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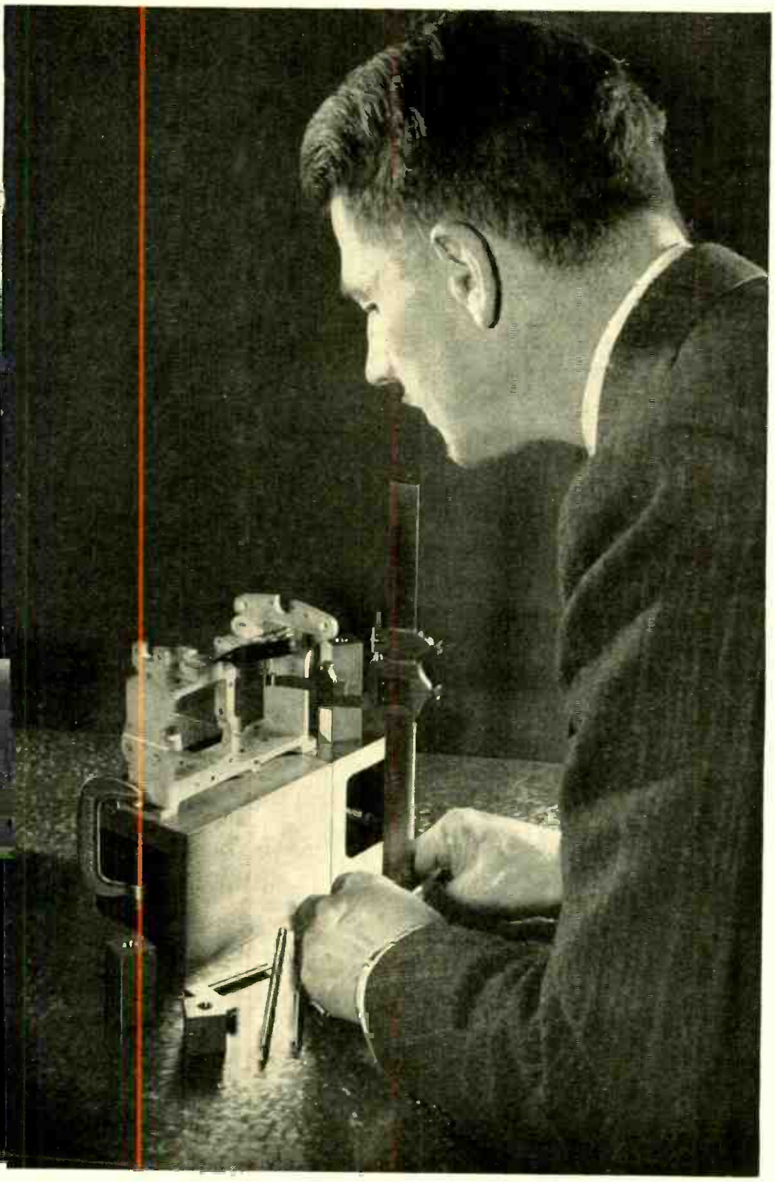

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Gauging machine switching parts

Applications of Junction Line Filters

By F. A. HINSHAW
Transmission Development Department

WHERE open-wire lines are brought into repeater stations or toll offices located in densely populated areas, the open-wire lines are terminated at the outskirts of the area, and the circuits are brought to the office through cables. These cables are usually loaded so as to provide a better impedance match between the open-wire line and the cable and to reduce the loss in the cable. For voice-frequency circuits, loading is required at about 6000-foot intervals. Where type-C carrier channels are operated on the open-wire lines, the situation is more difficult, because loading for the type-C range must be spaced at about 800-foot intervals. The creation of so many loading points is expensive, and becomes particularly so when long entrance or intermediate cables are to be loaded.

The type of loading commonly used for voice-frequency circuits on entrance cables has a cut-off around 7000 cycles, and thus will not transmit carrier frequencies. Sufficient gain margins are frequently available in the carrier amplifiers to permit the use of non-loaded cable pairs for the carrier circuits, but non-loaded pairs usually would not be satisfactory for voice circuits because of the increased loss, and because the impedance irregularity at the junction of open-wire line and cable would decrease the balance at the hybrid coil of the voice repeater, and would thus reduce the effective gain. By separating the carrier and voice circuits at the terminal pole, however, non-loaded cable pairs can be used for the carrier circuits and voice-loaded pairs for the voice circuits, thus reducing the expense of loading with the longer cables.

At repeater stations and terminals the separation of the carrier and voice circuits is ordinarily accomplished by filters at the office end of the cable, by an arrangement indicated in Figure 1. A composite set E is connected to the circuit on the cable side of the filters

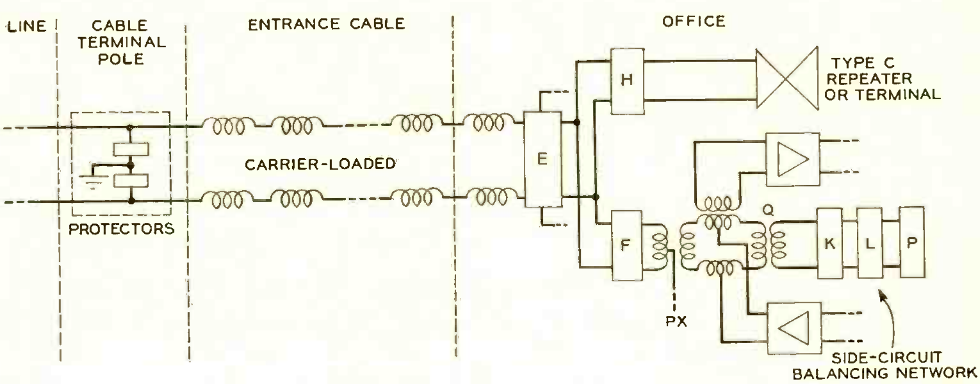


Fig. 1—Normal method for separating carrier and voice circuits

to take off the composited telegraph signals. Each composited telegraph circuit consists of one wire of the pair and a ground return, and if the composite set were connected at the office side of the filter, the capacitances and inductances of the filter would provide interference paths between the two telegraph circuits that would be undesirable except under certain limited conditions. To use the office filters to separate the carrier and voice circuits at the terminal pole, and thus to avoid the necessity of carrier loading, is not feasible for a number of reasons. In the first place the composite telegraph circuits could not in general be retained for the reasons already mentioned. The modulation in the filters might also be increased by the presence of the d-c telegraph currents in the coils. In addition, the component elements of the filters are not designed to withstand the changes in weather and temperature that they would be subjected to at a pole installation. Moreover, difficulties would be encountered in obtaining a suitable balance at the voice repeater because of the imperfect impedance match of filter and cable, and of the length of cable between filter and repeater, which would be different for each installation.

These difficulties have been overcome by the development of the junction line filter and its associated networks. In brief, the arrangement consists of a simple high-pass and low-pass filter at the terminal pole to separate the carrier from the voice signals. To keep to a minimum the amount of apparatus required at this exposed location, the loss in the attenuating regions of the filter is made only great enough to insure separation of the two frequency ranges without loss in signal power. The additional loss needed to provide the required singing margin around the loops formed by the voice and carrier amplifiers is provided by the regular carrier line filters in the office. By the use of these junction filters, carrier loading of the longer entrance cable is made unnecessary; the voice frequencies are brought in over a voice-loaded pair, and the carrier frequencies, over a non-loaded pair. Certain additional equipment is also required.

An impedance matching network c, on the cable side of the high-pass filter B, corrects the impedance mismatch that would otherwise exist at carrier frequencies between the filter and non-loaded cable pair. At the office end of the carrier pair a transformer network D is required to transform the

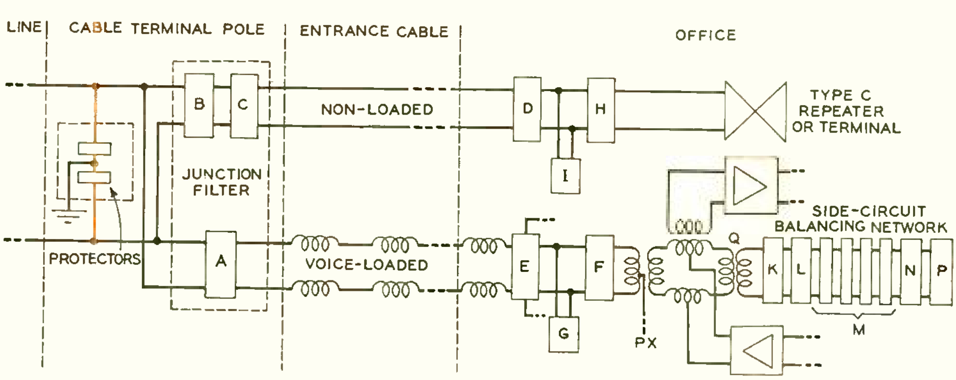


Fig. 2—By use of the junction line filter, carrier loading is avoided

relatively low impedance of the non-loaded cable pair to the 600-ohm office impedance. Since with this arrangement the office filters F and H are no longer connected in parallel, compensating networks G and I are required to simulate the impedance effect of one filter on the other. The composite set is kept in its original position since with the single-section junction filters the internal couplings are not great enough materially to affect telegraph transmission, and modulation is avoided by using air-core coils.

The insertion of the filter at the terminal pole, however, introduces an impedance irregularity in the voice-frequency pair and upsets the balance at the hybrid coil. To maintain a suitable balance, therefore, the effect of the filter and the length of cable must be duplicated in the balancing network. Where loaded entrance cable is connected directly to the open-wire line, the balancing network includes a section K to simulate the low-pass filter, a section L to simulate the composite set, and a two-terminal network P to simulate the impedance of the open-wire line or loaded entrance cable, as indicated in Figure 1. Where the junction line filter is employed,

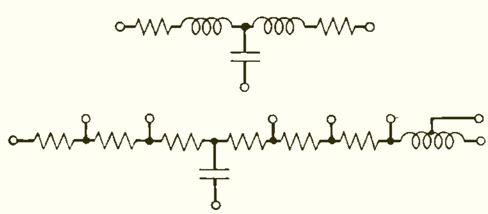


Fig. 3—Cable simulating networks

however, the network must include other elements to simulate both the filter and the particular length of entrance cable involved.

To provide for simulating the transmission characteristics of the entrance cable, which may be of different length for each installation, a series of cable-simulating units has been provided. A loading section for voice cable is about 6000 feet long, and in general an entrance cable will comprise some integral number of sections plus a terminal-pole section and an office or fractional section. Three types of simulating networks have been developed, and with a suitable combination of them and a suitable amount of building-out, any length of entrance cable can be simulated. One section of 16-gauge non-loaded cable can be simulated by the simple network shown in the upper part of Figure 3. The equivalent of one "loading section" of loaded entrance cable is obtained by adding a loading coil to this network. The inductance in the cable network can be combined with the inductance of the loading coil to form the network as shown in the lower part of Figure 3. To provide for duplicating the characteristics of 13-, 16-, or 19-gauge cable, taps are provided on the series resistances. To provide for the two weights of loading most commonly used, the coil is tapped to provide two values of inductance.

Terminal sections are built up in a similar manner to simulate the characteristics of the terminal section. Two forms of this terminal-section network are provided: one for fractional-coil terminations and one for fractional-section terminations. A network is also provided to simulate the fractional-office section, which varies widely in length for different installations. Adjustment is secured by adjustable series resistances and shunt condensers. The complete forms of these three types of simulating networks are shown in Figure 4. By using an office network, one of the two terminal-pole networks, and the required number of full-section networks, and building-out sections, any length of entrance cable may be simulated, of either 13-, 16-, or 19-gauge pairs and with H-31-18 or H-28-16 loading. These simulating networks are indicated at M in Figure 2, and to the right of them is connected the network N that simulates the junction filter. The balancing network is then completed by the network P that simulates the impedance of the open-wire line.

The development of this junction line filter and its associated networks was undertaken primarily for the type-C carrier system. It was realized, however, that such a method would be very helpful in certain situations where type-J carrier channels occupied the frequency space above the C carrier on some of the pairs. This possible use was kept in mind during the development, with the result that the junction line filter can be used in some cases where J-carrier circuits are present by adding the J-carrier line filter between D and H of Figure 2.

These junction filter sets have a nominal impedance of 600 ohms, and when associated with a 12-inch, 165-mil line, and terminated in an H-31-18 or H-28-16 loaded voice-entrance cable and a 16-gauge non-loaded carrier-entrance pair, they present on the line side about six per cent reflection coefficient in the type-C carrier range, and about three per cent in the type-J carrier range. The return loss over the voice range for these conditions is better than 20 db, and the loss in the transmitting range in the voice-frequency branch is approximately .05 db. In the carrier branch, the loss in the transmitting range varies from about 5 db at 6 kc to 2 db at 30 kc. When added to the loss in from three to four miles of non-loaded entrance cable, this results in a flat loss of about 8 db over the type-C range.

These filter sets are available in either of two types. One is used for installations having message circuits

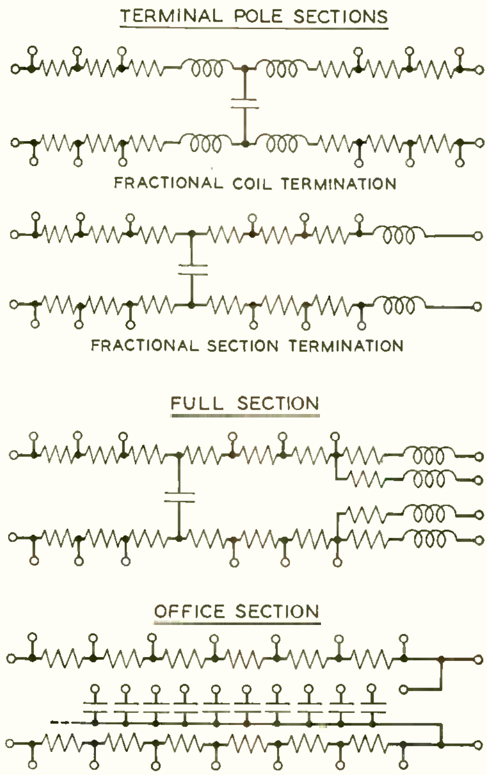


Fig. 4—Three types of networks

and type-CN carrier allocations,* and is known as the 3-kc filter set. The other is used where either program or message circuits are associated with CS, CT, or CU carrier allocations, and is known as the 5-kc filter set. Since it is generally necessary to preserve the phantom circuit, both side circuits must be equipped with junction filters, and additional networks must be provided for the phantom balancing networks. The design and appearance of the filter sets themselves are described in an accompanying article.

*RECORD, *Aug.*, 1940, *p.* 354.

The Junction Line Filter

By J. O. ISRAEL
Transmission Networks Development

AS DISCUSSED in the preceding article, the junction line filter is designed to mount at a terminal pole of an open-wire line to separate the carrier from the voice currents before passing them through cable pairs to a repeater station or terminal office. Because of the undesirable capacitance of long interconnecting leads, it is desirable to mount these junction filters as close as possible to the ends of the open-wire circuits. For this reason, the filter was arranged to fasten on the crossarm directly beneath the insulators that are used for terminating the circuit to which it is connected.

A terminal installation is shown in the photograph at the head of this article. Such a location places a number of severe requirements on the filter. Size and weight, for example, become of particular importance; and the wide range in temperature and weather conditions to which their position exposes them requires a radical departure from the more usual filter construction.

