the line, indicating particularly the need for a more reliable joint.

To meet this requirement the double-sleeve joint, shown in Figure 2, was developed. The wires at the point of union are cleaned and slipped through the two halves of the sleeve in opposite directions and about a half inch of wire is left projecting. The sleeve is then clamped by a tool at each end and twisted a specified number of turns. The projecting ends of the wire are bent over the ends of the sleeve to prevent the wire from pulling out, and cut short. The resulting union met the needs for the time and has been standard in the Bell System for a number of years. Although only what was essentially a line contact was obtained, it was in general rigid and tight enough to maintain a sufficiently constant resistance for satisfactory transmission over a reasonable service life.

With the introduction of carrier systems in recent years, a still higher order of constancy of the relative resistances of the various parts of the circuit has become imperative. A resistance balance of the various parts of the circuit must be maintained, and to accomplish this the twisted sleeve joints have been soldered on some of the more important circuits. Soldering is required not so much to reduce the initial contact resistance as to prevent an increase of resistance due to corrosion of the narrow contacting surfaces, which are exposed to moisture and gases throughout their length because of incomplete contact around the circumference of the wire.

Although soldering produces a union entirely satisfactory in its resistance characteristics, it introduces the danger of affecting adversely the mechanical strength of the line due to an annealing action during the soldering process. Much of the wire used for telephone lines is hard-drawn copper and would lose about half of its strength if thoroughly annealed. Although soldering, if properly done, will not have any such pronounced effect there is a possibility of its reducing the strength and furthermore it is a difficult and expensive operation to perform.

Quite aside from soldering, however, the mechanical strength of the twisted sleeve joint is somewhat below that of the wire, due to the cold working of the wire in forming the joint. A soldered twisted joint, therefore, although satisfactory electrically, is not wholly satisfactory either mechanically or economically so that it seemed desirable to attempt to develop a new joint which would provide the electrical characteristics of the soldered joint at a lower cost and without sacrificing strength.

Fig. 2—To obtain more satisfactory electrical contact a double-sleeve joint was developed

As it approaches perfection, a joint will assume more and more the characteristics of a continuous conductor of hard-drawn wire. The nearest practical approach to this ideal seemed to be a single tube of hard-drawn copper in such intimate contact with the two ends to be joined that there was no access between the sleeve and the wire for corroding vapors. Selecting the best method of applying such a sleeve, however, required a large amount of study and experiment.

Fig. 3—The new method uses a single sleeve rolled into intimate contact with the wire

Shrinking the sleeve on the wire was eliminated because of the objection to heating and to the close dimensional requirements. Screw couplings and similar mechanical devices did not seem desirable because the necessarily somewhat large diameters of the screw fittings would make it difficult to pull the wires over the cross arms. It seemed necessary, therefore, to adopt some method which by performing work on the outside of the sleeve would leave it tight around the wire. Only drawing, pressing, or rolling thus appeared to be promising.

All these methods have been successfully used in the laboratory and drawing had previously been applied abroad. Both drawing and pressing, by requiring much greater forces, and thus heavier apparatus, did not seem suitable for general use in the telephone field where the joints are frequently made aloft. Most of the experimental work, therefore, has been confined to the rolling process, and sleeves, tools, and a technique have been developed with the result that a new joint which appears to meet all requirements is now available for general use.

The sleeve employed, made of annealed copper, is shown in Figure 3. An indentation at the mid-point prevents either of the two ends of the wire from occupying more than half of the sleeve. The rolling tool is shown in Figure 4. The rolls are formed with four pairs of grooves of the proper diameters to take the four commonly used sizes of line wire. Flats are ground at one place on the flanges of the rolls so that by operating the ratchet till the flats are opposite each other the tool may be slipped over the wire. By turning the ratchet wrench the sleeve is then rolled tightly on to the wire. The casing enclosing the gears is completely filled with heavy oil to insure proper lubrication, which is of considerable importance since the forces between the rolls may be in excess of a ton. The method of use in the field is shown in Figure 5.

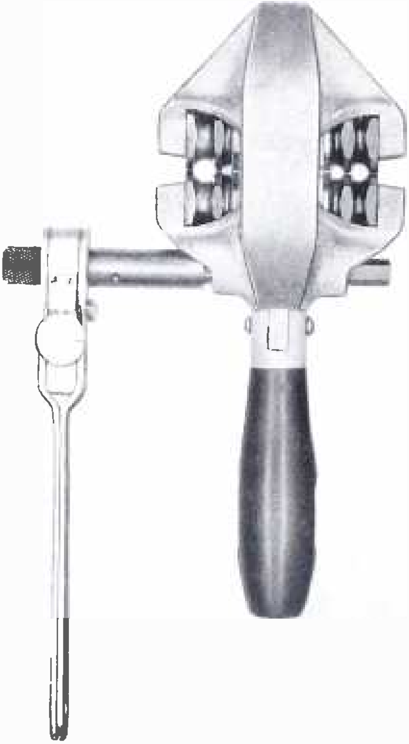
Fig. 4—The rolling tool, equipped to join four sizes of wire, weighs but four pounds and is thus easily handled aloft

In the rolling process the sleeve, originally soft, receives severe mechanical working which leaves it in a hardened state so that the finished joint is practically hard drawn throughout. The high pressures completely seal the area of contact between wire and sleeve, and as a result no moisture or air can enter, and no corrosion, therefore, can take place on the contact areas. Experimental joints, in service for nearly two years under normal line conditions, have not increased measurably in contact resistance. Vibration and tension tests have shown equally satisfactory results. No harmful effects resulting from the motion of the wire in service have been found, and when a joined section is tested to breaking, the failure always occurs outside the joint. In addition to these highly satisfactory strength and re-

Fig. 5—Making a rolled joint aloft

sistance characteristics, the sleeve is small and thus is much more easily pulled over cross arms than was the twisted sleeve joint as is obvious from a comparison of the two joints shown in Figure 6.

The size of the sleeve is determined by a design that balances the strength of copper against three primary forces: the tension tending to pull the sleeve apart, the circumferential tension in the sleeve that causes it to grip the wire, and the force of friction between sleeve and wire. Since the material of both sleeve and wire is the same, the sleeve should have the same cross-sectional area as the wire to be equal to it in tensile strength. This definitely fixes the minimum thickness of the sleeve for any size of wire. The total frictional force, tending to prevent the sleeve from slipping off the wire, depends upon the pressure between sleeve and wire, the coefficient of friction, and the area of contact which may be controlled by the length of the sleeve. The length of sleeve is thus determined by an adjustment of these three factors.

It seemed desirable to limit the circumferential stress in the sleeve, created by the rolling process, to one-fifth of the ultimate strength, because of the low yield point of copper. Using this stress and the limitation for thickness of sleeve already mentioned, it may be shown that the length of the sleeve (L) may be expressed in terms of the diameter of the conductor (d) and the coefficient of friction (f). An approximate solution based on the assumption that the wire and sleeve are rigid bodies gives $L = 6d \div f$ indicating that the length for any one size of wire is inversely proportional to the coefficient of friction. Substituting a value for f of 0.25 into the equation above gives an overall length of sleeve of about 24 times the diameter of the wire. This relationship was checked approximately by numerous experiments to determine the minimum length of sleeve required to develop the full strength of the wire. The result is a sleeve appreciably shorter than the double sleeve used before: the new sleeve for .165″ wire being made four inches long. To increase the friction, and thus to produce a stronger union, the inner sur-

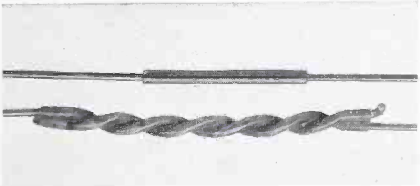

Fig. 6—The new sleeve is much smaller than the old, and thus more easily pulled over cross arms

face of the sleeve is given a thin coating of emery dust held in place by sprayed lacquer. This treatment is found not to affect the electrical resistance of the contact and approximately doubles the coefficient of friction, and provides a factor of safety to care for variations in the sizes of sleeves and line wires.

