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Radio Projects
Engineering

A MICROWAVE RELAY SYSTEM BETWEEN NEW YORK AND BOSTON

For a number of years Bell Telephone Laboratories has carried on a program of research and development to find out how radio relaying might supplement wire and cable facilities in the telephone system. This program had advanced well into the microwave region before it was interrupted by the war, which brought rapid progress in microwave electronics and circuit techniques. In the relay system installed between New York and Boston, some of these wartime microwave developments are applied to peacetime communication needs. The installation is essentially a full-scale field trial in which it will be possible to evaluate, under actual operating conditions, many of the economic and technical aspects of microwave relaying as a means for providing circuits for multiplex telephony, television, and various other broadband services.

The system operates at frequencies in the vicinity of 4,000 megacycles (wavelengths around 7.5 cm) and provides two two-way broadband communication channels between New York and Boston. Each channel has been designed to handle a signal band extending from 30 cycles up to 4.5 megacycles, with noise and distortion characteristics satisfactory for the transmission of present standard black and white television signals, or a considerable number of telephone channels using either time division or frequency division multiplex methods. In planning the system, the objective was not only to keep noise and distortion to low values, but also to insure a degree of reliability of performance such that the radio system could be integrated with the wire network.

One important factor that may affect the reliability of a microwave radio circuit is fading of the signals due to variations in atmospheric conditions over the transmission path. An essential step in engineering the new system, therefore, was to investigate the fading conditions that would have to be overcome to insure continuity of service. In this connection, a series of microwave propagation tests was made on a representative line-of-sight path forty miles long, extending from the roof of the New York Telephone Company building at 140 West Street to a hilltop near Neshanic, New Jersey. Data on transmission variations over this path were obtained by sending continuous carrier signals from New York and making continuous graphical records of received field intensity at Neshanic. The tests were carried on for a period of about two years to be sure that seasonal variations in propagation conditions were adequately covered. In the course of this investigation, observations were made at five different carrier frequencies ranging from 720 to 24,000 megacycles. The tests also included a comparison of fading on the over-all forty-mile path and the two twenty-mile paths obtained by setting up a temporary field sta-

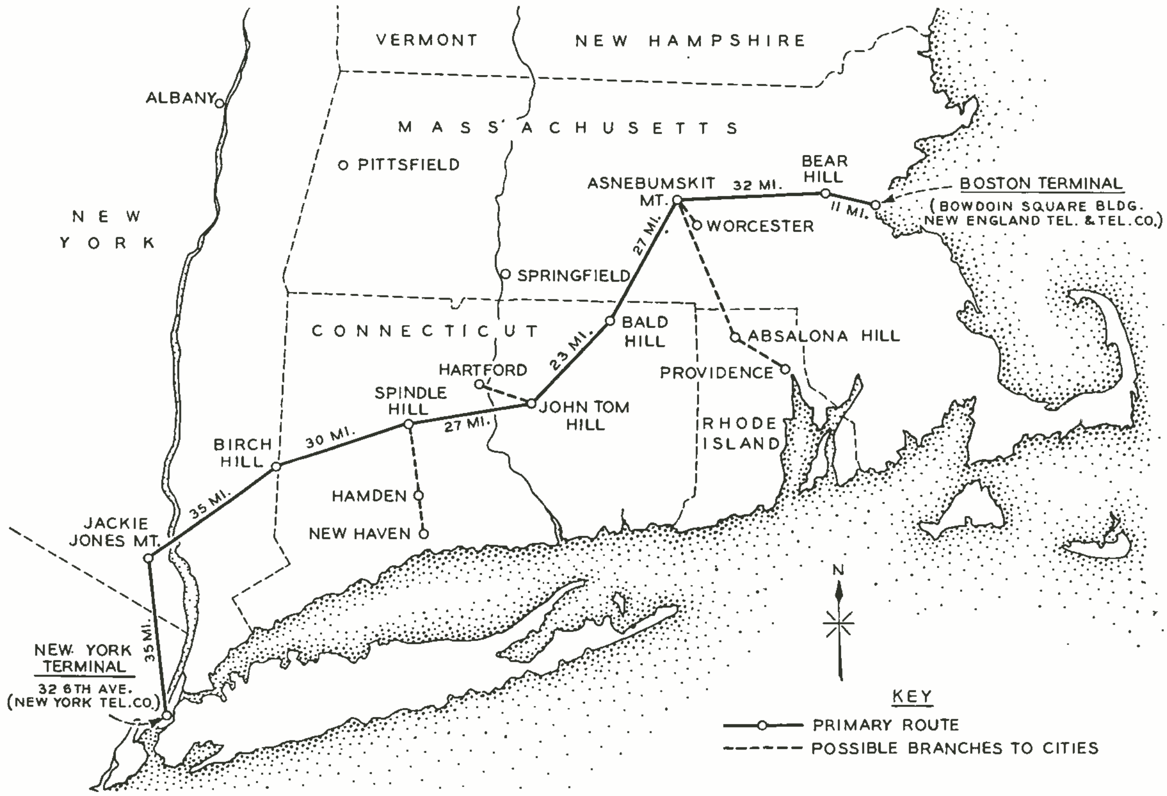


Fig. 1—Route of the microwave relay system between Boston and New York

tion midway between New York and Neshanic. The information provided by this test program was useful in deciding on the frequencies to be employed in the relay system, the fading range to be accommodated in the repeaters, and the maximum separation to be permitted between repeater stations.