Since four junction filters may be required on one crossarm, the length of the filter is limited to about twenty inches, and the depth must be restricted so as to give ample clearance between the filter and the wires on the arm beneath it. Double crossarms are usually employed on these terminal poles, and a width of as much as fifteen inches is permissible. Most of the available space is occupied by the filter which is 20 by 14½ by 7½ inches in size, and weighs 85 pounds. The greater part of this weight is due to the sheet-steel case, which is needed for mechanical protection. Although reasonably tight, the case does not provide adequate protection against humidity, and the filter and impedance network are, therefore, enclosed in two hermetically sealed copper containers.

A filter used in a heated building need withstand only a limited range of temperature, but for a pole installation, the design must provide for temperatures over a much more extended range; −40 degrees and 150 degrees Fahrenheit were taken as the limits for the junction line filter. The air core coils ordinarily used for carrier line filters are satisfactory, but condensers

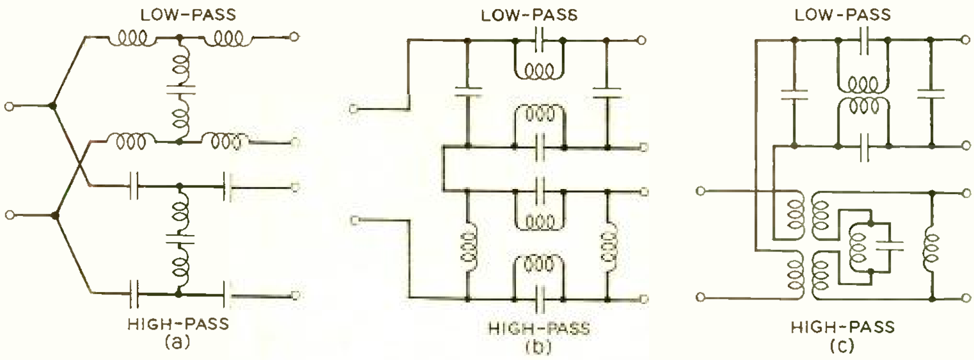


Fig. 1—*Transformation from balanced parallel operation to balanced series operation*

had to be selected that would have satisfactory characteristics over this wide temperature range, and also would have sufficient dielectric strength to withstand the high voltages that may occasionally be impressed on the filter as a result of lightning or power-line disturbances.

As already noted, the principal duty of the junction filter is to separate carrier and voice currents. This separation can be accomplished by two single-section filters, a low-pass and a high-pass. As soon as these filters are introduced into the line, however, several other factors become important, the most outstanding of which are longitudinal balance, reflection coefficient, and modulation.

A schematic of a pair of single-section line filters is shown in Figure 1a, with the customary parallel connection of the two filters. These filters are shown in balanced form, which is necessary so that longitudinal currents will have identical paths on the two sides of each filter. If one of the series condensers in the high-pass filter should differ from the condenser on the opposite side by even as little as a quarter of one per cent, a difference in longitudinal voltage between the two sides would be created which would cause noise. In addition to using nearly identical elements on the two sides of a balanced filter, it is also necessary to have physical symmetry, so that parasitic capacities of

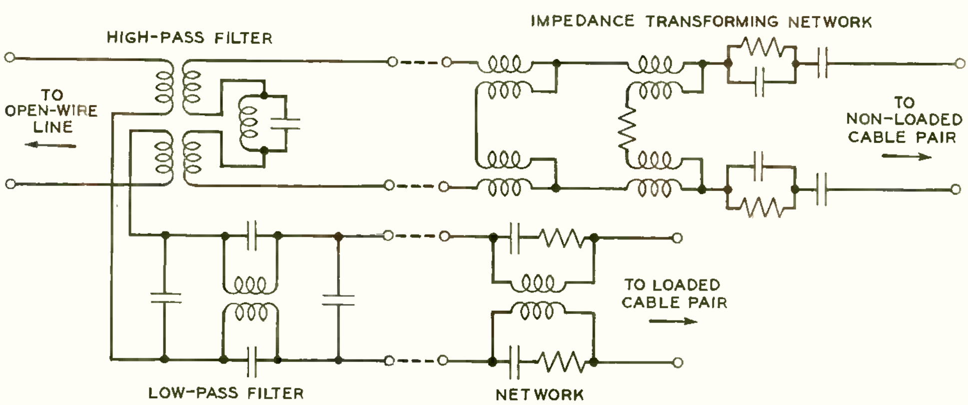


Fig. 2—*Simplified schematic of junction filters and networks for* 16-*gauge cable* the elements to ground shall be equal. Since it was impracticable to secure condensers which could maintain such a high degree of balance over a wide temperature range, it was necessary to modify the filters to avoid having condensers appear in the series branches.

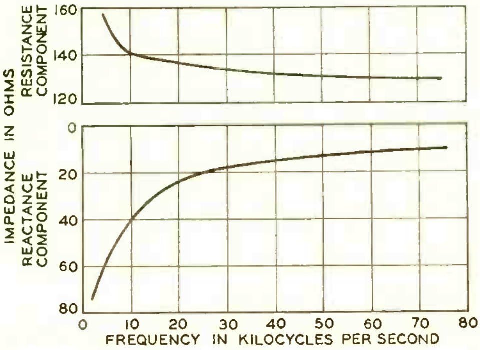


Fig. 3—Resistance and reactance components of the impedance of a 16-gauge non-loaded cable pair

The first modification is shown in Figure 1b. The inverse form of the filters is used, requiring series operation instead of parallel. Next, the end coil of the high-pass filter is made in the form of a balanced repeating coil, as shown in Figure 1c. With such a coil, the series low-pass filter can be placed at the midpoint of the primary side, and the opposite series branches of the high-pass filter can be combined and placed at the center of the secondary side without fundamentally altering the performance of the filters in any electrical characteristics except balance. In this form, the high-pass filter has no series elements to require balancing, and in fact contains only a single condenser. Although the low-pass filter still contains series condensers, these need not have a high degree of balance since each is shunted by one winding of a coil having high coupling between the windings.

The junction filters are designed for a 600-ohm line, and each filter must be terminated in 600 ohms to obtain a good impedance (low reflection coefficient) at the line end. The low-pass filter is terminated by loaded cable, which gives approximately 600 ohms over the voice frequency range. Above this range, the cable impedance does not provide a satisfactory termination for the filter, and a small network is added, between the low-pass filter and the loaded cable, as shown in Figure 2, to improve this impedance. The non-loaded cable, which terminates the high-pass filter, presents an impedance which is variable with frequency and which has a large reactive component, as shown on Figure 3. In joining such a complex impedance to a pure 600-ohm impedance by means of a transformer or a transducer, both of which are theoretically non-dissipative, the lowest reflection coefficient that can be obtained for both directions of transmission is shown on the upper curve of Figure 4 for a 16-gauge

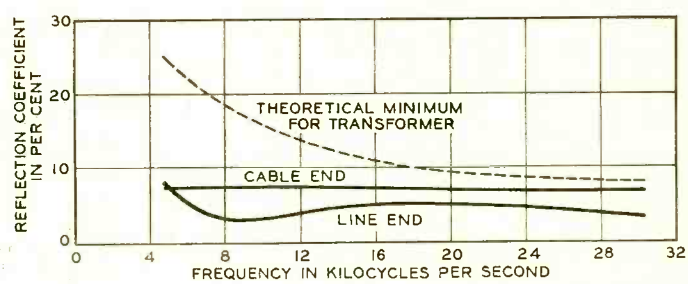


Fig. 4—Theoretical minimum reflection coefficient between open-wire and cable image impedance with a transformer compared with reflection coefficient at each end of the impedance transforming network

cable pair. Although the reflection coefficient at one end of the transformer or transducer can be decreased, that at the other end will be correspondingly increased.

To eliminate this difficulty, a new type of impedance transforming network is used, shown in Figure 2. By deliberately introducing resistance, and hence a certain amount of additional transmission loss, this network was designed to operate between the complex cable impedance at one end, and 600 ohms at the other end, with comparatively low reflection coefficients at both ends as shown on the lower curves of Figure 4. This network is, in effect, a transformer having a complex impedance ratio. It also resembles a high-pass filter, since it "cuts off" at about 5 kc. The added loss required to effect the complex transformation is shown on Figure 5.

Air core coils are used both in the impedance network and the high-pass filter to avoid modulation of the carrier frequencies, which would occur if magnetic cores were used. Since several of these coils are used not only as filter components but also as transformers, the coupling coefficients of some of the windings must be high to prevent excessive leakage inductance, which would impair the reflection coefficient at high frequencies. The four-winding coil of the high-pass filter, for example, comprises two sections wound with "parallel pair" wire, which gives a coupling of greater than 99 per cent between the primary and secondary windings. The coupling between the two sections of the coil does not affect the leakage inductance. Somewhat similar is the first coil of the impedance network, which is used as an autotransformer. Since an impedance ratio of about 3.3 to 1 is required, it is impossible to use full windings of parallel pair, which would give a ratio of 4 to 1. For this reason the coil is partially wound with parallel pair, and then single turns are added to the shunt windings to obtain the proper ratio. This coil is also modified to absorb the single shunt coil of the filter.

Two junction filters are available. In one, the low-frequency channel is

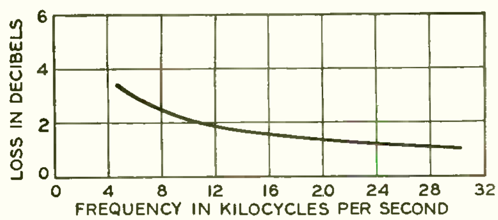
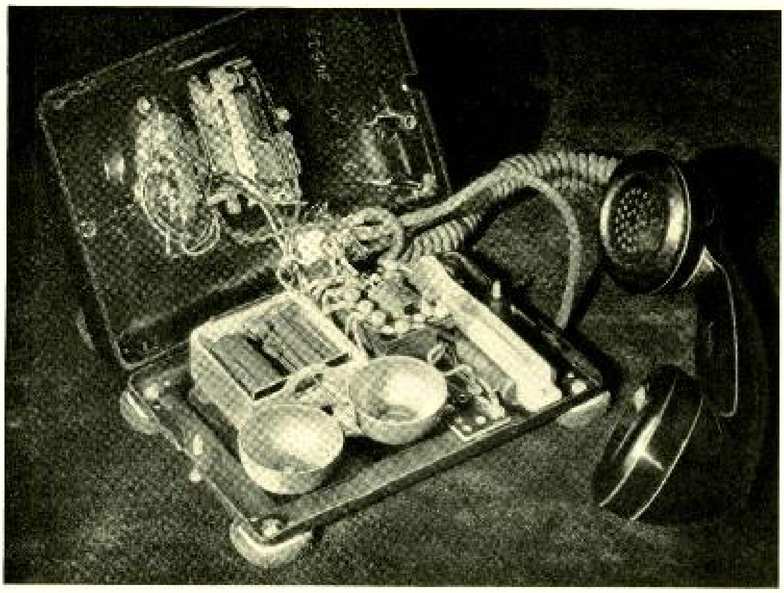


Fig. 5—Loss added by the impedance-transforming network

wide enough for a 5-kc program circuit, while the high-frequency channel is suitable for open-wire carrier telephone systems operating at frequencies as low as 6.5 kilocycles. In the other, the low-frequency channel is wide enough for voice frequencies up to 3 kilocycles, while the high-frequency channel passes frequencies as low as 4.8 kilocycles. The impedance-transforming network is provided with taps so that adjustments can be made for operation with either 13-, 16-, or 19-gauge cable pairs.

The ability of the junction filter to operate out-of-doors under all kinds of weather conditions and its comparatively low cost makes it an economical substitute for carrier loading on the longer entrance cables. While the junction filter gives transmission results sufficiently satisfactory to justify its use, it does not provide as good overall impedance matching as carrier loading, and it increases rather than decreases entrance cable losses.



Small Ringer for Combined Subscriber's Set

By C. F. WIEBUSCH
Station Apparatus Development

LIMITED space in the new combined telephone sets necessitated the development of a much smaller ringer than those previously in general use. In it were incorporated other features including a gong of better tone; also coils of higher impedance to permit using a smaller condenser and to make the ringer suitable for parallel operation of extension ringers and on multiparty lines.

The new ringer is similar in principle to earlier designs.* Two gongs and a polarized magnet with balanced armature, to which is attached a clapper, constitute the main structure. Alternating current vibrates the armature and strikes the clapper against the gongs. The armature oscillates on a shaft bearing and is held, when not vibrating, against a stop by a cantilever biasing spring made of phosphor bronze wire. Proper choice of the mass and stiffness of the clapper assembly makes the velocity with which the clapper strikes the gongs, and hence the sound output, independent of the ringer input over the range encountered in practice.

Polarizing flux is supplied by a U-shaped magnet M, Figure 1, of chrome steel, which has its two ends welded to a soft iron heelpiece. The north pole is at the bottom of the U and the south pole is at the bridged upper end. Thus the two legs are magnetically in parallel. The permanent magnet is of such strength that it produces an average flux density of about 1300 gauss in the air gaps between the armature A and the cores.

The cores are connected in series,

*Record, *July*, 1932, *p*. 385.

aiding for a flux path from the armature through one coil, then through the heelpiece and back by way of the other coil to the armature. Flux from the ringing current is superimposed on the biasing flux and alternately strengthens or weakens each arm relative to the other. This makes the armature and clapper vibrate. If the current is not actually reversed but only drops to zero, the armature is returned to normal by the biasing springs. The ringer thus operates either on alternating current or on pulses in the direction to oppose the pull of the spring. Pulses in the opposite direction tend to hold the magnet tighter against the upper stop, pin P1 of Figure 1.

Minimum operating current is determined by the torque per unit of current and by the bias supplied by the spring. In older ringers bias was continuously variable and required adjustment by the installer on a trial and error basis. The new ringer has three notches, N, Figure 1, into which the free end of the biasing spring can be slipped. The spring itself has been carefully adjusted during manufacture to just operate the ringer on slightly over three milliamperes with the end of the spring in the middle notch. This adjustment suffices for over eighty per cent of the installations. The remaining twenty per cent are taken care of by the low and high notches. Bias prevents false operation of ringers connected from one side of the line to ground when ringing voltage is applied to the other side of the line. It also prevents audible tapping when dials of telephones are operated.

To obtain high impedance at voice frequencies and thus permit its use on party lines with grounded ringing, the ringer was designed with permalloy cores. This construction also gives a high inductance at the twenty-cycle ringing frequency which reduces the size and cost of the series condenser required. Because of war needs, the cores are now being made of magnetic iron; tolerance margins permit this on most circuits.