This new joining process not only gives a joint which is satisfactory both electrically and mechanically but makes possible a reduction in maintenance costs, largely because of the additional permanence obtained, and a reduction of the number of joints where transpositions are required to be cut into existing lines. The former double-sleeve joint requires an overlapping of the wires at the point of union while the new single-sleeve method does not, so that where the wires are just long enough to meet, a single joint of the new type may be employed while the double-sleeve type would have required a short additional length of wire and two joints. These advantages, and the greater ease with which the new joint may be pulled over cross arms while the wires are being strung, are in a sense secondary to the major objective of this development, which was to improve transmission and save maintenance expense on the thousands of miles of open wire in the Bell System.

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The initial building unit at the transpacific receiving center, Point Reyes, California

Interference Effects with Shared-Frequency Broadcasting

By C. B. AIKEN
Radio Development

WHEN two radio transmitting stations operate simultaneously on the same frequency assignment and are located sufficiently near together so that each is within the sphere of influence of the others, interference effects of a complex and often highly objectionable character frequently arise. Within the region where the field strengths from the two stations are comparable, there will be impressed on the detector of a receiver both carriers with their sidebands. As a result the receiver output will contain, in addition to the desired signal, a group of interfering signals.

Where the difference between the carrier frequencies is very small, it may be considered as a difference in phase which changes slowly with time. This situation will be considered in a subsequent article; for the present attention will be directed to the case where the difference in carrier frequencies amounts to several cycles or more. Here phase relationships need not be considered, and the two carriers with their sidebands may be treated as separate groups of frequencies. Under this condition the six groups impressed on the detector are as shown in Figure 1. All of these, in amplified form, will appear in the output of the detector, but since they are radio frequencies, they will be rejected by the audio-frequency circuits and so are of no further interest. Due to the non-linearity of the detector, however, the six components will also interact with each other. Noting that in all cases of practical interest the carrier of the desired station is by far the strongest component impressed on the detector the heavy lines of Figure 1 indicate that its reactions with the other currents are of most importance.

The first group of reaction-prod-

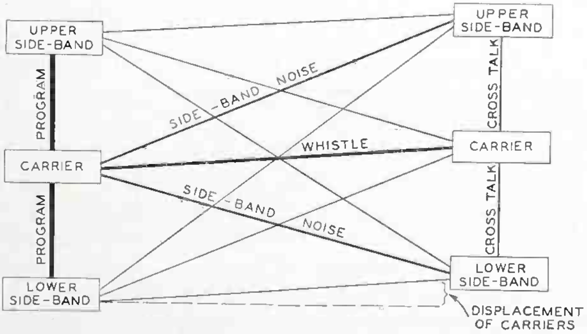

Fig. 1—Schematic arrangement of two carriers, slightly displaced, with their sidebands, and the various possible modulations of one group of frequencies by another

ucts is that formed by modulation in the detector between the carrier and the sidebands of the desired station. This constitutes the undistorted desired program, and is essentially identical with what would be received if the undesired station were absent. It is shown as the vertical lines at the left of Figure 1.

The second group contains but one frequency, the whistle between the two carriers. This is the strongest interfering component present and if the difference between the carrier frequencies is well up in the audible range it may be responsible for very objectionable interference. On the other hand if the difference in carrier frequencies is below the audible range, this component may be relatively unimportant.

The third group consists of frequencies due to the modulation between the desired carrier and the undesired sidebands. It is audible as highly distorted and extremely displeasing music, or as speech which may be almost unintelligible. This component of the detector output has been designated on the diagram as sideband noise. It is made up of two distinct spectra, each corresponding to the original program of the undesired station but displaced respectively upward and downward in frequency by an amount corresponding to the difference in frequency between the two carriers. Were the carriers of the same frequency, the difference would vanish and the two spectra would coalesce into an undistorted program from the undesired station.

Modulation between undesired carrier and desired sidebands is usually negligible as compared with other interference components. If the desired sidebands are strong, corresponding to a loud passage in the original program, the reception of the desired program will override this particular source of noise, while if the desired sidebands are weak, the noise will be less than that from other sources.

Also negligible is the ordinary cross-talk due to modulation between the undesired carrier and its sidebands. Unless this is true, reception from either of two stations transmitting different programs on the same channel is impossible. If the programs are identical, the cross-talk merges with the desired program. Analysis shows that there are still other frequencies present in the output of the detector, but they may be neglected as interference in comparison with the components already mentioned.

The carrier whistle and the sideband noise, as has been said, are the predominant components of the interference. For a given field-strength ratio a carrier beat will be most objectionable when its frequency comes within the frequency band of maximum efficiency of the transmission system consisting of the radio receiver, the loud speaker, and the human ear. The efficiency of this system is usually highest in the neighborhood of about 1000 cycles. With present day apparatus frequency differences of this amount are fortunately not very usual but whistles of a few hundred cycles are all too common and are responsible for extremely objectionable interference. Practically, for differences of less than 50 cycles, the carrier whistle may be neglected since the sideband noise will then be far more important. For a given carrier frequency difference the importance of the sideband noise, relative to that of the carrier whistle, is proportional to the degree of modulation of the interfering station.

So far, no reference has been made to the type of detector used in the receiver. In actual practice detectors are encountered which range from the parabolic or square-law type, exemplified by any detector operated at small input to those which approximate to the straight line or linear detector, as in the two-element detector at high input. Analysis shows that in so far as the important interfering components described above are concerned, the results are almost identical for the two types. This is fortunate since the square law and linear detectors are typical of the extreme types of detectors which occur in practice. A great many detectors have characteristics which are intermediate between these two types and since the results are so similar for the extremes it is safe to infer that they will not differ appreciably for intermediate types.

By means of formulae which have been derived elsewhere[1] it is possible to compute the amplitude of the carrier beat and of the components of the sideband noise in terms of the field strength ratio and the percentages of modulation of the two signals. Thus if the field strengths of the desired and interfering stations are measured at a number of points throughout a region it is possible to predict the type of interference which will occur and to estimate the service areas which may be expected. Consider, for example, two stations of equal power located 1000 miles apart. By assuming some simple formula of propagation for the waves, it is possible to plot curves marking the region within which the beat frequency, for example, will be any desired number of decibels below the desired frequency. Typical curves of this nature for an attenuation constant of .001 are shown on Figure 2.

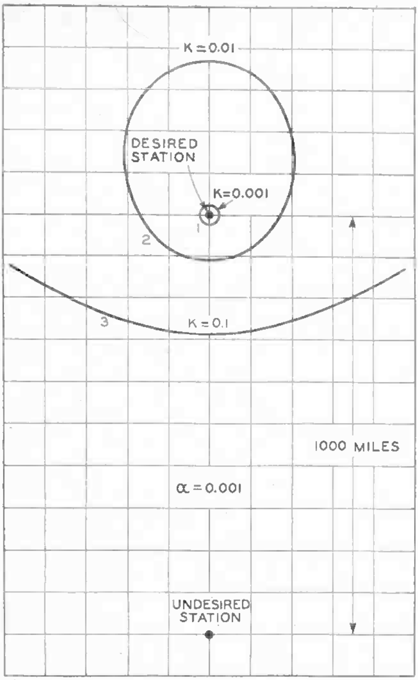

Fig. 2—A typical set of curves marking out areas where the intensities of various interfering frequencies are 20 and 40 db below that of the desired signal

Here the small curve marked 1 represents the area within which the beat frequency will be down 40 db from the desired frequency when the modulation is 10%. This represents an intermediate degree of modulation. During very soft passages the beat frequency will be of greater relative importance and during the louder passages, of less. Curve 2 marks off an area for similar conditions but where the beat frequency is only 20 db below the desired signal. The area

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[1] *"Detection of Two Modulated Waves Which Differ Slightly in Carrier Frequency"*, C. B. AIKEN, *Proc. I.R.E.*, 19, *pp.* 120-137, *January*, 1931.