Several requirements had to be considered in selecting the sites for the repeater stations. To insure satisfactory transmission over a microwave circuit, it is important to have a clear line-of-sight path between the transmitting and receiving antennas. The first requirement on a prospective station site, therefore, was that it be capable of providing an unobstructed path to the other stations with which it must work. This immediately put a restriction on the repeater spacings that could be obtained with reasonable tower heights. However, experience in the Neshanic tests and from other sources indicated that the depth of fading of microwave signals increases rapidly with path length. For transmission between New York and Boston, it was considered advisable to limit the repeater spacing to a maximum of about thirty-five miles, even though longer line-of-sight paths might be readily obtainable. Very short paths were avoided insofar as practicable, so as to minimize the number of repeaters in the system.

The first step in the selection of the route consisted in making a careful study of topographic maps of the terrain. High spots were picked out on the maps, and profiles of the transmission paths between them were plotted to determine whether the paths were unobstructed. If transmission considerations alone had been allowed to govern the choice of sites, some of the locations selected would undoubtedly have turned out to be very difficult to reach. In laying out the route, it was kept in mind that an entrance road would have to be built to each site, and that power and telephone lines would have to be brought in. An effort was made, therefore, to select high points which were close to existing roads as shown on the maps; less accessible locations were considered only when the profiles to the points first selected were found to be unsatisfactory.

As a result of this study, a chain of seven preferred sites was chosen, together with a number of alternates in case the first choices proved to be unavailable. The route finally obtained is shown in Figure 1. The average length of the eight repeater sections is 27.5 miles. The longest section is 35 miles, and the shortest about 11 miles. Before the sites were actually purchased, the ground elevations at them and also at high points along the transmission paths were checked against known elevations with a precision altimeter. This was done as a precaution against possible inaccuracies in the topographic maps. A final check on the suitability of the sites was obtained from radio transmission tests carried out with portable equipment. Representatives from the Long Lines Department and from the associated companies in the New England area collaborated in the task of determining the route and securing the sites.

The choice of operating frequencies for the relay system has an important influence on antenna and tower design, as well as on the output power requirements of the repeaters. Broadly speaking, frequencies in the range from 1,000 to 10,000 megacycles have possibilities for microwave relaying. There are advantages to be gained from using frequencies as high in this range as practicable. By so doing, antennas of moderate size can be built which will provide high directivity. This confines the radiated power to a narrow beam, thereby reducing repeater power requirements and also the possibility of interference into and from neighboring systems. However, frequencies in the upper part of the 1,000 to 10,000 megacycle range are subject to rain attenuation, the severity of which increases rapidly with frequency. Furthermore, the Neshanic tests showed that fading tends to be worse at the higher frequencies. With these considerations in mind, frequencies in the vicinity of 4,000 megacycles were finally chosen for the system between New York and Boston.

To transmit the two two-way broadband channels, four radio frequency bands, each about 10 megacycles wide, are employed. These bands are centered at 3,930, 3,970, 4,130 and 4,170 megacycles, and they are used in pairs. One pair is required for each two-way channel. Whenever the signal goes through a repeater, however, a frequency change is made, 3,930 to 3,970 megacycles for example, to avoid interference between the high-level outgoing and the low-level incoming signals. In the next repeater station, the change is from 3,970 back to 3,930 megacycles. Two frequencies are thus used for transmission in one direction through the system, but the same two frequencies are also used for transmission in the opposite direction. The method of changing these frequencies, which is illustrated in Figure 2, is such that there is never a high-level and low-level signal of the same frequency at any one repeater station.

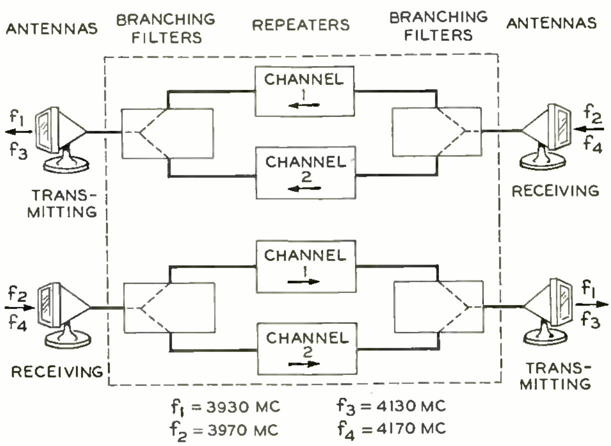


Fig. 2—Frequencies are shifted at repeater stations to prevent having signals of high and low level at the same frequency