Smaller gongs had to be used to fit the allotted space in the new ringer but a more efficient motor element allows them to be struck hard enough to produce as much sound output as the larger gongs of the older ringers. When two gongs are sounded together the effect is more pleasing if

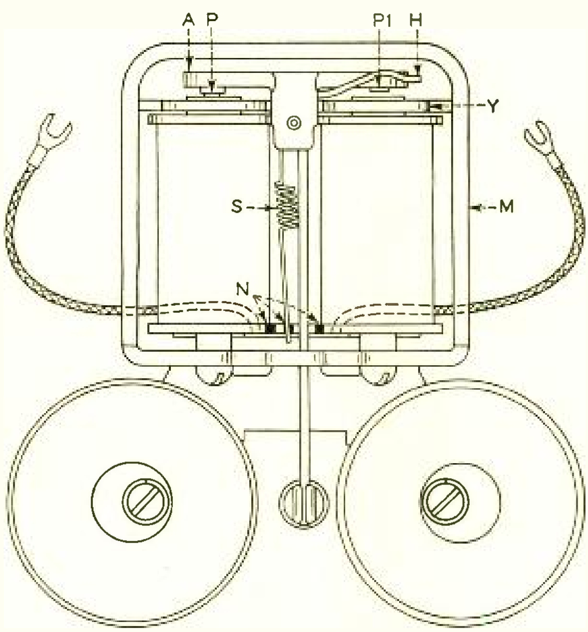


Fig. 1—Polarizing flux is supplied by a U-shaped magnet of chrome steel. Flux from the ringing current superimposed on this makes the armature and clapper vibrate. A stroke limiter H adjusts the intensity of the sound; the biasing and restoring force of the spring is controlled by the notches N

they differ by one of the simpler musical intervals, such as the major third or fifth. In the new ringer the major third, which corresponds to a frequency ratio of five to four, was chosen. The sound power radiated drops off rather rapidly with these small gongs for pitches lower than 1600 cycles per second. This frequency was therefore chosen for the lower pitched gong and 2000 cycles for the other one. An interval of a fifth would have placed the higher pitched gong at 2400 cycles per second which is well beyond the region of maximum hearing sensitivity for many people. Sounds of this higher frequency are also attenuated more in passing through partitions and passages.

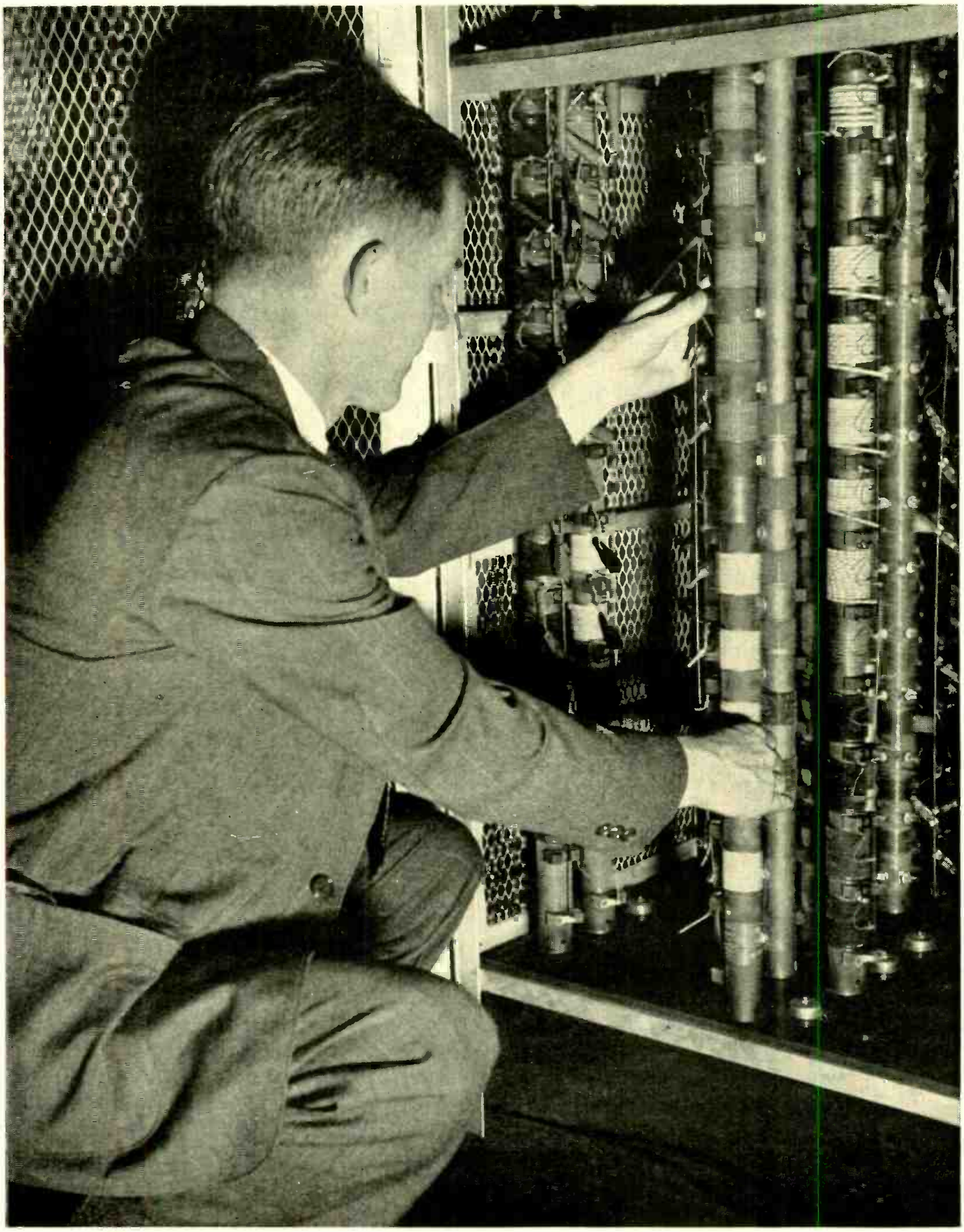
When a gong is struck, a series of overtones is produced as well as the fundamental. For a simple gong of uniform thickness such as that in the new ringer, the loud overtones bear the frequency ratios of about 2.7 and 4.8 to the fundamental. The overtones actually carry many times as much power as the fundamentals.

Since sounds of low pitch are transmitted and heard better than higher ones, it is desirable to increase the power radiated at the fundamental frequencies of the gongs. The 101A gong attachment has been provided for this purpose. It is a modified form of Helmholtz resonator mounted inside the gong to increase the coupling to the air. This resonator raises the fundamental by about 17 db, thus making it approximately equal in intensity to the overtones. The total sound output increases only about two db, but this suffices generally for installations requiring more output than is furnished by the unresonated gongs and is valuable in most cases of hearing loss.

When the normal ringer with unresonated gongs is too loud for small homes and offices, an adjustment is provided on its armature to limit the stroke. This stroke limiter, H, Figure 1, is a rod attached to the armature so that it strikes a lug on the ringer frame when bent toward it. With short strokes the clapper strikes the gong at a lower velocity and less sound is produced.

The B1A ringer was designed to serve many different installations but there are certain classes of service for which it is not suitable. Other ringers such as the B2A, for two-party message rate service, and the B3A ringer with a vacuum tube, have been designed around the frame of the B1A to use as many of its piece-parts as possible. All of these ringers can be mounted in the set interchangeably and all are known as "B" type ringers.

NEWS AND PICTURES



Testing the effect of continued high humidity and high voltage on wire insulation

President Walter S. Gifford's Statement

at the Annual Meeting of Stockholders of the American Telephone and Telegraph Company

OVER 9,500 BELL SYSTEM EMPLOYEES are already in the military services. The rest of us in the system are aggressively doing our part to win the war and to protect the liberties we so dearly cherish. We are determined to see to it that those in uniform are backed up on the home front with all the skill and energy and resourcefulness that we have. I am sure that is what you, the stockholders, want us to do. You have provided the wherewithal with which the telephone lines, the switchboards and buildings have been built. You have invested your savings in a great public service in peace times and a vital part of the nation's defense in war times—vital to fighting the war through to victory.

As you have seen from the statement enclosed with your dividend check that arrived in your home or office this morning—the earnings of the system with present tax rates are more than covering the dividend. This, in spite of the fact that these taxes are nearly $5 a share per year greater than in 1940. You will also have noticed that the tax proposals of the Secretary of the Treasury would reduce earnings by an additional $4 per share per year, so that, if those proposals were enacted into law, the usual dividend would not be earned in full. In fact the earnings on investment would be reduced to the lowest point on record, including the worst year of the recent depression. During the depression, you will recall, the company continued to pay dividends at the usual rate although, because of depressed business conditions, they were not fully earned and were paid in part out of surplus.

There are too many uncertainties ahead today to say in advance what it might be wise to do if, due to war time taxes and not to a depression, earnings again should not fully cover the dividend requirements. Conditions are obviously not the same as in the depression. Then we had a telephone plant which could handle more business than we had and it was clear that we would again earn the dividend as soon as we had more business. Now we have all the business that we can handle—with no spare or idle plant, in spite of having added nearly one billion dollars of telephone plant since 1935—and yet because of increased taxes needed for the winning of the war, we may not fully earn the $9 dividend. We are making all possible operating economies and if and where it becomes necessary, we shall ask regulatory bodies to permit us to increase revenues by increases in telephone rates so far as is not inconsistent with winning the war or with the public interest.

Because of the urgent need of copper and other essential materials for the war effort, construction of new facilities to care for civilian demand for telephone service is being more and more restricted by government priority regulations. This will mean great inconvenience and even hardship for increasing numbers of persons.

However, whatever the difficulties ahead for the Bell System and for telephone users, they are difficulties growing out of the war. And how long will the war last—my own answer is—it will last until we win it. I have spent my working life with the Bell System—nearly 38 years. I have seen the system go through many trials and tribulations but it has always come through stronger than ever. Because telephone service is worth so much more than it costs and because of the high character and ability of Bell System personnel and for other important reasons, as a stockholder myself—and nearly all my personal savings are invested in the business—I look to the future of the Company with full confidence.

For the duration, the Bell System, come what may, can be counted on to do its full part in the war and by so doing it will be keeping faith with those in the fighting forces and on the fighting fronts who, after all, have the toughest job to do.

New Board Member

Frederick William Bierwirth, Vice-President and Manager of the Telephone Sales Division of the Western Electric Company, was elected a member of the board of directors of the Laboratories on March 4, succeeding James W. Bancker who retired from the Western Electric Company on March 31 under the Retirement Age Rule.

Mr. Bierwirth joined the Western Electric Company in 1912 following a term of service with the United States Steel Corporation. After working in various positions in the tracing and service branches of the Hawthorne Works he was placed in charge of the installation service division in 1922. A year later he transferred to the New York office

F. W. Bierwirth, new Director

as superintendent of the installation and equipment service. During the following two years he became assistant and then general accounting superintendent.

Returning to Hawthorne in 1926, he became commercial contract manager and then a year later came back to New York as general price manager. In 1928 he was appointed assistant comptroller of manufacturing. He was made operating superintendent at the Kearny Works in 1929, became assistant Works manager in 1931 and Works manager in 1935. Mr. Bierwirth re-

James W. Bancker

turned to the New York office in 1939 as general sales manager, this position becoming manager, telephone sales division, on April 1.

* * * * *

At a recent directors' meeting of the Western Electric Company, Stanley Bracken, David Levinger, Frederick W. Bierwirth and Frederick R. Lack were elected vice-presidents. All other officers were reëlected.

Mr. Lack was Vacuum Tube Development Director of the Laboratories when he transferred to Western Electric in 1938; previously he had contributed to the development of quartz crystals which play such a large rôle in controlling frequencies in communication systems, and to the Bell System's first commercial ship-to-shore radio on *S.S. Leviathan.*

Dr. Buckley's Kelvin Lecture

London, April 23—The past and future of transoceanic communication were reviewed this afternoon for the Institution of Electrical Engineers in a paper prepared for the 35th Kelvin Lecture by Dr. Oliver E. Buckley, president of Bell Telephone Laboratories, New York. Since Dr. Buckley could not attend in person, he had recorded a brief sound-picture. After he had appeared on the screen before his audience in London, his paper was read by Sir Stanley Angwin, vice-president of the Institution.

Telegraphic communication across the Atlantic was first accomplished in 1866 over a submarine telegraph cable, to whose engineering Kelvin had made important contributions. Voice communication followed years later after Bell System engineers demonstrated in 1915 that radio telephony across the Atlantic was possible. It was twelve years, however, before regular two-way commercial service was established between the United States and England.

Meanwhile, advances made in telephone engineering, notably Bell Telephone Laboratories developments in magnetic loading materials, were applied by Dr. Buckley and his associates to underseas telegraphy, with the result that modern cables have four times the traffic capacity of the earlier ones. Information gained in that work was in turn applied to the problem of underseas cable telephony and in 1930 a short experimental section was actually built and tested in the ocean. Advances in short-wave radio, and the business depression, made the possibilities of that cable seem less attractive and, although it appeared technically sound, the project was discontinued.

Due to the strain on short-wave radio facilities in the last few pre-war years, the cable project was revived, and experiments so far indicate that it is feasible on a multiplex "carrier" basis, much like that of the coaxial cable which is now in use between New York and Philadelphia, and elsewhere. The cable which Dr. Buckley described would itself be not unlike other modern underseas cables, but it would include a departure which sounds daring in the extreme. That is to make vacuum tube repeaters an integral part of the cable, placing them at 40-mile intervals on the bottom of the ocean, where the tubes are expected to function for as much as 20 years without attention. Power for the repeaters would be furnished by direct current transmitted over the cable conductors themselves. There would have to be two cables, one for transmission eastward; the other, westward. Twelve conversations could be transmitted over these two cables with speech quality as good as on land lines.

Actual construction of such a system is well into the future, since many details of construction must be designed and tried out under actual sea conditions. Twelve years, it will be remembered, intervened between the first transatlantic radio telephone experiments and everyday commercial service.

Costs of a cable system appear to be comparable with those of an equivalent radio system, and the cable system offers important advantages in reliability, privacy, and improved speech quality. A combination of the two types of communication systems—radio for some links and cable where large parallel groups of circuits are required—seems desirable.

Thus there would be possible the operating economies of large circuit groups, which have been demonstrated in land-line telephony, and the flexibility inherent in radio systems. It should be remembered that at the pre-war rate of growth the available non-interfering radio channels were rapidly diminishing. By carrying as many channels as possible in undersea cables, the radio spectrum would be left free for those routes where radio alone would be practicable. "From purely physical considerations," Dr. Buckley said, "it now appears feasible to provide all of the facilities for telephone connection between all points on the earth that its inhabitants are likely soon to require."

Major R. W. Harper
is now in the Equipment Coördination Division of the Office of the Chief Signal Officer

Capt. M. A. Specht
is now an instructor in the Field Artillery School at Fort Sill, Oklahoma

News From Men in Service

Captain Harold T. King writes: "I am still stationed here at Fort Bragg, commanding a Battery of Radio Specialists in the Field Artillery Replacement Training Center. I might say that I would be glad to see more Bell System men pass through my battery, for the scarcity of communications men in general and radio specialists in particular makes my job more difficult. We are succeeding, however, in turning out radio operators in considerable quantity. This is no doubt due largely to the enthusiasm and willingness that the average American soldier shows in tackling jobs that are given him."

Captain Emil Alisch, since February 21, has been attending the Command and General Staff School at Fort Leavenworth, Kansas, where he is taking a course in operations and training.

Captain Albert G. Kobylarz is in Washington as the Executive Officer for the Officer in Charge of the Maintenance Division, Office of the Chief Signal Officer. This Division deals with maintenance of all Signal Corps equipment and establishes schools for training of civilian maintenance personnel.

Major Kermit O. Thorp carries on as Army Air Force resident representative for the Indianapolis area. He says: "The job is most interesting and instructive. We are getting more work here every day and the organization under my supervision is growing steadily larger."

Charles J. Kuhn is at Indiantown Gap, Pennsylvania, where he writes that he is in the best of health and well accustomed to the life. He is reviewing all the training received during the last year.

Since the latter part of January, Cap-

Active in Greater New York Fund Campaign
R. E. Kuebler, one of the Bell System volunteers who was loaned by the Laboratories to interest business houses in participating in the campaign; G. T. Selby, who addressed the opening city-wide rally of the 1942 campaign; and R. M. Burns, chairman of the campaign committee sponsored by the Bell Laboratories Club

In the Nation's Service

The following members of the Laboratories have been given leaves of absence to enter various branches of the Nation's services.