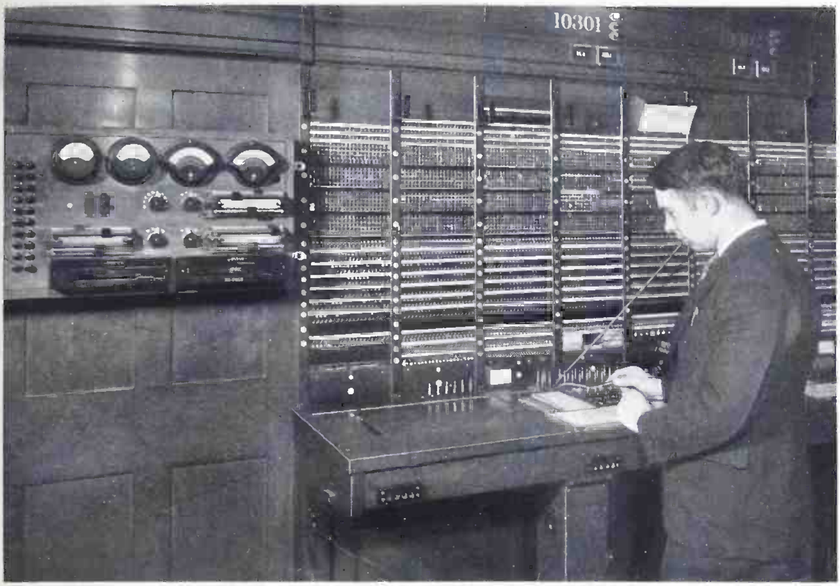
included by this curve is much greater.

For sideband noise the factor of modulation does not enter if the two stations are broadcasting the same program since the modulation at any instant will be at the same value at the two stations and will thus cancel out in the formula for relative intensity. Also the sideband noise is 20 db below the intensity of the beat frequency, since the modulation is assumed to be 10%, so that curve 2 marks the area within which the sideband noise is 40 db below the desired signal, and curve 3 has been added to define the area within which the sideband noise is down 20 db. If the two stations are nearly enough at the same carrier frequency so that the beat frequency is below the audible range, curve 3 will thus mark off the area within which all interference will be 20 db below the desired signal.

If the stations transmit different programs, however, the situation is somewhat less favorable, and varies from time to time since the modulation at the interfering station will not be at the same value as at the desired station. It may be a maximum when that at the desired station is a minimum. The area bounded by curves corresponding to 2 and 3 for such a condition will be considerably reduced. The situation regarding the beat frequency, however, will remain the same.

These curves graphically illustrate the importance of the various types of interference that the analysis has shown to exist. The value of attenuation used is low which is of particular interest when the distance between the stations is large since with the high values of attenuation neither station will have much effect on the service area of the other. At night, of course, the signal strength may correspond to a simple inverse-distance law with zero attenuation, and thus form a serious limitation to shared-frequency broadcasting at night. Conditions will differ somewhat for stations nearer together but similar curves are readily computed for any set of conditions.

One fact that stands out is that with a carrier frequency difference of several cycles, satisfactory reception cannot be expected in the regions which lie midway between two transmitting stations. To avoid distorted reproduction resulting from interference effects, the field strength of one station must be predominately higher than that of the other. Consequently the coverage obtainable with any common frequency system must necessarily consist of a series of detached service areas separated by regions of greater or less magnitude in which impaired reproduction may be expected. Other studies indicate that the size of these regions of unsatisfactory service can be greatly reduced by a very close approach to isochronous operation.



Service Insurance for Toll Cord Circuits

By E. R. SMITH

Toll Circuit Development

TOLL CORD circuits are the connecting links between toll lines and trunks to the various central offices at each end of them. For any one toll call there are thus always at least two toll cord circuits employed and if the toll circuit is built up through intermediate toll switchboards, more may be required. It is important, therefore, that the toll cords and the equipment associated with them be kept in good condition at all times. To provide a ready means of testing, and of correcting any incipient irregularities, semi-automatic testing and adjusting circuits have been provided. The arrangement of equipment varies somewhat depending on the type of board and size of office in which it is to be used, but the fundamental principles are similar for all. The equipment described below is for the No. 1 toll switchboard—a commonly used type and one in which the cord circuit contains more equipment than does that of the standard No. 3 switchboard.

The major part of the apparatus is housed in a small cabinet which may be mounted in any convenient place in the toll office. An installation in the Long Lines Building in New York City is shown at the head of this article. The equipment is divided into two parts: one for applying the required tests, and one employed in making any adjustments found necessary. For use with the testing circuits, jacks, in groups of three, are multipled throughout the front of the board. Into these the cords at the various positions are inserted for testing. There is one jack for each end of a cord pair and one for a connection to a portable test box. For adjusting purposes jacks are multipled along the rear of the board. The usual procedure is for a maintenance man to pass along the front of the board making tests on all the cords and then to go to the rear of the board and make the necessary adjustments.

A toll cord circuit has a plug on each end—one for connecting to the toll line and one for the trunk to the office to or from which the call is being completed. Associated with each plug is a supervisory lamp, controlled by its respective supervisory relay, listening and ringing keys. The trunk supervisory relay, operated on direct current, lights its lamp on signals from the local subscriber and should be able to follow the "flashing" of the switchhook or the "busy back" signals. The toll supervisory relay, operated on alternating current, is energized by signals coming over the toll line, and in turn operates another relay which locks up and lights the supervisory lamp. The second relay and the supervisory lamp may be released by operation of the listening key. The ringing keys, used in connection with the two ends of the cord, send ringing current over either the trunk or toll line.

Tests are made, therefore, to determine whether the supervisory lamp will light properly under conditions, more severe than will be met in service and whether the ringing keys properly send out the signalling current. In addition a third test is applied, known as the continuity test, to make sure that the conductors and contacts of the cord are continuous and in good condition.

The arrangement of these principal elements of a cord circuit and of the connections from the testing circuit are shown in Figure 1. Before beginning a test it is necessary to set up the proper values of test currents by the

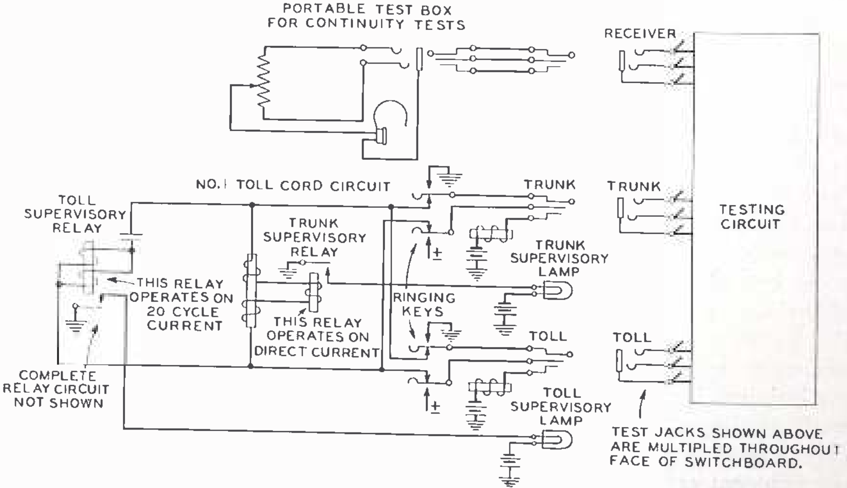


Fig. 1—The testing circuit checks the operation of the supervisory signals, the action of the ringing keys, and the continuity of the circuit

use of keys, potentiometers, and meters which are provided on the front of the cabinet. After the proper adjustments have been made, the circuit will apply the tests automatically in response to the actions of the maintenance man making the tests.

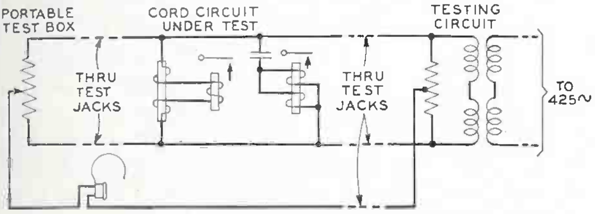


Fig. 2—Continuity of the cords is determined by an arrangement that makes them part of a Wheatstone bridge

Having set up the proper values of test current, the maintenance man starts down the front of the board to test the long array of cords. He first inserts the trunk end of a cord into the proper test jack whereupon the test circuit applies a current that should light the trunk supervisory lamp. Following this a flashing test is automatically applied. At the satisfactory completion of this test, the toll cord is inserted in the toll jack at the testing circuit and an alternating current is sent out by the test circuit which should light the toll supervisory lamp. The maintenance man then extinguishes this lamp by operating the listening key—not shown in Figure 1.

The values of test current sent out correspond in all cases to conditions more severe than will be expected in service so that the correct operation of the supervisory lamp shows that they will operate under all service conditions. Similarly the rate of flashing is the highest to which the lamps and d-c supervisory relays are supposed to respond. In some of the smaller offices the trunk supervisory relays are tested with a portable current-flow set, which is used also for other tests in the office. This allows a smaller investment in equipment reserved solely for the testing of cords. Under these conditions the flashing periods for operating the trunk supervisory relays are regulated manually but the application of current for operating the toll supervisory relays is controlled automatically but by a slightly less accurate and less expensive method than used in the larger offices.

The testing circuit, by proper bay settings, may be arranged to set automatically for either continuity or ringing key tests after the completion of

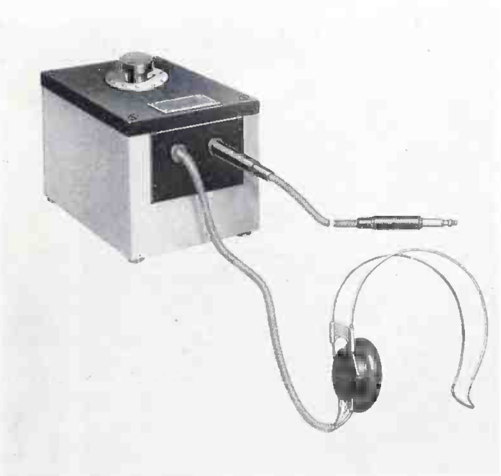


Fig. 3—Adjustments of the continuity bridge are made by a potentiometer in the portable test box. A head receiver serves as the detector

the supervisory relay tests. Continuity tests may be made independently of the others, however, if desired. Ringing key tests are made by operating each ringing key in succession, and the correct action of the key is indicated by the lighting of the toll supervisory lamp.

For the continuity test the portable test box is connected by a patching cord to the jack, as indicated in Figure 1. This completes a circuit through the cord circuit, which remains plugged up from the preceding test, as shown schematically in Figure 2. The test box, shown in Figure 3, contains a potentiometer which, with one side of a receiver connected to a movable contact, completes a Wheatstone bridge circuit. The potentiometer dial is moved till the 425 cycle tone in the receiver becomes a minimum. This will occur within a specified narrow range of the dial if the cord is in good condition. After this balance is obtained the cords are shaken, when any broken strands will make their presence known by changes in the volume of the tone heard.

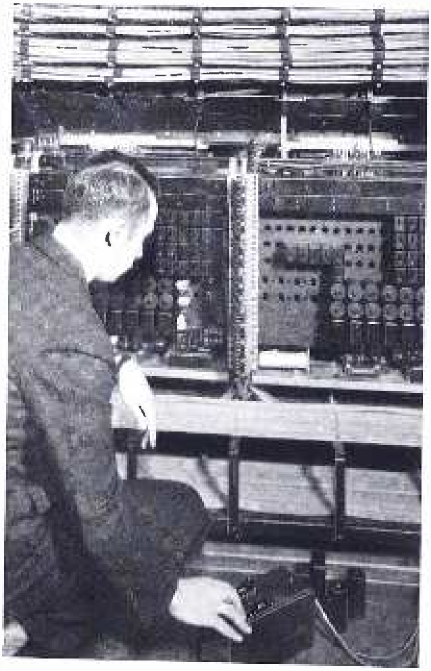


Fig. 4—Adjustments are made behind the board where the action of the relays may be watched

In making adjustments behind the board a portable control box is used as shown in Figure 4. The schematic arrangement of the circuit is given in Figure 5. To one of the test jacks connections are made from the cord fasteners of the circuit being adjusted, and into two other jacks are inserted the plugs from the control box. On the top of this box are keys for controlling the application of adjusting currents, and a lamp to indicate when the relays have operated. The proper current values for adjustment are first set up at the control cabinet as was done before the test procedure.

The adjusting currents may be applied either manually, under control of keys on the control box, or automatically under the guidance of the adjusting circuit. Manual application is usually employed first so that the test man may observe the action of the relays under single impulses of current. The automatic application is then used for a final check to insure that the relays will meet periods of operation somewhat more severe than expected in service. Adjustments in the smaller offices are made in a similar manner except that the direct-current test values are obtained from the current-flow set. The periods of operation are applied manually.

By means of a permanently mounted cabinet and two portable boxes, a maintenance man is thus able to test and adjust accurately a large number of cord circuits in a comparatively short time. The test and adjust values of current used all conform to those prescribed by the standard maintenance practices so that irregularities are found and corrected before they actually give trouble under operating conditions. Cords that test satisfactorily will thus operate under conditions more severe than will be met in actual service.

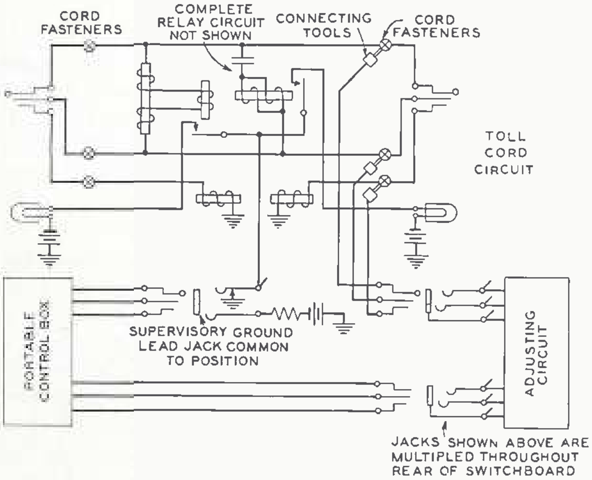


Fig. 5—Schematic arrangement of the adjusting circuit showing essential connections

Shielding for Electric Circuits

By JOHN G. FERGUSON
Telephone Apparatus Development

IN its simplest form a condenser consists of any two conductors separated by a dielectric. It follows, therefore, that since air is a dielectric any pair of neighboring conductors will act as a condenser, and current will flow from one to the other when a varying potential is impressed across them. In circuit design this capacity effect may be objectionable for two reasons. It makes the value of any impedance dependant on its surroundings, and also the stray current through the capacity may flow into other parts of the circuit, causing objectionable interference. Such stray capacities may be eliminated either by separating the various parts of the circuit sufficiently to reduce the effect to negligible proportions, which is usually impracticable, or by introducing a shield between the conductors. Although shielding eliminates the capacity that depends on position it introduces a capacity of its own which is of greater magnitude. This is partly because the shield is larger than the conductor but chiefly because being between the conductors it is nearer to both. Shielding, therefore, does not offer a simple and complete solution of the problem. Careful consideration must be given in each case to the effect of the capacity introduced, and a shielding scheme adopted which will give the best overall result.