MILITARY SERVICE

Capt. Emil Alisch
Sgt. Nils H. Anderson
Lieut. Dick S. Barlow
Louis R. Bell
George Bickard

Charles T. Bolger
Capt. M. Maxwell Bower
Capt. Charles R. Brearty
Lieut. Sherman T. Brewer
Sgt. George Bukur, Jr.

Gerard E. Campbell
Raymond P. Chapman
Lieut. David F. Ciccolella
Major Andrew W. Clement
Capt. Francis A. Coles

Michael Collins
Sgt. Joseph F. Daly
Major Richard A. Devereux
Capt. Robert L. Dietzold
Thomas J. Doherty

Robert J. Drout
Lieut. Stephen Duma
Major William H. Edwards
Major Albert M. Elliott
Lieut. Col. Hiram B. Ely

Major Albert J. Engelberg
Major Raymond O. Ford
Lieut. Joseph E. Fox
Major William J. Galbraith
Owen N. Giertsen

Corp. Thomas J. Gilchrest
Ernest G. Graf
Lieut. Ernest Graunas
Major Charles H. Greenall
Lieut. Harold B. Guerci

John F. Gulbin
Lieut. Walter S. Gunnarson
Major Robert W. Harper

Major John M. Hayward
Capt. Henry E. Hill
Corp. Francis M. Hodge
Lieut. Lester H. Hofmann
Lieut. Harry W. Holmlin

Ralph D. Horne
John P. Houlihan
Alexander Howitt
Sgt. Frederick J. Hurt
Burton L. Jamison

Lieut. Glover D. Johnson
Oliver C. Kanouse
Capt. Robert L. Kaylor
Lieut. Howard J. Keefer
Lieut. William Kes

Capt. Harold T. King
Capt. Albert G. Kobylarz
Robert J. Koechlin
Charles J. Kuhn
Lieut. William H. Lichtenberger

Capt. Stanley H. Lovering
Major William R. Lyon
Sgt. Walter W. Maas
Major Joseph A. Mahoney
Lieut. Paul Mallery

Herman E. Manke
John Marrero, Jr.
Lieut. Roderick K. McAlpine
Major Thomas A. McCann, III
Corp. Charles J. McDonald

Peter F. McGann
Robert F. McLaughlin
Major James W. McRae
William J. Meehan
Charles E. Merkel

Lieut. John K. Mills
Capt. Floyd A. Minks
Major Harvey N. Misenheimer

Sgt. Robert T. Monahan
Lieut. Frederick B. Monell, Jr.
Robert C. Nance
John Nichol
Karl J. Ogaard

Lieut. Orving C. Olsen
John J. O'Shea
Thomas A. Pariseau
Lieut. Frank A. Parsons
Lieut. Edwin H. Perkins

Sgt. William G. Pimpl
Capt. Clayton W. Ramsden
Lieut. Einar Reinberg
George M. Richards
Capt. John C. Roe

Major Ward K. St. Clair
George A. Schiehser
Charles R. Schramm
Lieut. Charles L. Semmelman
Michael Sheehan

Capt. Hubert A. Sheppard
Lieut. Frederick J. Skinner
Thomas J. Slattery
Major Walter F. Smith, Jr.
Major Arthur D. Soper

Capt. Malcom A. Specht
Lieut. Lambert W. Stammerjohn
John H. Stelljes
Major William W. Sturdy
Lieut. Samuel C. Tallman

Capt. Donald E. Thomas
Major Kermit O. Thorp
Lieut. William G. Turnbull
Lieut. Kenneth L. Warthman
William P. Weiler

Major Allen L. Whitman
Lieut. Robert C. Winans
Lieut. James E. Zendt

NAVAL SERVICE

Edwin L. Chinnock
Lieut. Comm. Rodman D. deKay
Ensign Laurence G. FitzSimmons
Lieut. Charles A. Hebert
Ensign Raymond A. Kempf

Albert J. Leimer
Lieut. Thomas H. Neely
Lieut. Charles M. Redding
Lieut. John R. Sackman

Carl E. Stone
Lieut. Clarence Unnewehr
Donald L. Viemeister
Lieut. Comm. Nels C. Youngstrc

NAVY DEPARTMENT

Bureau of Ordnance

Walter B. Ellwood
Joseph F. Keithley

Bureau of Ships

John W. Smith

WAR PRODUCTION BOARD

Hamilton Baillard

U. S. MARITIME COMMISSION

Frank J. Fleischer

NATIONAL DEFENSE RESEARCH COMMITTEE

Walter H. Brattain
William B. Callaway
Paul V. Dimock

William Herriott
Horace T. O'Neil

Max S. Richardson
Charles C. Rock
Leon J. Sivian

William B. Snow
George R. Stibitz

Walter L. Tierney
Albert L. Thuras
Robert G. Watling

TAIN FLOYD A. MINKS has been working on special wire-communication projects at Fort Monmouth.

MAJOR ALLEN L. WHITMAN is assistant to the Executive Officer of the radio-locator laboratory of the Signal Corps at Camp Evans. On April 7 he wrote saying he was about to start on a five-week trip covering the entire United States for the purpose of recruiting new civilian personnel for the laboratory.

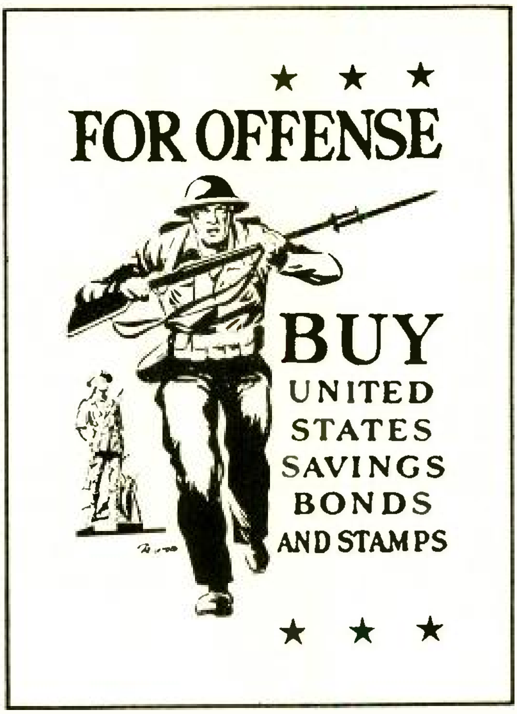
LIEUT. JOSEPH E. FOX, at the Aircraft Radio Laboratory at Wright Field, admits that he is working very hard on matters that he can't write about.

MAJOR WILLIAM W. STURDY from Washington writes: "I have been on duty in the Office of the Chief Signal Officer since June 13, 1941. My duties and assignments have varied from time to time, and have included the direction of development work on miscellaneous items including trucks. At the present time I am in charge of the Allowances Division, which recommends the amounts of signal corps equipment to be used by the various tactical organizations of the Army. There are about twenty officers and twenty-five civilians in this division."

CAPTAIN C. W. RAMSDEN is now with the Signal Corps at Fort Monmouth where he is taking a three-month "refresher" training course on long lines transmission and operation.

FROM WASHINGTON H. BAILLARD writes: "I am in the Staff Branch, Production Division of the War Production Board. This is quite a local group of Bell System temporary exiles. My boss is Mr. Frank Evans, Vice-President and General Manager of the Bell of Pennsylvania. Also in our Staff Group is a man from the accounting department of the same company and a statistician from the Southwestern Bell. Construction is in charge of Bill Kahler, Chief Engineer of Illinois Bell; Mr. Landry of the Western Electric heads up the production work of the Staff, and there are three or four other Bell men in various capacities.

"My duties relate mostly to the production planning and scheduling of Army Ordnance. Working very closely with the Ordnance Department of the Army, also located in this building, we maintain a constant watch on those portions of the ordnance program which represent the most serious production problems, and which, in general, are those most badly needed. This requires a system of records which permits us, at any time, to answer all sorts and kinds of questions about every item our army uses, from pistols to tanks. More recently I have been putting in most of my time on a study of what types of army equipment—ordnance, chemical warfare, signal corps, etc.—can be most readily manufactured by the various civilian industries due for curtailment. This is a subject of very serious concern to us, but the industrialists themselves are showing amazing ingenuity in adapting their shops to war work."



CAPT. MALCOLM A. SPECHT is now an instructor of gunnery at the Field Artillery School, Fort Sill, Oklahoma. He says: "My students are officer candidates who, at the successful completion of the twelve-week course, are commissioned as Second Lieutenants. Gunnery is the longest component of this course and takes six weeks. By June, approximately 480 new officers will be turned out each week."

ENSIGN LAURENCE G. FITZSIMMONS informs us that he is at present the commanding officer of one of the Navy's sub chasers.

Trial "Alert" at the Davis Building

At the request of the Board of Transportation, which occupies a majority of the space in the Davis building, the Laboratories coöperated in a trial air-raid "alert" held there on April 7. The standby alarm was sounded at 4:10 P.M. at which time members of our emergency groups under the direction of G. Wismar, senior post warden, went to their posts; the all-out "alert" was sounded at 4:25 P.M. and the all clear at 4:40 P.M., at which time the 410 members of the Laboratories in the Davis building returned to their normal duties.

To observe the evacuation of the Laboratories personnel, L. E. Coon, J. S. Edwards, G. F. Fowler, W. A. Tracy, P. J. Doorly and W. Wissel covered the various floors involved. The time for evacuation of our section of the building was three and one-half minutes and a total of less than five minutes to reach the shelter areas. As an additional test, after the people had reached the shelter areas, Mr. Wissel issued an order for a group of four members of the fire squad to report in front of the freight elevator on the thirteenth floor. This was carried out under the direction of H. A. Flammer, the brigade chief at the Davis building.

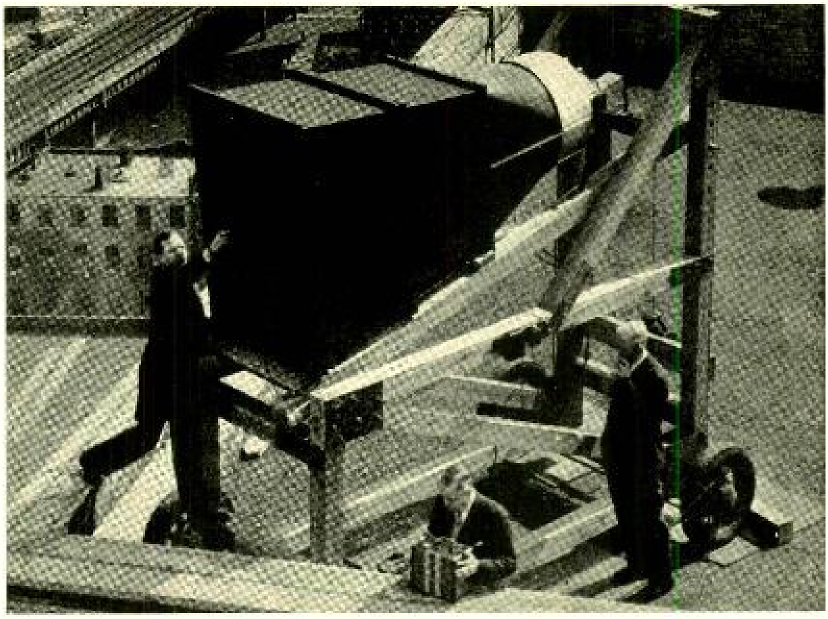
Stock Control

The Graduate School of Business Administration, Harvard University, has taken the papers on Stock Control written by R. H. Wilson and combined them into a textbook which it has had mimeographed and has distributed to the students for classroom use. This is the system of stock control summarized in the Bell Laboratories Record, issue of September, 1941. Each student has been requested to submit a report on the system not to exceed 1600

Members of the Laboratories to Whom Patents Were Issued During the Months of February and March

L. G. Abraham	W. D. Goodale, Jr.	W. P. Mason (4)	V. L. Ronci
H. A. Affel	H. L. B. Gould (2)	E. C. Matthews	V. E. Rosene
W. P. Albert	C. R. Gray	C. F. Mattke	A. H. Schafer
L. H. Allen	F. Gray	M. B. McDavitt	E. E. Schumacher (2)
W. M. Bishop	R. O. Grisdale	J. B. McKim	A. H. Shangle
W. S. Bishop	O. D. Grismore	H. J. McSkimin	O. A. Shann
B. G. Bjornson	L. N. Hampton	L. A. Meacham	A. M. Skellett
A. L. Bolz	H. C. Harrison (2)	W. J. Means	T. Slonczewski
A. R. Bonorden	G. Hecht (3)	A. F. Melhose	E. M. Smith
G. M. Bouton (2)	R. A. Heising (2)	C. G. Miller	E. St. John
H. A. Bredehoft	A. Herckmans	D. Mitchell	H. F. Stover
S. T. Brewer	W. J. Hill	L. W. Morrison, Jr.	W. G. Straitiff
E. Bruce	W. H. T. Holden	J. A. Morton	L. K. Swart
O. Cesareo	W. E. Ingerson	R. Mueller	K. D. Swartzel, Jr.
J. G. Chaffee	H. E. Ives	H. Nyquist	P. W. Swenson
I. E. Cole	K. S. Johnson	L. A. O'Brien	R. A. Sykes
J. Davidson, Jr.	A. R. Kemp	R. A. Ogg	R. V. Terry
E. F. Dearborn	D. H. King	R. S. Ohl	R. J. Tillman
O. E. DeLange	B. A. Kingsbury (2)	G. L. Pearson	F. A. Voos
T. L. Dimond	W. A. Knoop (2)	E. Peterson	P. W. Wadsworth
J. T. Dixon	C. D. Koechling	W. A. Phelps	C. A. Webber
S. O. Ekstrand (2)	M. E. Krom	J. R. Pierce	H. W. Weinhart
W. B. Ellwood	L. Y. Lacy	C. E. Pollard, Jr.	C. L. Weis
C. B. H. Feldman	E. Lakatos	G. A. Pullis	C. F. Wiebusch
E. B. Ferrell	V. E. Legg (2)	R. O. Rippere	R. S. Wilbur
H. J. Fisher	C. A. Lovell	T. D. Robb	J. R. Wilkerson
M. Fritts	A. A. Lundstrom	G. H. Rockwood, Jr.	L. R. Wrathall
C. S. Fuller	J. M. Manley	J. M. Rogie	A. W. Ziegler

Apparatus for making sound propagation experiments from the roof of the Laboratories building on West Street. In the photograph J. B. Little (left) and R. T. Jenkins (center) are measuring the sound power level at the mouth of a Western Electric "bull horn" while J. B. Kelly gives instruction by telephone to the power-amplifier operator



words and to set ordering amounts and ordering points from examples given, showing the operation of stock items.

The system is also being introduced into other businesses. The Ingersoll-Rand Company wrote Mr. Wilson: "We are pleased to tell you that our experiments in applying this system to our type of merchandise are giving highly satisfactory results."

An article by Mr. Wilson on this method of stock control was recently contributed to the March issue of *Executives' Service Bulletin*, published by the Metropolitan Life Insurance Company.

Air-Raid Signal Sound Tests

Further tests in the Laboratories' program of investigations along the line of air-raid signals have been made during the past month. The purpose of these studies of the propagation of sound was to find out something about the acoustic shadows cast by large buildings near the listening point. A sound source, which for convenience took the form of a tone generator, a power amplifier, and a Western Electric "bull horn," was set up on the roof of the Laboratories building at West Street. A photograph of the apparatus is reproduced above. Tone tests were made at various intervals with about 500 watts of acoustic power being radiated in each signal.