Certain of the elementary principles involved can be illustrated by a few simple circuits. With the single impedance of Figure 1A, for example, there is a capacity from different parts of the conductor to other parts of the circuit and particularly to ground, as indicated by the dotted condensers. These capacities affect the impedance between terminals, and since they vary with the location of the impedance, the value of the impedance is variable, and is known only for the location in which it is measured. By placing a shield around the impedance and connecting it to one point of the circuit, as shown in Figure 1B, the capacity between impedance and the shield remains the same regardless of position, and as a result the value of the impedance is also independent of position. There remains a variable capacity between the shield and ground but this capacity is concentrated at the single point A and may be readily measured for any position and allowed for. If it is possible to ground the terminal A, all capacities that vary with position are avoided.

If the impedance of Figures 1-A and B is adjustable, the capacity to the shield will differ for each setting but a calibration may be made once and will hold regardless of the position of the impedance since the capacities to the shield do not vary with position. The same method of shielding may be applied to any number and arrangement of impedances provided there is only one control, since for any setting the value of the capacity to the shield will always be the same. If there is more than one method of adjustment, however, that is if two or more parts of the impedance can be varied independently, the adjustment of one part changes the effect of the shield on the other. With two impedances inside a single shield, as shown in Figure 1-C, the distributed capacity between CB and the shield is in parallel with the impedance AC through CB. If the value of CB is adjusted, therefore, the value of AC will vary because of the change in the overall impedance from CB to the shield.

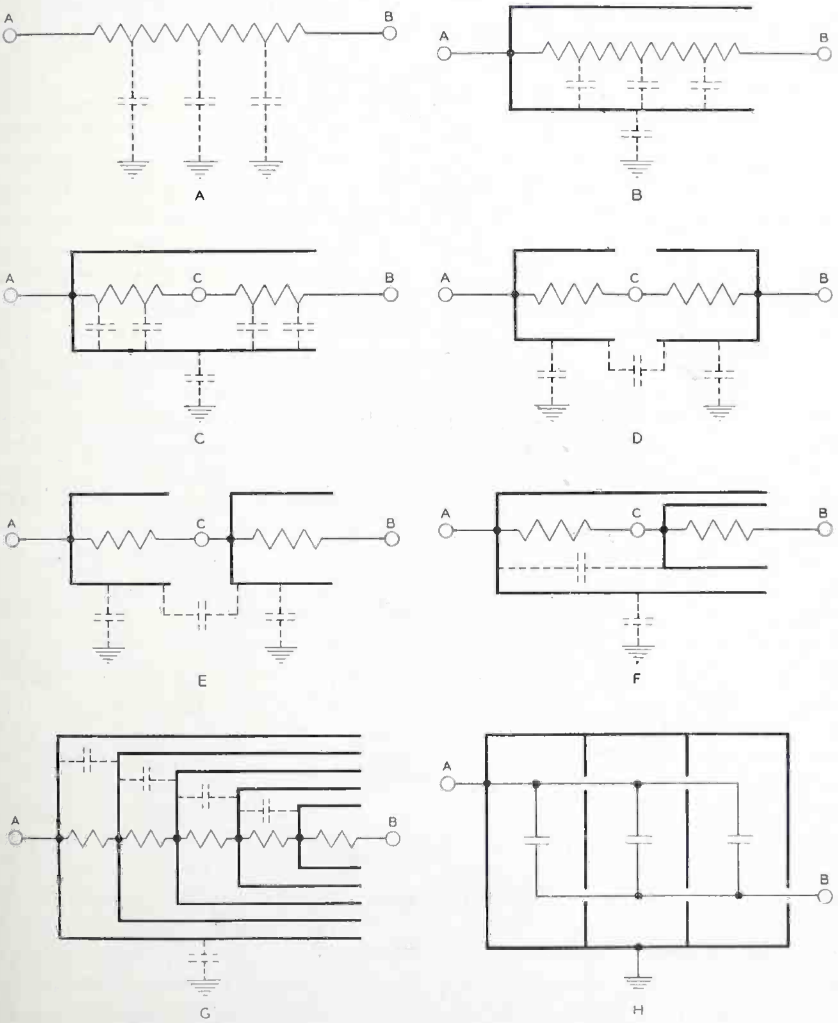


Fig. 1—*Various shielding arrangements for an impedance or a group of impedances connected in series or in parallel*

To avoid this condition, separate shields may be placed over each impedance, with that over AC connected to the point A, and that over CB to the point B, as shown in Figure 1-D. With this arrangement changes in the setting of either AC or CB may be made without affecting the other, but there will exist an additional capacity, that between the shields of AC and CB, which depends on position. This capacity is slightly more objectionable than capacity from shield to ground since while either A or B may be grounded, both points may not, so that there will always remain a capacity from one shield to ground which will vary with position.

An alternative arrangement of the shields for such a circuit is shown in Figure 1-E. The variable capacity between shields remains, but it is across one impedance only. If now the shield connected to A were extended to include the other, as shown in Figure 1-F, the only capacity that varies with position is that from the outer shield to ground. If the outer shield is grounded there will be no capacities that vary with position. The extent to which the capacity between shields is objectionable depends on the form of the impedance between A and C. If it is a capacity, that across the shields is merely an addition to it and is not objectionable. If it is a resistance, however, the capacity between shields increases its phase angle, while if it is an inductance the shield capacity increases the variation of inductance and effective resistance with frequency. The principle may be extended to include any number of variable series impedances, the effect being to place a capacity across all but one and to enclose the whole in an outer shield. Such a system for five elements is shown in Figure 1-G.

The shielding of variable parallel impedances is comparatively simple since each or any number may be shielded individually and all the shielding connected to the same point. This may be reduced to the form of a single shield with partitions to separate the individual elements from one another. Figure 1-H indicates the arrangement for three capacities in parallel. By a combination of these two methods it is possible to shield any combination of series or parallel impedances so that all capacities from the shielded elements to external conductors will be concentrated at junction points or terminals, one of which,

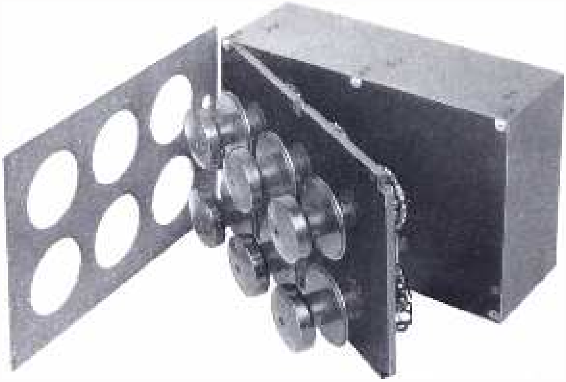


Fig. 2—A typical six-dial resistance with only a single outer shield surrounding it

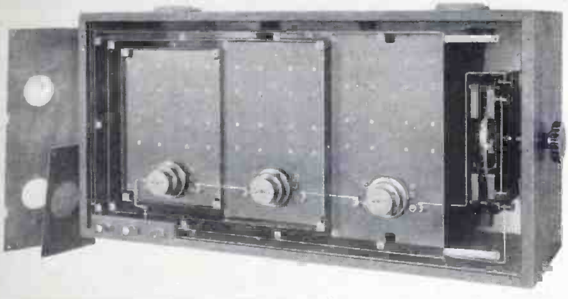


Fig. 3—Nested shielding applied to three inductance dials

and only one, may be grounded. The determination of which terminals the various shields should be connected to, and the terminal that should be grounded, depends on various conditions and no general rules can be given.