Observing crews were stationed at points in the vicinity, some of these extending to a distance of about two miles. Sound readings were taken with the pick-up in direct line with the source and then behind nearby buildings. Observations were spread over several weeks in order to determine the effect of wind direction and velocity.

"Super-High Precision"

An article by L. A. Meacham in the March, 1942, issue of the Record described a circuit used to test high-frequency oscillators, which is capable of measuring a deviation of one hundred thousandth cycle per second. This article brought the following letter from the editor of *Instruments*.

Dear Findley,

What a model of restraint, that article by Meacham! He and his associates have achieved super-high precision. I was reading it last night and mentally computed the "specifications" of a pointer-and-scale frequency meter of equal precision. Here they are—roughly—for a frequency meter with a 5-cycle scale for use on 60 cycles:

(1) Scale span: 57.5 to 62.5 cycles;
(2) White enamel scale with billionth-of-a-cycle graduation 0.30 inch apart;
(3) Width of pointer tip, 0.02 inch;
(4) Scale length for 5 cycles, 24,902 miles.
(5) Housing, the Earth. Reason, this well-known length which, in the press releases Bell Labs might well send out, would simply be called the Equator.

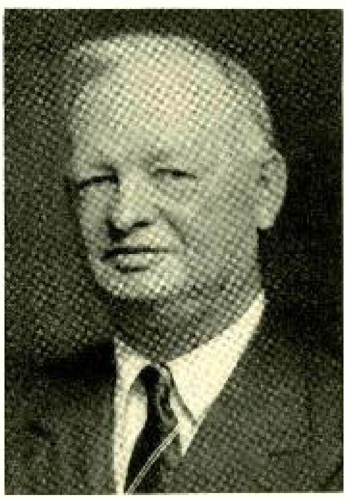
Yours for Victory, M. F. Behar.

tion and also to give an account of the enomena of vast stellar explosions, known as novae and supernovae.

E. C. Larsen discussed *Thermoelectric Phenomena in Contact Erosion* at the March 16 meeting. The erosion of negative contacts when the opening of an electrical circuit is accompanied by a luminous gaseous discharge can be attributed to positive ion bombardment. However, a satisfactory explanation for erosion of positive contacts, a type of erosion observed on contacts used to close a capacitative circuit, or to open a circuit where no gaseous discharge occurs, has not been previously advanced. Evidence was presented showing that the mechanism involving electron bombardment of the positive contact is untenable. It appears that the transfer of material from the positive to the negative contact occurs by formation of molten metal bridges. Motion pictures were presented which showed the formation of a molten bridge between bismuth contacts and the preferential melting of the one contact due to Peltier heating.

The last regularly scheduled bi-weekly meeting until after the war, as noted in the last issue of the Record, was held on March 30. At this meeting K. K. Darrow discussed *The Concept of Entropy*. The famous principle of Nernst, often called the third law of thermodynamics, affirms that the entropy of any pure crystalline solid is zero at the absolute zero of temperature. Modern statistical theories affirm that the entropy of a gas at any temperature and pressure has a definite and calculable value. Now it is well known that all experiments give values of the entropy-differences only. It seems, therefore, as though the two foregoing statements could have no physical meaning. However, the combination of the two statements does have a physical meaning which is brilliantly verified. The process of verification was shown by Dr. Darrow and the concept of entropy reviewed in the light of the results.

Thomas R. Griffith
of the Physical Research Department completed thirty years of service in the Bell System on April 29



Otto F. Vollheim
of the Plant Department completed forty years of service in the Bell System on April 10

Trial Blackout Successful

The Police Department rated the Laboratories 100 per cent in the March 25 blackout of lower Manhattan. At the scheduled time of 9:00 p.m. members of the Air Raid Warden group, under the supervision of W. A. Tracy, Zone Warden, were at their stations, including roof and street areas, for observations at West Street and at the Graybar-Varick and Davis buildings. All lights were extinguished except those in blacked-out areas; and in those locations, equipped with blackout curtains, work was not interrupted. During the twenty-minute period a comprehensive inspection at the West Street buildings was made by G. F. Fowler, Mr. Tracy and W. Wissel, fire brigade chief, and at the Graybar-Varick and Davis buildings by P. J. Doorly.

* * *

F. B. Jewett's address, *The Mobilization of Science in National Defense*, presented before the Winter Convention of the I.R.E., was published in the March issue of the Institute's *Proceedings*. In the same issue is an article by R. V. L. Hartley entitled *A More Symmetrical Fourier Analysis Applied to Transmission Problems*.

In the March issue of *Industrial Standardization*, R.

L. Young discusses the recently approved ASA American Standard on Graphical Symbols for Use on Drawings in Mechanical Engineering (Z32.2). This is the first standard completed in a rounded program on graphical symbols that is being undertaken by Committee Z32 on Graphical Symbols and Abbreviations for Use on Drawings. This committee was organized in 1936 to consolidate all other work that was being done along these lines by other committees and organizations.

C. L. Weis, Jr., 1901-1942

Who's Who in America, which has just issued its twenty-second volume for the years 1942-43, includes among its new listings several more members of the Laboratories. These are Ralph Bown, A. B. Clark, R. M. Foster, R. A. Heising, R. L. Jones, M. J. Kelly and A. R. Thompson.

It is gratifying to note that recent reports regarding Bruce Freile are greatly exaggerated. Mr. Freile, who retired from the Laboratories last year, is living in his new home at Eau Gallie, Florida, where several of his friends in the Laboratories have called on him. That he is in the best of health and spirits is evident from his recent commission as a Lieutenant in the Naval Reserve.

In *Modern Plastics* for March appears an article, *Cellulose Acetate Yarn for Wire Insulation*, by D. R. Brobst, which was reprinted from the Record for January, 1942. Mr. Brobst is the engineer shown in the Frontispiece on page i.

Women Research Experts Shoulder Invisible Guns, an article by Virginia J. Fortiner, appeared in the Newark *Evening News* for March 10. It was based on interviews with Matilda Goertz, Eugenia V. Wyckoff, Sallie P. Mead and Anna K. Marshall, and was illustrated with pictures taken by P. B. Findley.

Further tests and demonstrations have been made of the blower-type air-raid signal described on page 200 of the April Record. After the Detroit demonstration the apparatus was returned to New York City. It was then driven by John Hanley, one of the Laboratories' chauffeurs, to Forked River, New Jersey, where further tests were conducted by R. C. Jones and F. K. Harvey. Mr. Hanley then drove the truck to Washington where demonstrations were carried on under the supervision of Dr. E. J. Abbott of the Office of Civilian Defense and T. L. Dowey of the Laboratories. Upon completion of these demonstrations Mr. Hanley drove the truck back to New York City. Since then the Office of Civilian Defense has demonstrated the apparatus at Worcester, Mass., and is planning to make a country-wide tour, particularly along the West coast.

* * * * *

Charles L. Weis, Jr., a supervisor in the High Frequency Transmission group, died on April 12. After graduation from Massachusetts Institute of Technology in 1922, he entered the Laboratories and was continuously active in the development of carrier telephone systems, among them the early single-channel systems. In recent years he was concerned with transmission of television signals over coaxial and paired cables. In that connection he had charge of the transmission phases of the television pick-up and broadcasting of the Republican National Convention in Philadelphia in 1940. For the past year he has been engaged in development work for the government.

Mr. Weis is survived by his wife and a young son and daughter.

* * * * *

Continuing the work offered during the summer of 1941 and the present academic year, Brown University will offer opportunity for instruction and research in mechanics and allied branches during an eleven weeks period beginning on June 14. Emphasis will be on preparing men for the present emergency. S. A. Schelkunoff has been chosen as one of the faculty of eight who will conduct this course.

W. G. SHEPHERD spoke on *Deionization Considerations in a Harmonic Generator Employing a Gas-Tube Switch* before the New York section of the I.R.E.

R. M. BURNS discussed *Protective Coatings for Corrosion Prevention* before sections of the American Chemical Society at Providence, Boston and Lewiston (Maine).

W. T. BOOTH and N. Y. PRIESSMAN visited the Sprague Specialties Company at North Adams, Mass., in connection with electrolytic condenser problems. At the International Telephone and Radio Manufacturing Corporation in Newark they also discussed selenium rectifiers.

IN A SERIES OF LECTURES designed to "humanize" engineering, conducted weekly from February 4 to May 13 by the New School of Social Research, WILLIAM FONDILLER, on April 8, spoke on *Electrical Research and Development* and J. R. TOWNSEND, on April 22, *Materials of Engineering*.

RETIREMENTS

JOHN F. TOOMEY and HARRY J. CHRISTOPHER have retired from the Bell System. Mr. Toomey retired under the Retirement Age Rule on the thirtieth of April upon completion of over forty-eight years of service and Mr. Christopher retired on a service pension due to disability on the sixteenth of March after forty-four years of service.

Mr. Toomey, who has been concerned with almost every phase of telephone systems development, joined the New England Telephone and Telegraph Company in 1892 as a night operator and successively held various positions in the operating field. Then, after a year's interruption, he returned to the Engineering Department of the New England Company where he had charge of placing common-battery central offices in service and of investigating transmission and equipment troubles. In 1904, Mr. Toomey transferred to the American Bell Telephone Company in Boston to assist in early development and engineering work on dial equipment. He later was sent to investigate transmission difficulties on certain toll lines, and after two years in several midwestern cities came to the Engineering Department of the American Telephone and Telegraph Company in New York to engage in problems of central-office equipment engineering.

From 1909 to 1925, Mr. Toomey, first in the Engineering Department and after 1919 in the Department of Development and Research of the A T & T, was concerned with toll circuit development work, including testing facilities. During this period he had a part in numerous important long distance projects, such as the opening of the New York-Denver line, the transcontinental line, the first Key West-

At the invitation of the Defense Training Institute, J. H. Miller (left) and A. B. Kvaal (right) of the Laboratories reviewed with Dr. H. W. Redick, Director of the Institute, the qualifications of graduates who might be considered for vacancies in the drafting and other departments of the Laboratories. The Institute is a governmental organization which attempts to relieve the shortage in technical personnel by offering free training in the elements of engineering, using the facilities of the engineering colleges in New York City. Mr. Miller collaborates with the Institute in selecting those who are admitted as students

Havana cable, and the naval demonstration at Washington when for the first time two-way radio telephone communication was established between a ship at sea and the various naval stations. During World War I he was sent to Washington to assist in handling special transmission and maintenance problems that arose in connection with the government's telephone service.

Three months after the Laboratories was organized in 1925 Mr. Toomey transferred to the Toll Development Department where, until 1938, he was in charge of of toll system analyzation work. Since then, in the Switching Development Department, he has been responsible for investigating special problems relating to toll switching systems. The ninety-three patents issued to Mr. Toomey bear witness to his many contributions to the communications art.

J. F. Toomey

H. J. Christopher

Mr. Christopher joined the Plant Department of the New York and New Jersey Telephone Company at the Erie Street shops in Jersey City in 1897. Six years later he transferred to the New York Telephone Company at 15 Dey Street as an installer and for many years was responsible for the installation and maintenance of all telephone equipment used in the executive quarters of the American Telephone and Telegraph Company. When the building at 195 Broadway was constructed he had charge of all telephone wiring. Due to his familiarity with the headquarters building and his aptitude for special installation and wiring jobs, he was called on continually for special demonstration set-ups. Mr. Christopher did much of the special wiring in connection with the demonstration on the occasion of the opening of the transcontinental line during the 1915 World's Fair at San Francisco. Soon after this he was loaned to the A T & T for installation work connected with the transatlantic radio telephone experiments conducted from Montauk Point and Arlington, Virginia.

Upon completion of these experiments Mr. Christopher was transferred to the A T & T to take charge of the test station maintained by the Engineering Department as a place for the assembly and testing of apparatus for field investigations and for making tests of Long Lines circuits. This test station, which was transferred to the D & R when this department was organized in 1919, was first located at 15 Dey Street and subsequently relocated at 32 Sixth Avenue and was a valuable adjunct in the work done by the D & R. Since 1934, when the D & R merged with the Laboratories, the test station under the able guidance of Mr. Christopher has continued to serve a number of the departments of the Laboratories.

* * * * *

BEFORE THE CONNECTICUT VALLEY section of the I.R.E., F. R. STANSEL discussed *A Secondary Frequency Standard Using Regenerative Frequency Dividing Circuits.*

ON SEVERAL OCCASIONS in the past month E. ST. JOHN has been to the Haydon Manufacturing Company, Forestville, Conn., to discuss synchronous motor-driven timers and timing mechanisms.

E. B. WOOD visited Hawthorne in connection with enamel-wire problems.

H. A. FLAMMER was at the Patent Office in Washington and Richmond during March relative to patent matters.

P. B. FINDLEY was elected vice-president of the Princeton Engineering Association.

Some Members of the Laboratories

This month the Record presents the following biographies of members of the Laboratories chosen by lot.

* * *

Jeannette Granger likes her work in Specification Files (4-A) but she'll admit that on a fine spring day her thoughts run to the old farmhouse and orchard which her family owns near Saugerties. At home in Woodhaven, Jeannette has a good deal to do with housekeeping, but she gets out a good deal too. Roller skating used to be her evening diversion; now it's dancing. From her brother Bob, who is a wireman in section 2-K, we learn that she has yet to find someone who can teach her to swim.

Jeannette Granger

Soon after graduating from Franklin K. Lane High School, Jeannette entered the Laboratories as a messenger, first in the Mailing Department, later in the Apparatus Files. In November, 1940, she became a file clerk. Her friends in 4-A say she is a bit reticent, but they've observed that the frequent visits of the younger draftsmen to the Specification and Drawing Files have not been without effect on her interests.

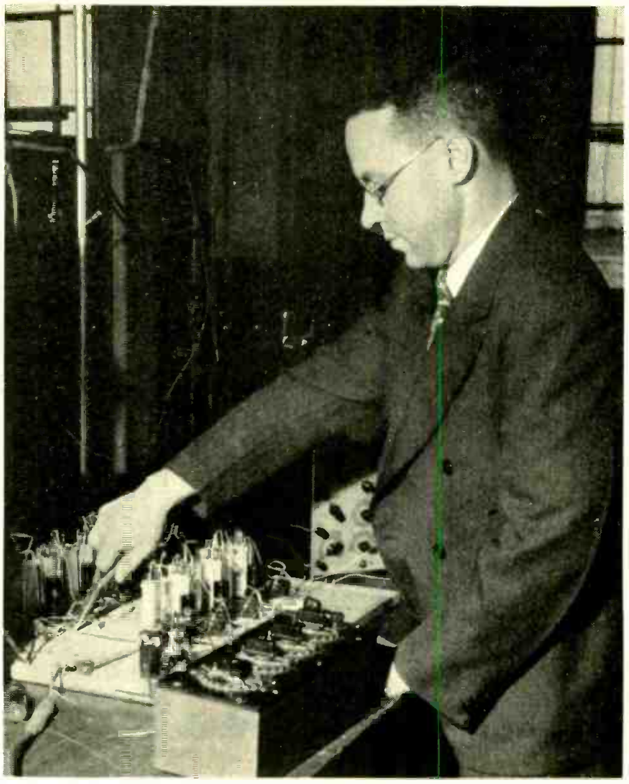
Jake Schaefer

Before this issue of the Record is delivered, Jake Schaefer may be wearing gold bars on his shoulders as "2d Lt. Jacob W. Schaefer, Air Corps, U.S.A." Any day now he may be called from the design of military gadgets in the Laboratories to their practical use in the war.