With the above procedure it is possible to make the impedances independent both of position and of each other. It must be remembered, however, that troublesome capacities have not been eliminated. Fixed capacities have been substituted for variable ones but in general they are larger, and if the substitution is at too great a price in the way of an increased total capacity, the improvement may be questionable. In practice it is necessary to consider each case individually for the best results.

One of the most important capacities that varies with position is that between a unit and the operator's hand that may be moving the dial to adjust it. In a resistance box, for example, the first requirement, therefore, is that the whole group of units be enclosed in a shield that completely covers the top so that there will be no variable capacity between the hand and the various resistances. If there is only this one outer shield, there will still be variable capacities between resistances which will vary with the settings of the dials. Although nested shields, as shown in Figure 1-G, would eliminate these variable capacities, in many cases the high additional capacities they introduced would be more objectionable than the capacities between resistances, which are generally negligibly small except for high-resistance units. For most cases even the highest resistance units do not need individual shields. A typical resistance box with only an outer shield is shown in Figure 2.

With adjustable inductances the size of the coils is usually much greater than with resistances, so that individual shielding is more important. Because of the difficulty of bringing the various dials through a series of suc-

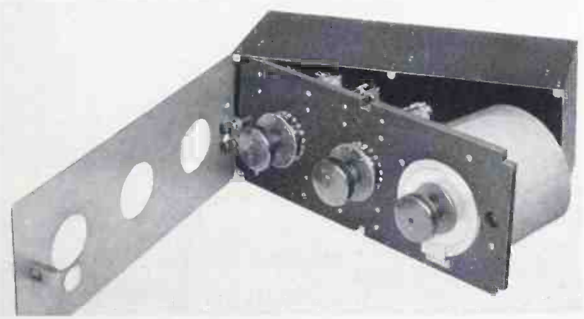


Fig. 4—A three-dial capacity standard with an outer shield, and an inner shield around the smallest unit only

cessive shields, however, and of the large size of the units, three dials represents about the maximum number that can be shielded in this way. Figure 3 shows a typical example of such an arrangement, since only three of the four elements are nested.

Shielding is usually simplified with condensers because they are connected in parallel. Such a connection seems as a rule to confine all stray capacities to the terminals of the condensers. A shielded capacity standard, with two dials of mica condensers and a variable air condenser, is shown in Figure 4. Since the dials are connected in parallel only a single shield is required. It is not necessary, experience has shown, to place shields around the individual dials of mica condensers since the capacity between them is small compared to the value of their smallest unit. Because the capacity of the air condenser is smaller than that of the mica condensers, however, it is enclosed in an individual shield.

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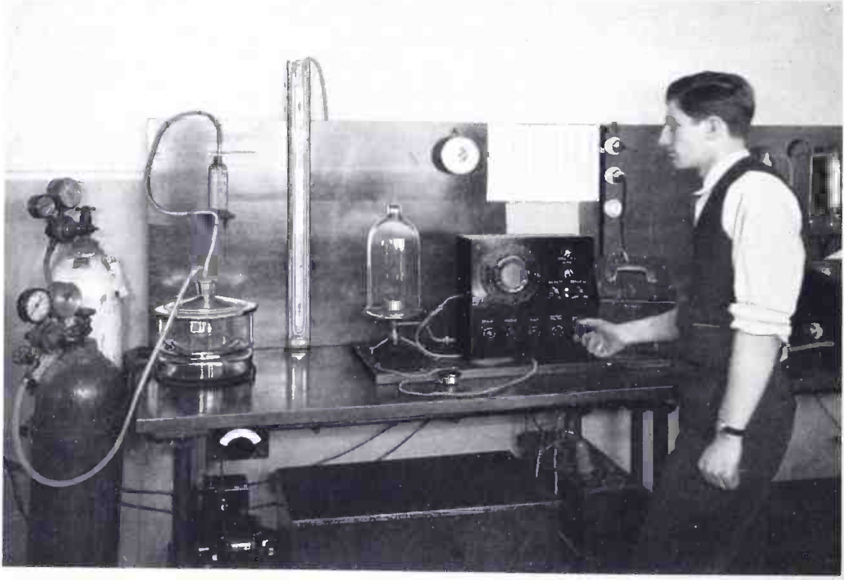

R. Zimmerman of the Research Department is here filling a condenser microphone with nitrogen. The completely assembled microphone is placed under a bell jar, shown in the center of the picture, and after the air is exhausted, nitrogen is introduced at atmospheric pressure to prevent possible oxidation of the inner parts and consequent reduction in pressure

Squares and Rectangles

By H. F. DODGE

Inspection Engineering

WHICH of the three rectangles in Figure 1 do you prefer? Try to make your choice as abstractly as possible, regarding each rectangle simply as a shape. You probably will choose C. Most people do. If you choose the square A, or the rectangle B with its sides in the ratio of 1:2, it is perfectly all right. You may just be an exception. One of these more extreme shapes may better satisfy your own individual temperament.

Now refer to Figure 2, and again pick out the rectangle that you prefer. This is probably somewhat more difficult as the differences here are not so clearly marked. If a large number of persons were to state their preferences, however, rectangle D would probably prove to be slightly more popular than E or F. Rectangle D is the "golden" rectangle, with sides in the proportion of .618:1, E has sides in the ratio of .570:1 and F has proportions of .667:1 or 2:3.

Just what is it that determines the best proportions of any simple figure, the best arrangement and proportions of the objects in a painting, or the most pleasing design of a piece of telephone apparatus? There will rarely be a perfect agreement among several individuals in the answers that they will give to any one of these questions. Tastes and preferences differ, often widely. But there are certain fundamental principles underlying this general type of problem, and what is "best" can only be determined from the opinions of those who are competent to pass judgment on the object in question.

In connection with a recent study relating to standard conventions in graphical presentation, the problem arose as to what might be considered the best proportions for a graphical chart. Most charts are rectangular in shape. Some are prepared for conference display purposes or for lantern slides and tend to be regarded as simple shapes. Many are prepared for purposes of reproduction in scientific magazines or texts and are therefore associated with a panel of printed

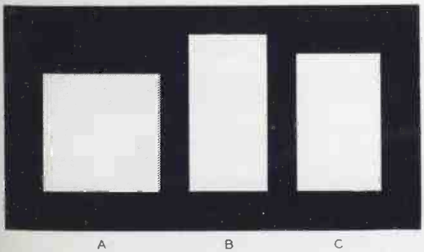

Fig. 1—Which shape do you like best?

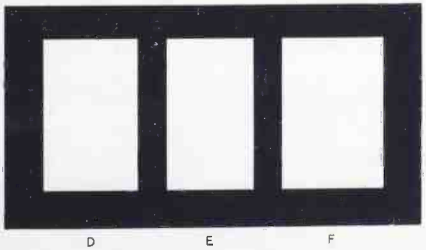

Fig. 2—What is your preference here?

matter with which they should be related if possible in some way to give the appearance of page unity. In either case there are a number of interesting considerations that may throw some light on just why some proportions are more pleasing and stimulating than others.