Jake joined the Laboratories last summer, having just graduated in Mechanical Engineering from Ohio State. At O.S.U. he met the present Mrs. Schaefer. Besides their interest in each other, both are interested in archery and music. Jake likes to get his hands on real things, so he has teamed up with the superintendent of his apartment house in Lyndhurst in the joint equipping of a workshop.

* * *

WITH A BACHELOR'S DEGREE from Brigham Young University, QUENTIN E. GREENWOOD entered the Laboratories in 1929. He kept on studying, however, and received his M.S. from Columbia in 1935. For several years he was a member of the Wire Transmission Research Department; among his investigations were the application of gas tubes to echo suppressors and the technique of measuring phase-delay on picture circuits. Transferring at the end of 1934 to submarine cable development, he has since been occupied with design problems relating to long submarine telephone cables and associated apparatus. One of those problems had to do with the twist which comes into an armored cable by reason of the tension due to its own weight as it leaves the ship. Mr. Greenwood developed a mathematical theory for the twisting and checked it by experiment. He also contributed improvements to the so-called "unity feedback" circuit, in which one amplifier stage with positive feedback is prevented from singing by negative feedback imposed on the entire amplifier circuit.



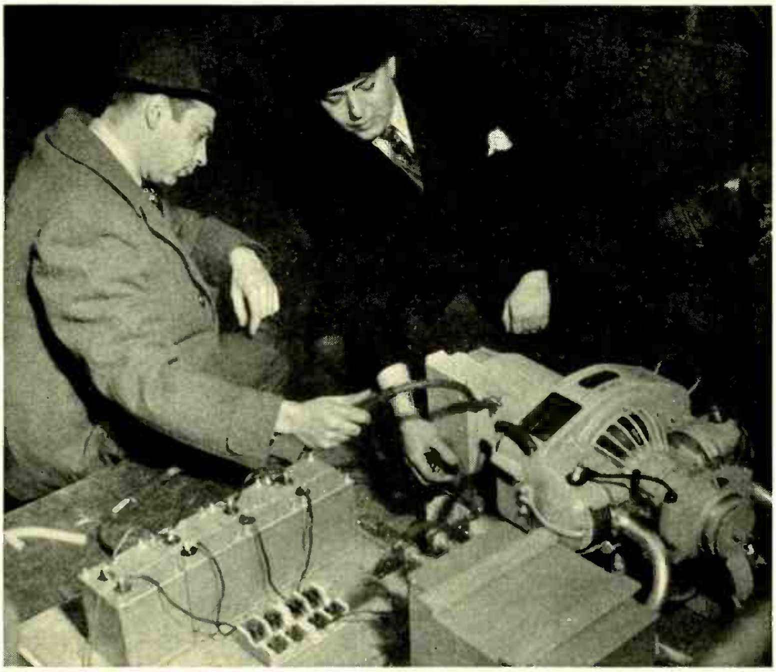
Quentin E. Greenwood

Mr. Greenwood plays the piano and is organist in his church in Flushing. He and Mrs. Greenwood have two children, a daughter eight years old and a son, five.

* * *

FROM RICHMOND HILL High School, LOUIS MILARTA entered the Laboratories in February, 1925, as a messenger. The next fall found him enrolled in Cooper Union, and in 1930 he graduated as an electrical engineer. Meanwhile he had become an assistant in the Transformer Laboratory.

Louis Milarta



On March 27, engineers of the New York Telephone Company tested an emergency power supply for maintaining the Laboratories' PBX batteries in case of a general power failure. The equipment, which weighs about 125 pounds and can be easily carried by two men, consisted of a portable 3000-watt gasoline-driven generator and was set up on the sidewalk on Bethune Street with temporary leads running to the batteries. In the photograph F. W. Tillistrand (right), assisted by W. A. Hessler, both members of the Plant Department of the New York Telephone Company, adjusts the charging rate

H. M. STOLLER and A. E. DIETZ were at the Small Motors Company in Chicago on the manufacture of special motors.

G. A. RITCHIE visited Hawthorne on matters of keys and switching apparatus.

C. KREISHER of the Outside Plant organization at Point Breeze was at Kearny, West Street and Murray Hill in connection with problems of protective coverings for buried types of lead-covered cables.

R. H. COLLEY attended a meeting of the Executive Committee of the American Wood-Preservers' Association in Chicago. He also went to Minneapolis in connection with full-length treatment of western cedar and Douglas fir poles and the open-tank treatment of crossarms.

When the power transformer group was organized in 1929 Milarta was a member of it; and a year later he became a member of the technical staff. His work is the development and design of rectifier transformers and associated choke coils which are used in power conversion from a-c supply to direct current, principally for vacuum-tube circuits.

Milarta's recreations are sailing and swimming in summer and skating in winter. He and Mrs. Milarta have one girl and two boys, a lively trio who put plenty of action into their home in Hollis.

* * * * *

W. G. LASKEY, at Hawthorne, discussed various meter problems with Western Electric engineers.

C. R. MOORE made a trip to Rochester to discuss with the Gleason Gear Works the manufacture of hypoid gears for dials.

CONSERVATION OF MATERIALS
TYPED COMMUNICATIONS

TO GENERAL DEPARTMENT HEADS:

Typewriters, typewriter ribbons, carbon paper, letter-paper and rubber erasers are all going to be scarce before this war is over. Let us economize on them as far as we can without loss of efficiency. Retyping is perhaps the principal way in which we waste these materials and waste as well the time of the typists.

I suggest that we avoid retyping intramural communications whenever the changes to be made are few or small. Make changes in handwriting or by interlining on a typewriter. Those that come to me I shall accept for their content and judge them for that and not for appearance.

Also when letters or memoranda for outside the Laboratories must pass through several hands before final approval or signature, I suggest handwritten alterations until the text is approved, then they can be retyped once and for all in their final form.

These are not new ideas. They have been suggested before as ways of economizing. Now they have become matters of national importance.

O E Buckley
O. E. BUCKLEY

About 150 men and 45 women took the final examinations in the Standard First Aid Course during the week of April 13. Pictured above, an instructor and his assistants demonstrate how to turn a victim who may have a broken neck. Some 75 graduates of previous courses took the Advanced Course this spring

MEMBERS OF THE LABORATORIES who completed twenty years in the Bell System during April were:

Research Department

F. W. Cunningham	Coke Flannagan
R. C. Field	Daniel Wallace

Apparatus Development Department

W. J. Sullivan	Cornelius Tanis

Systems Development Department

H. H. Abbott	L. A. Kille
E. G. Andrews	Newton Monk

M. W. BOWKER spent several days in Laramie, Wyoming, in connection with a trial installation involving new methods of splicing cables.

AT THE HAWTHORNE PLANT of the Western Electric Company, D. H. WETHERELL discussed control equipment for dial systems, J. G. FERGUSON, general problems of step-by-step systems, and W. G. SCHAER and W. W. BROWN, information centers.

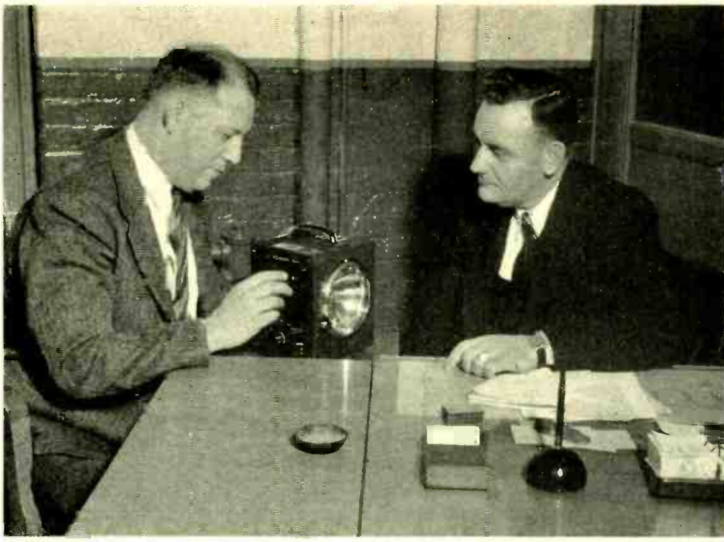
R. L. LUNSFORD and T. J. GRIESER discussed equipment with Signal Corps engineers at Fort Monmouth.

R. L. TRENT visited the Republic Steel Corporation at Cleveland, Ohio, in connection with additional stations required on the automatic switching teletypewriter system.

THE CENTRAL INSTRUMENT BUREAU

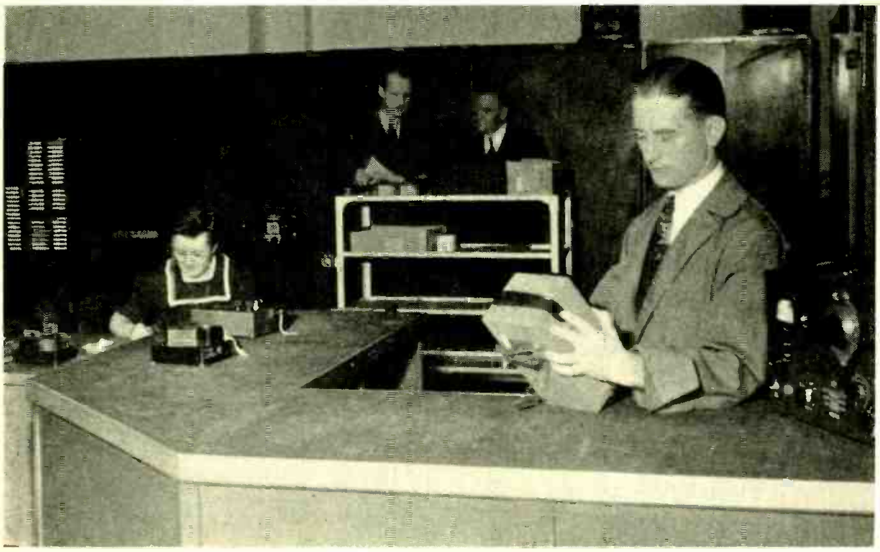
THE CENTRAL INSTRUMENT BUREAU has recently been combined with the Research Instrument Service organization in its new location in Section 2A. Under the jurisdiction of the Bureau are some 2800 instru-

Richard Rafferty checks the accuracy of a meter at the Bureau's test table



J. M. Hudack (left) inspects a strobotac in the office of M. L. Clarke who is in charge of the Bureau

Central Instrument Bureau



General view of the Bureau in Section 2A. Left to right: Miss Phyllis Barton, John Stelljes, M. L. Clarke and Richard Rafferty

Miss Barton checking record to determine location of an instrument on loan

Joseph Gramels of the Repaired Apparatus Department asks a temporary loan of Wheatstone bridge from John Stelljes

ments which are available for use. The functions of the Bureau are to expedite the work of the various technical staffs by making readily available on a short-term loan basis standard types of testing and measuring instruments which do not have sufficient use to warrant purchase on a department plant account; by supplementing laboratory-owned instruments at peak load periods when additional facilities are required; and by maintaining files to assist in locating specialized instruments required for such short periods that their purchase would not be justified.

In addition, records are maintained of requests for instruments filled and unfilled. When number of requests indicates that additional equipment should be secured, the Central Instrument Bureau Committee reviews these requests and purchase requisitions are forwarded for approval on the basis of the Committee's recommendations. Also as new measuring instruments are developed and become commercially available they are purchased for general use.

Twenty-Five-Year Service Anniversaries

During his twenty-five years of service with the Western Electric Company and the Laboratories, E. L. Nelson has made many varied and valuable contributions to the development and design of radio systems, including ship-to-shore, commercial broadcasting, aircraft, police and marine systems and equipment for the Army and Navy. Following his graduation from Armour Institute with the B.S. in E.E. degree in 1914, Mr. Nelson was with the Pullman Company in Chicago for a little over two years. He then entered the Research Department of the Western Electric Company. He was first concerned with general vacuum-tube applications and later with the development of radio telephone systems for airplanes and submarine chasers which were then under development as part of the Laboratories' program during the war.

Mr. Nelson went to England during the latter part of World War I as a civilian employee of the Bureau of Engineering of the Navy Department with a Special Service Party handling anti-submarine devices. In this party he was responsible for the radio telephone communication equipment used in conjunction with the submarine listening devices. While in England he was commissioned as a Lieutenant in the U. S. Naval Reserve. He returned to Washington in February, 1919, where he was stationed for a time at the Naval Research Laboratory at the National Bureau of Standards. Later that year he returned to the Research Department in New York in connection with ship-to-shore radio development. He was engineer in charge of the Deal radio station while the original buildings at that point were being constructed and equipped as a three-channel ship-to-shore terminal.

Subsequently Mr. Nelson returned to New York to undertake the development of a line of standardized radio telephone transmitters and receivers for point-to-point and other similar applications. Shortly thereafter commercial broadcasting swept the country, opening a large and rapidly expanding market for the equipment. During the next few years intensive development work was carried on to improve tone quality and to increase power output. Water-cooled tubes were used and radio transmitters up to 50 kilowatts were developed and used throughout the country.

Following a survey of the possibilities in the aircraft field and extensive transmission tests in the East and West to determine operating frequencies, Mr. Nelson's department was responsible for developing a complete line of transmitters and receivers for this service including both ground stations and equipment for the planes. Later a second line of similar equipment was developed. Following this, standardized equipment for police and harbor craft was developed. This apparatus has been used extensively by the commercial airlines of the country. More recently Mr. Nelson has been engaged in the design and development of special equipment for the Army, Navy and Air Corps.

The Nelsons live in Mountain Lakes with their five children, the youngest of whom was born on the twenty-fifth of February. Mr. Nelson is very much interested in boating and for a number of years has been active in the instruction program of the United States Power Squadrons. He owns a small cabin cruiser which he uses in Barnegat Bay and along the Jersey coast.

E. L. Nelson

Amelia Blauvelt

Eginhard Dietze

After being graduated from the Eagan School of Business at Hackensack, New Jersey, Amelia Blauvelt was in the secretary's office of the J. L. Mott Iron Works of New York City for a time. In 1917 she joined the Engineering Department of the Western Electric Company. After two years in the Transcription Department she transferred to the Physical Research Department as secretarial stenographer. In 1923 she became a secretary in the department and since then has worked in this capacity for various research physicists and engineers.

Miss Blauvelt's home is in Hillsdale, New Jersey, with her mother, father and sister, but during the week she stays at the Allerton House in New York City. A married brother completes the family. She has been a member of the Laboratories' Stamp Club for many years and, being fond of contract bridge, belongs to the Bridge Club of the Central Branch of the Y.W.C.A. Vacations usually find her somewhere along the Jersey shore, particularly Asbury Park or Ocean Grove. She is a member of the Edward J. Hall Chapter of the Telephone Pioneers of America.

* * * * *

During the summer following his junior year at the University of Michigan, Eginhard Dietze worked in the Engineering Department of the Western Electric Company at Hawthorne on the design of telephone cable, particularly the continuous loaded submarine cable. After receiving his B.S. in E.E. from Michigan in 1917 he joined the student course of the A T & T in New York. This course covered all phases of telephone engineering, transmission, equipment and outside plant. Then, in the Engineering Department of the A T & T, he was engaged in the design of telephone circuits, theoretical studies of selective networks and filters, economic studies of local plant design and the preparation of information for field engineering of new transmission station apparatus.

With the formation of the Department of Development and Research in 1919, Mr. Dietze joined the local transmission group of the Transmission Development Department. He came to the Laboratories at the time of the 1934 consolidation and since then has been in what is now the Station Apparatus Development Department as Station Studies Engineer.

Since 1919 Mr. Dietze has been primarily concerned with local transmission problems and studies of the performance of transmission instruments. This has involved theoretical and field work on the design of telephone station circuits and instruments, and the development of testing methods and apparatus such as a reverberation meter and a sound meter. He was also associated with studies made on the effects of improved operators' transmission facilities and service conditions on the accuracy and speed of telephone service; with the development of methods of transmission rating of operators' equipment and circuits; with investigations of methods of excluding street noises from operating rooms and the development of window ventilators with acoustic filters; field observations and demonstrations in selected central offices; and in coöperative work with the Associated Companies. For the past year Mr. Dietze has been engaged with problems concerned with war work.

Mr. and Mrs. Dietze live in Westfield, New Jersey. They have one son who is a junior in High School. Mr. Dietze is a member of the Telephone Pioneers of America.

* * * * *

A SHORT TIME AFTER ANTHONY GRIECO joined the Engineering Department of the Western Electric Company he entered the Transmission Laboratory where he was engaged in testing and investigating non-Western Electric apparatus. At this time comprehensive articulation studies covering the intelligibility of instruments and circuits was inaugurated and he was associated with this work. During World War I he spent much of his time making articulation tests of transmitters used in gas masks and transmitters and receivers in the helmets used by airplane pilots.

Following the war Mr. Grieco transferred to the acoustical research group where he assisted in making hearing studies and in the development of audiometers and cone-type loud speakers. He was also quite intimately associated with the design and development of the artificial larynx. He learned to talk with one of them and as a result was often called upon to demonstrate its use at technical meetings and more informally before small groups at the Laboratories. For the past few years he has been concerned with studies of carbon for mechanical amplifiers and repeaters. On March 30 he transferred to the electronics research group of the Physical Research Department where he is now working on X-ray and electron diffraction studies.

For many years the Griecos lived in Fordham but last December they moved to Summit preparatory to his transfer to the Murray Hill Laboratory with the rest of the Physical Research Department. They have two sons, six and eleven years old. Reading is Mr. Grieco's main diversion, with vacations usually spent in the mountains of Pennsylvania.

* * * * *

CHESTER D. JONES joined the Engineering Department of the Western Electric Company in 1917. Previous to this he had spent one year on civil engineering work in connection with the Long Island Motor Parkway and nine years in the drafting room of the American Brake Shoe and Foundry Company at Mahwah, New Jersey. His twenty-five years of service in the Bell System have been spent in drafting work in the Apparatus Development Department.

Anthony Grieco

C. D. Jones

G. H. Keillen

teletypewriter or table at the switchboard to provide the necessary facilities for training purposes.

The training circuits consist of equipment equivalent to two subscriber lines with supervisory keys and lamps and a teletypewriter key to associate the teletypewriter with either of the two lines. The switchboard terminations of these lines appear in front of the student, who may complete calls to them or receive calls from them. In addition to these training circuits, standard inter-toll trunk equipments are arranged locally for practice purposes to simulate two toll-line circuits between two offices. These practice toll circuits appear both at the instructor's position and at the student's position. The line lamps in the switchboard multiple for the two subscribers' lines and for the practice toll circuits are removed at positions other than the two used for training purposes.

With the two subscriber lines on the training table and the two practice toll-line circuits, the instructor may act either as a calling or a called subscriber or as a distant operator with respect to the student, and instructions may be carried out in such basic connections as an outward toll call, a local call, an inward call and a through call.

Operators' training arrangements as described above have been adopted for teletypewriter switching offices equipped with No. 3A TWX switchboards, where it is frequently desired to have a regular operator devote part of her time to instructing a student. This type of teletypewriter switchboard is now in use at about forty switching centers, with most of them provided with this training equipment.

Bell System Management Commended

The annual meeting of the American Telephone and Telegraph Company's stockholders has become of late years an interesting phenomenon. Here is a concern with an invested capital of some five billions of dollars, to all intents and purposes a "monopoly" in its field of operations, taking in a gross revenue of over one hundred millions of dollars a month with an overall net return of about 5 per cent on its investment, and a system of telephone service with over seventeen million customers in this country which enables each one to talk with every other at will, and, for good measure, to talk with the ends of the earth—all developed in less than three-quarters of a century from two primitive instruments with communication over less than one hundred feet. Its financial history is bare of scandal or bankruptcy, its service has been developed uninterruptedly and with unequalled rapidity of growth and steadily improved in quality as it grew. It stands today unequalled in the world. Its stockholders have received dividends uninterruptedly for at least two generations and the present rate of 9 per cent—the highest in its history—has been paid for twenty years. On Wednesday some five hundred stockholders present at the annual meeting unanimously expressed their commendation of the company's management.

From an editorial in the "Wall Street Journal" of April 17, 1942.

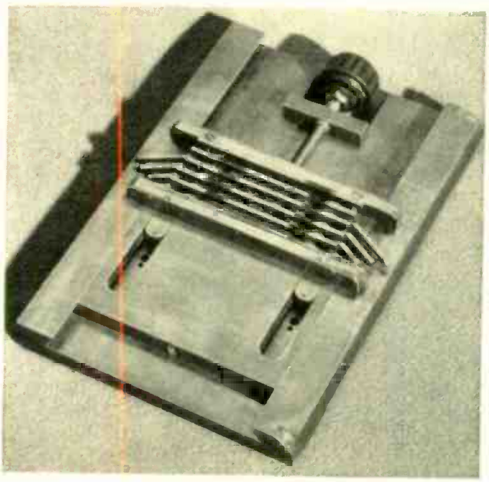
Printing Oscillator Scales

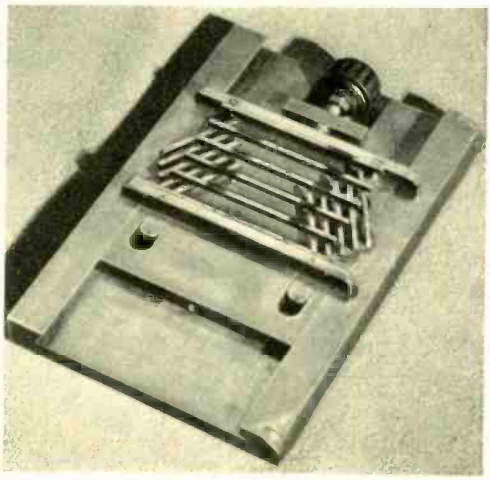
Drawing the film through the press to get it into position for an impression

WHEN an oscillator covers a wide frequency band, the provision of an accurately calibrated scale is a difficult problem. One solution has been to use as a scale a strip of film long enough for the desired number of divisions to be marked on it with good visual separation.* The calibration is made in two steps: first, the scale is pencil-marked at intervals of about ½ to 1¾ inches, using a standard frequency source for comparison; then each interval is divided into the desired number of equal parts. The first marking follows accurately the irregularities of the variable condenser which serves as a tuning element; and the intervals are made small enough so that no important error is introduced within an interval by equal subdivision.

Most laborious part of the process has been the second step. A drafts-

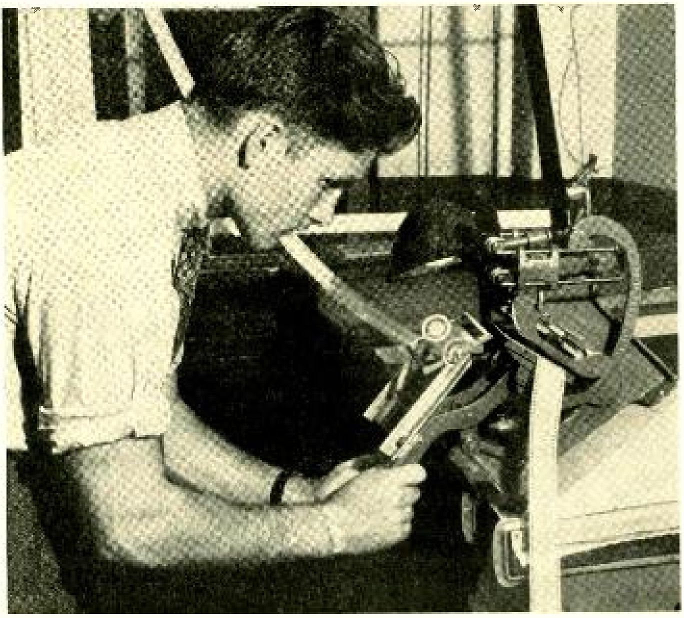
*This method is used in the 17B Oscillator described in the RECORD for *May*, 1939, *p*. 291.





The printing form is a set of steel strips mounted on a pantograph device adjustable by a screw; on the left, the strips are shown close together, and on the right, they are shown spread apart man, even using a mechanical means for determining the widths of the small divisions, has needed two or three days to finish a 24-foot scale. A printing method devised by T. Slonczewski has reduced this time to about two hours.

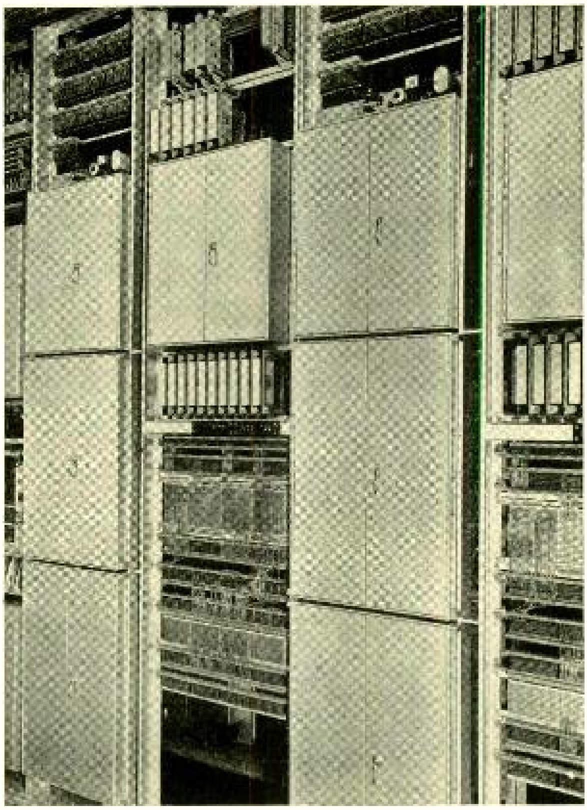
The printing form is a set of steel strips mounted on a pantograph device adjustable by a screw, so that when the end strips are set any distance apart, the inner strips are automatically kept at equal distances from each other and from the ends. The subdivision can be made in either four or five equal parts, depending on which side of the form is used. Fastened to the bed of a small hand-operated printing press, the form is lined up with the broad divisions on the scale. A mirror fastened to the press brings the image of the steel strips against the scale without parallax, so that the operator's position is not critical. A quick adjustment of the screw and an easy swing of the press lever give an accurately printed set of subdivisions. Then the film is pulled through the press far enough for the next impression.



A small hand-operated press is used to print the scale

A Circuit Continuity Test for the Crossbar System

By A. F. BURNS
Switching Development Department



Open circuits may generally be recognized by their failing to pass current, but with circuits varying widely in resistance and having perhaps high leakage to ground, this criterion may be unreliable. An open circuit with high leakage may draw more current than a closed circuit with low leakage. This article describes a method of distinguishing between open and closed circuits even under such adverse conditions by taking advantage of the difference in phase of the currents flowing.—Editor.

IN DIAL telephone systems, a talking connection is established through a large number of contacts, and it has been felt desirable to test in one way or another to make sure that after the circuit is closed through to the called subscriber, there will be no open circuits in the offices through which the call passes. With the panel system, a continuity test is made by the sender at the calling office, and a partial check is made on a routine testing basis at the terminating office. With the crossbar system, the sender also makes a continuity test at the originating office, but it was found to be impracticable to provide a suitable routine testing procedure for the terminating office because of the multiplicity of paths that any particular call might follow. It was decided, therefore, to arrange the terminating marker* to apply a continuity test for each call to make sure, before it disconnected, that a circuit is completed to a subscriber line.

In brief, the method consists in sending grounded 20-cycle current through the central-office contacts, out on one side of the subscriber line, through the station ringer, or signal, and to ground either at the subscriber station or at the central office. In greatly simplified form the circuit is as shown in the upper part of Figure 1. The actual situation, however, is far more complicated than is indicated here. In the first place, the impedance of the subscriber line and station

*Record, *July*, 1939, *p.* 356; *Aug.*, 1939, *p.* 373.

equipment may vary from two or three thousand to as much as eighty thousand ohms. This wide range is due partly to variations in the length of the loop but chiefly to the type of ringing equipment, which may be an ordinary station ringer, one of the tube-type subscriber sets,* or one of the various PBX ringing circuits, some of which use a high-resistance thermistor† in series with an a-c relay. In addition there will be a varying amount of capacitance to ground at the central office due to the office wiring and contact multiple.

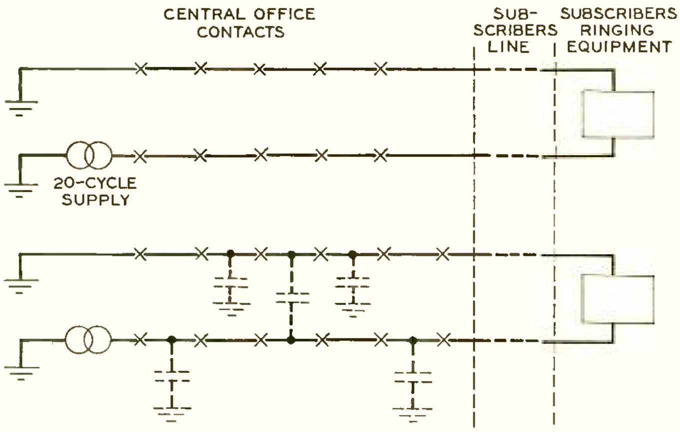


Fig. 1—Circuit for continuity test under ideal conditions, above, and with the ground at the central office, below. Crosses indicate contacts where circuit may be open

The actual circuit is thus more as indicated in the lower part of Figure 1, where the dotted condensers indicate capacitance paths by which the 20-cycle supply may flow to ground at the central office. When this capacitance is high, the current through it may be as great as the total current flowing when the capacitance is low and the resistance of the ringing equipment is high. In other words, the current flowing with an open circuit but high capacitance to ground may be as great as with a closed circuit and low capacitance to ground. It might seem impossible, therefore, to determine continuity by such a method under these conditions, but the difficulty was overcome by taking advantage of the difference in phase between the current that flows through the office capacitance, and that flowing over the subscriber line, which is chiefly resistive under extreme conditions. When the ground capacitance is zero (to take the extreme case) and the circuit is closed, the current that flows is in phase with the applied voltage, while when the capacitance from the 20-cycle supply to ground is a maximum and the circuit is open, the current flowing is 90 degrees out of phase with the applied voltage.

Current flowing in the test circuit is determined from the voltage drop across a condenser in series with the subscriber line. The circuits for the two extreme conditions mentioned above are thus as shown in Figure 2, where the left-hand diagram represents the conditions when there is an open circuit and the ground capacitance is a maximum, and the right-hand one, when the circuit is closed and the capacitance to ground is zero. In these diagrams Cx represents the maximum value of this capacitance, and Rx the maximum resistance of the ringing equipment, while C1 is the capacitance across which voltage is to be measured. It happens that under these extreme conditions

*Record, *Dec.*, 1936, *p.* 111.
†Record, *Dec.*, 1940, *p.* 106.

the absolute value of the impedance of Cx is approximately equal to the absolute value of the impedance of Rx. For convenience this absolute value of impedance in ohms may be called P, and the absolute impedance value of the capacitance of C_1 may be expressed as some factor, k, times P.