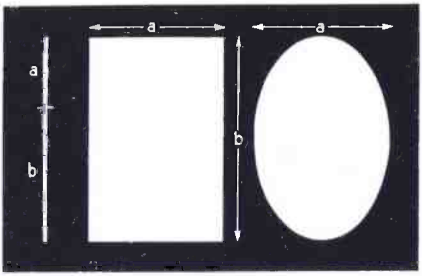

Fig. 3—Showing the proportions of the golden section

Searching through the history of art, one is impressed with the frequent reference to the so-called "golden section" wherever form and proportion are discussed. Fundamentally, the "golden section" is nothing more or less than the division of a thing into two parts (a) and (b), such that a/b = b/ (a + b) ; that is, the ratio of the smaller part to the larger is the same as the ratio of the larger to the whole, numerically .618/1.00. Whether applied to the sub-division of a line or to the proportion of simple geometrical shapes as shown in Figure 3, this ratio in days gone by, when the significance of numbers was regarded with awe and superstition was believed by many to possess attributes of the divine, to be the fundamental basis of natural beauty.

Today we are probably nearer the truth when we approach the problem from the standpoint of psychology. Some of the earliest attempts to discover æsthetic principles by scientifically controlled experimental methods were made by the German physicist Fechner in the latter part of the nineteenth century. In one of his experiments he laid upon a black background twelve white rectangular cards having the range of proportions shown in Figure 4, including one with the proportions of the golden section and also a square. About 350 men and women were asked to choose that which appeared to have the most pleasing proportions. They were asked to make their selections as abstractly as possible, and to free their minds so far as possible from all associations whatsoever. A number of the observers were not able to choose any one shape as best but could narrow down their preference to two, or in some instances to three, of the rectangles in the group. In such cases, the chosen rectangles were accorded a half vote or a third vote.

The results of the experiment are indicated in Figure 5. It shows that the golden rectangle was preferred in about 35 per cent of the cases. This in itself does not lend any prestige to the exact mathematical ratio of .618,

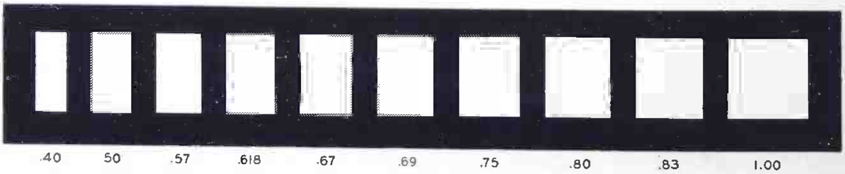

Fig. 4—Rectangles used by Fechner to determine the most pleasing proportions

for the wide spread of preferences would indicate that had he used a rectangle with sides in the ratio of 3:5 (.600) or 5:8 (.625) in place of the golden rectangle (.618) the 3:5 or 5:8 shape would undoubtedly show about the same pre-eminence. The important point brought out by this experiment is that the representation of measurements based on æsthetic judgments of many individuals is of the nature of a statistical distribution. Regardless of what proportions Fechner had used for his rectangles, the results would have been substantially the same.

Assuming that the data were good data, that the conditions under which they were obtained were well controlled—assumptions which appear well justified—the important information is lodged in the distribution curve that was obtained, in the average value and in the value of standard deviation or spreading out of the individual observations about that average. The observed average*, .621, may be taken as an estimate of the true "best" proportion. With a possible error in the observed average of as much as ±.011 for a sample of 350 observations, such as were taken by Fechner, these results give evidence that the best proportion lies somewhere in the range of .610 to .632.

From the standpoint of convenience in design and architecture, there is practical value in using the exact proportions of the golden section in many cases, but from the æsthetic point of view, mathematical accuracy is of no great importance. Human preferences are not so exacting. It does appear definitely true, however, that most people prefer an asymmetrical figure to a purely symmetrical one. A square with its perfect symmetry is almost always uninspiring and often disagreeable. The usual demand is for greater variety, for something that will awaken interest. The amount of variety in a rectangle that is considered pleasing depends upon the individual's grade of intelligence, his experience and his tastes. Just why we desire a proportion approximating the golden section is somewhat speculative. Psychologists speak of the pleasure derived from adjustment of the human organism to meet complex situations. In line with this thought, Langfeld, author of "The Aesthetic Attitude", believes that the "complexity or inequality represented by the golden section taxes the adjustment of the ordinary organism to its limit."

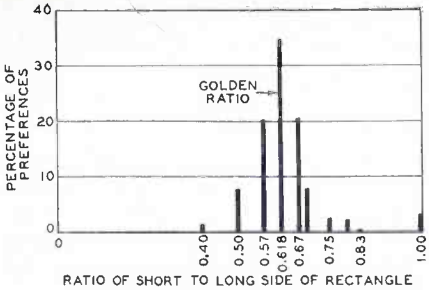

Fig. 5—Results of Fechner's experiments to determine the most pleasing proportions of a rectangle

If we add content to a rectangle, as we do when plotting curves in a rectangular graphical chart, the problem is made somewhat more complex. We are no longer regarding the rectangle simply as a shape. If, for example, we draw a vertical or a hori-

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* *There is good reason to believe that the observations do not represent a single homogeneous universe, but rather two distinct subgroups of individuals; those preferring asymmetry and those preferring the symmetry of the square. The average for the first group was* .621, *and for both groups combined was* .632.

zontal line inside a rectangle as in Figure 6, the effect is to change the apparent proportions of the rectangle. This would tend to dictate a different ratio of height to length than one would choose otherwise. Generally speaking, however, the content of a graphical chart does not exert an influence so strong as to modify materially what might be considered the best proportions.

The best proportions for a graphical chart reproduced on a printed page, as in a technical book or magazine, depend also to some extent on the shape of the page and of the panel of printed matter. In this connection, measurements were made of the proportions used in a hundred scientific text books selected at random from the shelves of the technical library in Bell Telephone Laboratories. The results were as shown in Figure 7. The point of interest is that the panel of printed matter, with which illustrative figures or charts are closely associated from the standpoint of layout and page design, has in general a proportion that approximates the golden section. It would be unsound, however, to recommend too strongly any particular proportion or any rule to be followed in preparing illustrations for publication because factors relating to the utility of the chart, such as a choice of scales that will most effectively display some relationship curve, may be vastly more important than the design or appearance of the printed page. The overall appearance of a page is, of course, affected by additional factors such as the size of the chart, style of printed type used, the position of the chart or charts on the page and the impression of stability or instability that may be created by resting a rectangle on its longer side or by standing it on end. While we rarely are conscious of these things when studying a text, they do nevertheless create a background which has an effect, often appreciable, on our mental attitude during the reading process.

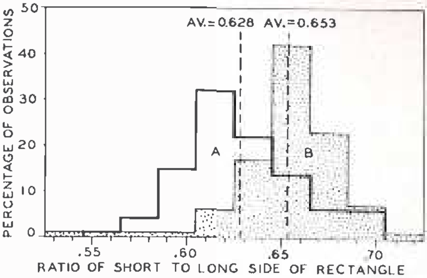

Fig. 7—Measurements of proportions of (A) typed area, and (B) page of 100 *scientific text books*

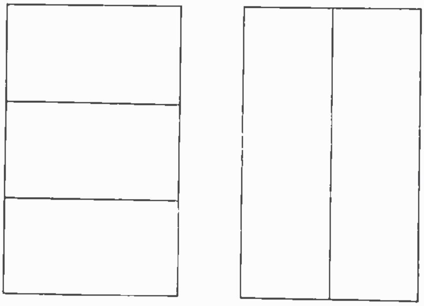

Fig. 6—The apparent shape of a rectangle is affected by its content

The Golden Section

By MARION M. DILTS
Inspection Engineering

IN looking around, do you sometimes notice that you lose a sense of details and find instead a general impression of simple geometric patterns and proportions? Whether the object is a house, an engineering graph or a radio set, this general impression bears a subtle influence on our liking or disliking it. For this reason pleasing proportions are a primal consideration in design, and a relation of length to width which guarantees satisfaction is a valuable tool for any designer, be he architect, draftsman or cabinet maker.

Such a relation is the Golden Section mentioned in the preceding paper. It is a proportion with a long and curious history. As an architectural rule-of-thumb the Golden Section has been construed to be identical with the Sacred Quotient, Seqt., which a papyrus in the British Museum records was used in building the earliest pyramid in 4750 B. C. Contemporary artists have found it oft-repeated in their measurements of the Parthenon and classical Greek sculpture.

As a mathematical concept the Golden Section appeared in Euclid's Elements. It is a proportion in which the smaller part is to the greater as the greater is to the whole (numerically equal to $\frac{0.618+}{1}$). Fra Luca Paccioli in the first noteworthy mathematical treatise after Euclid's named this the "Divine Proportion." "Like God," he says, "it has a peculiar and unique unity; its component parts ally it with the Holy Trinity; as God cannot be defined by words neither can this proportion by numbers, for it is an irrational; like God it is all in all, and all in every part."

It was not, however, until about 1850, when Zeising became acquainted with Paccioli's book, that the empirical rule for achieving beautiful proportions and the mathematical formula were correlated. In a great flare of enthusiasm measurements were taken in all realms of Art and Nature which seemed to point to the Golden Section as a fundamental principle underlying all creations of beauty. The London Royal Botanical Society found the Golden Section expressed in the arrangement of seeds, buds and leaves of many plants, and critics found it "in every intersection of Titian's 'Assumption'", in

This familiar view of a handset conforms in outline to a Golden Section ellipse in which $A:B = 0.618 +$

Raphael's "Madonna of the Cradle" and other works by Hals, Botticelli and Turner.

A modern French writer says that Leonardo da Vinci and most other artists and scholars of the Renaissance thought the Golden Section to give an impression of linear harmony and equilibrium in inequality more satisfying than that produced by any other combination.

Whether the use of the Golden Section by many generations of distinguished artists has been intuitive or reasoned, their success recommends it as a practical aid to less inspired craftsmen, a rule not to be followed slavishly, but used wherever it is consistent with the functional and dynamic elements of the design.

The Golden Section is helpful in a surprising number of problems. It may be applied to the spacing of lines on a page and to the subdivision of lines as well as areas. It is as effective in the proportions of ovals and ellipses as it is in rectangles. The accompanying picture shows a handset circumscribed by a Golden Section ellipse.

Probably the Golden Section's secret of success lies in the fact that it provides an interesting variety in dimensions together with an effect of unity and balance.

Contributors to this Issue

A. A. Oswald received from Armour Institute of Technology the B.S. degree in 1916 and the E.E. degree in 1927. With the Laboratories since 1916 he has been continuously engaged in its successive radio projects. He took part in the development of long-wave transatlantic telephony, and was at Montauk for the early transmission experiments. During the World War he had charge of the field-testing of airplane-telephones for the Signal Corps, and devised a method of radio-control for airplanes in flight. From 1919 to 1922 he assisted in the development of ship-to-shore communication. Since then he has been concerned with the long-wave and short-wave transoceanic systems.

C. R. Moore graduated from Purdue University in 1907, receiving the degrees of B.S. in both mechanical and electrical engineering. He then became assistant instructor in the Electrical Department and the following year was made instructor. In 1910 he received a master's degree in electrical engineering and became Assistant Professor in Electrical Engineering. He later did research work leading to an M.S. degree at the University of Illinois but in 1916, before quite finishing, left to join the Engineering Department of the Western Electric Company. Here he was in charge of transmitter development and during the war directed the work on submarine detecting devices and other undertakings of a similar nature. Subsequent to the war he was in charge of the development of the hand-set transmitter and also of the construction of two types of harmonic analyzers. He recently transferred to the Outside Plant Department where he is in charge of tool development. He has some thirty-five patents and applications to his credit since joining the Laboratories among which are those covering the barrier and H-type microphones.

E. R. Smith began his telephone experience with the Western Electric Company in 1902. After 17 years in telephone operating and manufacturing companies he joined the Systems Development organization at West Street. In the Toll Systems department he has participated in toll circuit development and is now in charge of the Toll Circuit Testing Laboratory.

C. B. Aiken received a B.S. degree from Tulane University in 1923. He then went to Harvard and received an M.S. in Electrical Communication Engineering in 1924, and a


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M.A. in Physics the following year. After two years with Mason, Slichter and Hay of Madison, Wisconsin, engaged in geophysical exploration, he joined the Laboratories in 1928. Here he was occupied with work on aircraft radio receivers and special measuring equipment. In 1930 he was made supervisor in charge of broadcast radio-receiver development, which position he now holds.

T. Slonczewski received a B.S. in E.E. degree from the Cooper Union Institute of Technology in 1926 and immediately joined the Technical Staff of the Laboratories. With the Electrical Measurements Group he was first associated with the development of alternating current bridges, but more recently has been concerned with the development of vacuum tube circuits. Since joining the Laboratories he has continued his studies at Columbia University, where he has taken graduate work in physics.

J. G. Ferguson received the B.S. degree in electrical engineering from the University of California in 1915. After spending the following year there as Research Assistant, he received the M.S. degree in Physics in 1916 and immediately joined the engineering department of the Western Electric Company, now incorporated as Bell Telephone Laboratories. Here he was engaged in the development of condensers and of methods of measuring capacity. Later, this work was extended to the general development of methods of electrical measurement, and at present he is in charge of the electrical measurement group in the General Development Laboratory.

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C. B. Aiken

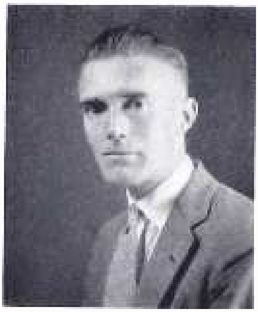

T. Slonczewski


J. G. Ferguson

phone Laboratories 1925. Mr. Dodge was earlier associated with the Research Department in the development of telephone instruments and allied products. The sound ranging microphone used by the Signal Corps and the electrical stethoscope are some of the developments with which he was identified. He entered the Inspection Engineering Department in 1924 and has been for some time in charge of the Methods and Results work. His interests center on the applications of statistical methods to inspection procedure planning, to the analysis of data, and to the evaluation of quality of apparatus and equipment entering the telephone plant. An allied field of statistical method to which Mr. Dodge has contributed is that of effective graphical presentation of data. In this connection, he has been identified with the activities of the A.S.M.E. in its work on graphical standardization. An aspect of this study is dealt with by Mr. Dodge and Miss M. M. Dilts in their articles in the present issue.

Miss Marion May Dilts entered the Laboratories shortly after her graduation from Wellesley in 1924. At first associated with the Complaint Department, she subsequently transferred as a member of the Technical Staff to mathematical and statistical work with the Inspection Engineering Department. Her work here related to analysis of quality inspection data for telephone apparatus.

On a leave of absence in 1929-30, she visited the Orient and Europe, where she observed the extent to which statistical methods were being applied to the various problems of inspection in the larger telephone manufacturing plants. As a part of a wider field in the development of statistical methods, Miss Dilts extensively studied appearance factors and layouts for graphical presentations.



H. F. Dodge

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