With this notation, the absolute value of the impedance of the left-hand circuit, which may be called Z_N, is $P(k+1)$, and that of the right-hand circuit, which may be called Z_O, is $P\sqrt{k^2+1}$. The ratio of Z_O to Z_N, for any positive value of k, is always less than one, as may be seen by writing $k+1$ as $\sqrt{k^2+1+2k}$. Since the currents that flow under the two conditions are inversely proportional to the impedances, the current in the left-hand circuit will always be less than that in the right-hand circuit, and thus the open and closed circuit conditions may be distinguished.

To secure the most favorable ratio for the two currents, k in the above expressions should equal one, but other circuit conditions do not make this feasible, although the value of k used permits a considerable amount of discrimination. The possibilities of the situation, however, have not yet been exhausted. If, for example, the impedance of Rx could be decreased relative to that of Cx, the ratio of the currents under the two conditions would be improved, since Z_N would then become larger relative to Z_O. This effect may be obtained without any actual change in Cx and Rx themselves, which of course cannot be controlled, by putting a resistance R2 in parallel with Cx and Rx. When this is done, the Cx and Rx of Figure 2 are replaced by the two circuits of Figure 3. The two impedances, Z_Q and Z_R, shown in Figure 3, are smaller respectively than those of Cx and Rx, but the reduction in impedance is greater for Z_R than for Z_Q due to the different phase relationship between the component impedances. In Figure 2, the absolute value of the impedance in series with the measuring capacitance C_1 is the same for both situations, while with the elements of Figure 3, inserted in place of Cx and Rx of Figure 2, the impedance in series with C_1 is greater for the left-hand condition than for the right-hand one. The difference in current flow through C_1 for the two conditions is thus greater than if R2 had not been used, and it is easier to discriminate between an open circuit with maximum ground capacitance, and a closed circuit with maximum line impedance and a zero ground capacitance. The actual ratio of Z_O/Z_N is now approximately 0.62 as compared with a value of 0.75 without the R2 resistance.

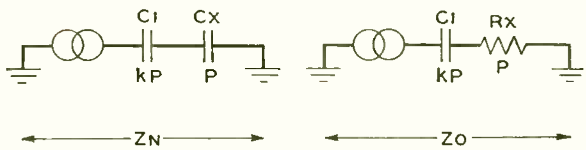


Fig. 2—When current is to be determined by the voltage drop across a condenser, C_1*, the impedance of the circuit may be represented as in the left-hand diagram when there is an open contact, and as in the right-hand one when all contacts are closed and there is no ground capacitance*

With the circuits of Figure 3 in place of Cx and Rx of Figure 2, the test circuit becomes as shown in schematic form in Figure 4. Here M represents a device to determine the voltage across C_1, and B represents any of the points at which the circuit may be open.

Another novelty in this continuity test circuit is the use of a cold-cathode* tube to distinguish between operate and non-operate conditions in accordance with the voltage across the condenser C1. The tube has an anode, a cathode, and a control anode. It is non-conducting across the main current path from anode to cathode until the voltage across the control anode and cathode reaches a definite value. A considerably higher voltage across the main anode and cathode will also cause the tube to "break down" and pass current, but no use is made of this characteristic in the continuity test. Such a tube has two major advantages over a relay circuit for a circuit of this type: the accuracy with which the breakdown voltage is maintained, and the rapidity of operation. The former is important because of the narrow margin between the operate and non-operate current; and the latter, because the test must be performed rapidly, since the circuit is part of the terminating marker, which has a holding time a little under 0.8 second.

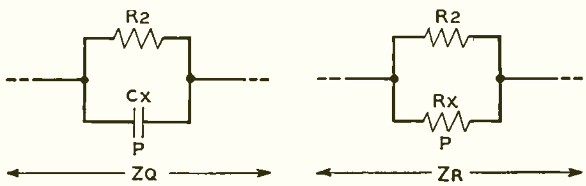


Fig. 3—The effect of shunting Rx *and* Cx *with a resistance,* R2, *is to make the ratio of* Zr *to* Zq *less than unity*

The actual circuit for the continuity test is shown in Figure 5. A connection to the subscriber line is made at points T and R, and the crosses on the line between these points and the test circuit itself represent various contacts through which the current passes. After the line has been connected to the test circuit, relays NK1, GLH, and GLH1 operate in sequence. This connects 20-cycle current to ground through the front contacts of NK1 and the primary winding of a repeating coil that is used to secure the desired voltage. The secondary winding of this coil is connected to ground through the C1 condenser and to the line through a back contact of CON3 and a front contact of GLH1. A condenser C2 serves a purpose described later. If the test is for a call to a subscriber on the tip conductor of a party line, the tip and ring conductors are interchanged so that the testing current flows out over the tip conductor rather than over the ring conductor.

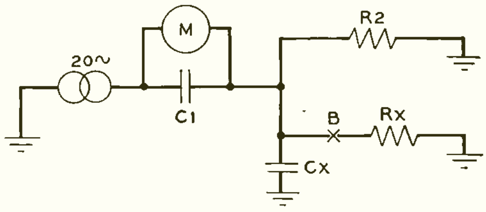


Fig. 4—Schematic arrangement of impedances in test circuit

The control gap of the tube is connected across the C1 condenser through a resistance. If the test current causes a drop across this condenser exceeding the breakdown voltage of the control gap, current will flow in the main gap from a 120-volt d-c supply through a front contact of the GLH relay, which operated immediately following the operation of NK1. Sufficient current will flow to operate CON, and the operation of this relay indicates to the marker that the crosspoints through the switches up to the line are closed.

Besides decreasing the ratio be-

*Record, *Dec.,* 1936, *p.* 114.

tween the non-operate and operate currents, resistance R2 serves another important purpose. When a line is tested, it is necessary that there be no electric charge on it, or the charge might produce enough voltage across the control gap of the tube to break it down. When a line is connected to the test circuit by a closure at points T and R of Figure 5, the tip side of the line is connected to ground through the back contacts of CON, and is thus discharged. The ring side of the line is also connected to ground through a back contact of GLH1. Operating current is applied to the winding of this relay immediately after the closure at R, however, and so this ground remains only during the operating time of GLH1, which may not be great enough to discharge the line completely. Moreover, there may be a charge on the wiring of the test circuit left over from the previous test. R2, however, serves to discharge the circuit under either of these conditions, and its value must be small enough to discharge the circuit completely before the C2 condenser can be charged to the breakdown potential of the tube. The value of C1 also enters into this calculation because there may also be a charge on it which must be dissipated before the test can be made. The values selected for R2, C1, and C2 were determined by these various functions which they are required to perform.

Relay CON3 is inserted to decrease the time during which the test current is applied to a subscriber line, and thus to decrease the possibility of bell tapping. Like CON, it was made a polarized relay so as to secure fast operation, and it operates on the same current. Since the circuit has already been found continuous as soon as this current starts to flow, it is safe to open the line circuit at once. When CON3 operates, it connects battery to the line to charge it up to 48 volts so that there will be no charging current to interfere with the test for a grounded line condition, which is subsequently made by the marker.

Relay CON1, which is operated by CON, interconnects the cathode and control anode of the tube as soon as the test has been made. The current through the tube therefore divides between these electrodes, and since the cathode area is thereby doubled, the life of the tube is prolonged.

Another condition that must be guarded against is the possible induction of momentary voltages in the circuit that might break down the control gap. The conductors used in

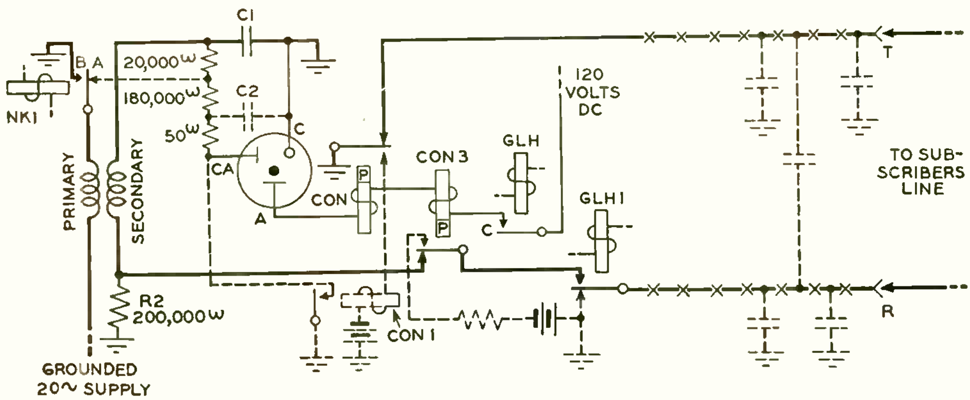


Fig. 5—Schematic of continuity test circuit of terminating marker

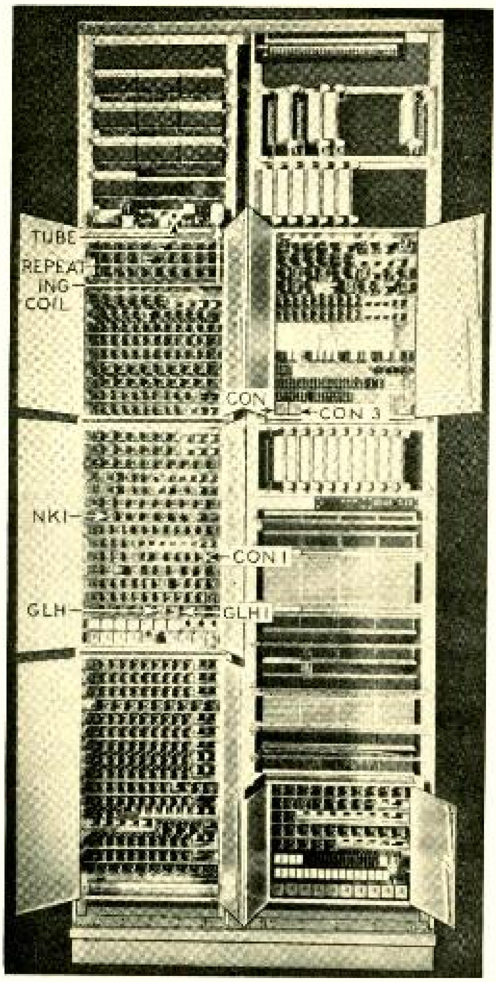


Fig. 6—A terminating marker with doors of relay cabinets open, and the position of the continuity test circuit indicated

connecting this circuit to a subscriber line pass through central-office cable, many pairs of which may connect to electromagnetic apparatus, such as relay windings. When such inductive circuits are opened, high voltages are generated which induce momentary high voltages in the other conductors of a cable. It was necessary, therefore, to make the test circuit inoperative to high voltages of very short duration. This is accomplished by the condenser C2. Before the voltage across the control gap of the tube can reach its breakdown potential, the condenser C2 must be charged to this potential through a resistance of 200,000 ohms. Although the time required to charge C2 to the breakdown potential is very small, it is longer than the duration of these induced voltages, and C2 thus serves to absorb momentary potentials. These resistances through which C2 is charged also limit the current in the control gap, and a tap to them from the back contact of relay NK1 is used to apply a small current through the control gap while a test is not being made. This holds the tube in an active condition, and minimizes the possible deviations in its operating voltages.

A terminating marker includes two bays of equipment as shown in the photograph at the head of this article. The left-hand bay includes three relay cabinets, and the right-hand includes one in the regular marker, and two in the special service marker shown in Figure 6. Both regular and special service markers include the continuity test feature. The repeating coil and tube for this testing circuit are mounted immediately above the upper relay cabinet in the left-hand bay, and most of the other elements are in the middle relay cabinet of this bay. The actual positions of the various elements of the crosspoint continuity test circuit are indicated in the figure.

The application of this test on each call provides more thorough testing for continuity through the central-office relay and switch contacts than has been done before at terminating offices, but the circuit serves another purpose that would make its use worth while even though it did not make the continuity test as well. Markers are expensive, and the number required depends on their "holding time," or the time they are in use for each call. A few thousandths of a second saved in holding time may be worth hundreds of dollars in the marker costs of a central office. If this continuity test circuit were not available, it would be necessary to provide a timing circuit that would permit the marker to advance to its next function only after allowing sufficient time for the crossbar switches it controls to operate. There is a variation of the order of .035 of a second, however, in the operating times of the different crossbar switches, and if a timing circuit were employed, it would have to allow for the slowest operating switches. By using the continuity test circuit to advance the marker as soon as the last hold magnet has operated, the marker holding time is reduced about .025 second on the average. This gives more than enough saving to justify the entire cost of the continuity test circuit. Furthermore, the completion of a satisfactory continuity test permits the terminating marker, following the performance of its other functions, to disassociate itself from each call with reasonable assurance that ringing and subsequently talking can be performed successfully.

Contributors to this Issue

L. A. GARDNER graduated from Worcester Polytechnic Institute in 1917 with a B.S. degree in Electrical Engineering. After two years in the U. S. Naval Reserve Force, he joined the Department of Development and Research of A T & T, and engaged in the development of telegraph repeater equipment and associated apparatus. In 1925 he became design and development engineer for an automotive accessories concern and later was associated with the manufacturing of gas-filled tubing for display signs. Since 1929, with the D & R and the Laboratories, he has been concerned with the development of central-office exchange and private switching systems for teletypewriter equipment.

AFTER A. F. BURNS received his E.E. degree from the College of Applied

L. A. Gardner

A. F. Burns

J. O. Israel

Science of Syracuse University, he immediately joined the Engineering Department of the Western Electric Company—now Bell Telephone Laboratories. With the Systems Development Department he has been engaged in the development and testing of low-frequency signaling methods and devices for telephone systems. These have included station ringers, a-c operated relays, and tone signals as well as miscellaneous signaling and testing arrangements such as the continuity test described in this issue.

J. O. ISRAEL received the degree of B.S. in Electrical Engineering from Lafayette College in 1927, and spent the following year doing graduate work at Yale University, for which he received the master's degree in 1930. He joined the Laboratories in 1928, and has since been engaged in the development of filters and networks, principally for single-channel carrier telephone systems.

C. F. WIEBUSCH was graduated with the B.A. degree in physics at the University of Texas in 1924. He received an M.A. there the following year and served as instructor in physics at the same institution from 1925 to 1927. Mr. Wiebusch joined the Laboratories the latter year to work on the development of sound recorders and reproducing equipment which engaged his attention until 1935. The following two years he spent developing miscellaneous station and central-office equipment. Since 1937 he has been in charge of the development of ringers and other subscriber signal apparatus. At present Mr. Wiebusch is devoting his time to the development of apparatus for government use.

F. A. HINSHAW received the B.S. degree in Electrical Engineering from Kansas State College in 1926 and immediately joined the Technical Staff of the Laboratories. For about eleven years he was associated with the transmission network group of the Apparatus Development Department, during which time he designed filters, equalizers, and regulators for long toll circuits, including high-grade program and telephotograph circuits. In 1937 he transferred to the Transmission Development Department where he prepared transmission objectives for high-gain carrier repeaters and for carrier-line filter sets. Since 1940 he has been in the Systems Development Department engaged in the design and development of new terminals for carrier systems.

C. F. Wiebusch

F. A. Hinshaw