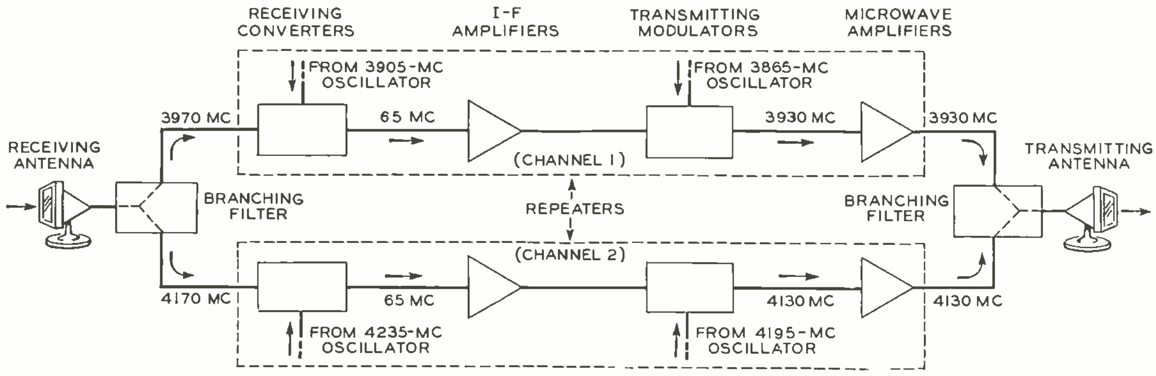


Fig. 3—Block diagram of a repeater station

Four shielded lens antennas* of high directional discrimination are provided at each repeater station. Separate antennas are used for transmission and reception, but each antenna handles both channels; one pair of antennas receives and transmits the two channels in one direction, and the other pair receives and transmits the two channels in the opposite direction, as indicated in Figure 2. Branching filters separate the channels at the outputs of the receiving antennas and combine them at the inputs to the appropriate transmitting antennas after they have gone through individual repeaters.

Each repeater in the system is required to introduce sufficient gain to offset the loss in the preceding radio path. Some of this gain is obtained from a microwave amplifier, but the greater part is supplied by an intermediate-frequency amplifier at 65 megacycles. A block diagram of the essential elements of a repeater is shown in Figure 3. The incoming microwave signal is brought down to 65 megacycles in the

*Record, *May,* 1946, *page* 193.

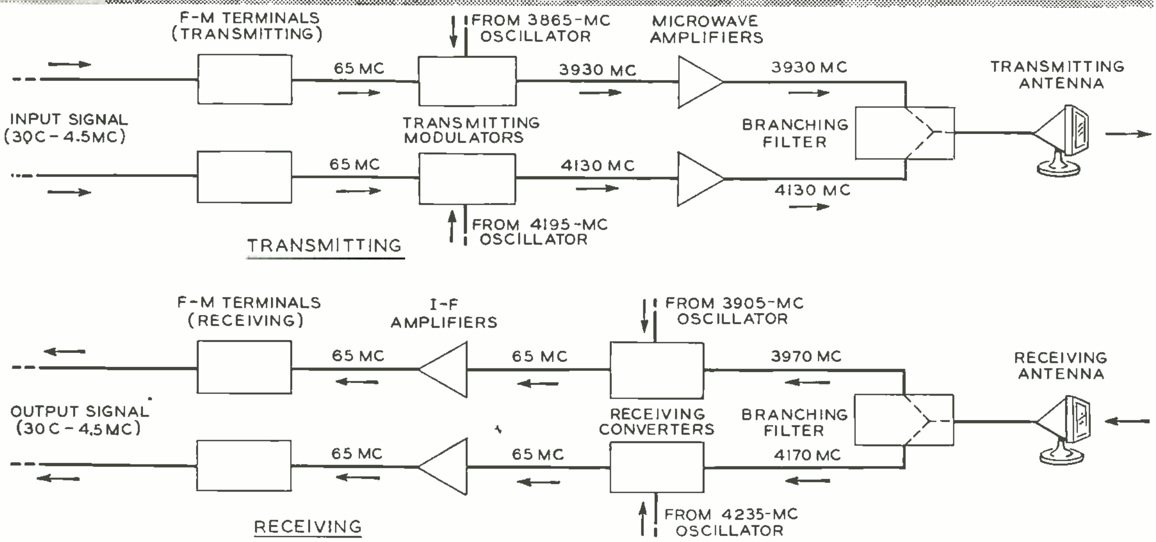


Fig. 4—Block diagram of a terminal station

receiving converter. After amplification at this frequency, the signal is translated back to the microwave range by the transmitting modulator, where it is further amplified and applied to the transmitting antenna.

At the New York and Boston terminal stations, equipment is provided for putting the multiplex telephone, television or other broadband signals onto the outgoing radio relay channels, and for removing them from the incoming radio channels. Block diagrams of the essential elements in the terminal stations are shown in Figure 4. In the transmitting terminal equipment, a 65-megacycle carrier is frequency modulated by the broadband input signal. This modulated carrier is then translated to the microwave range and amplified, using transmitting modulator and microwave amplifier units similar to those in the repeaters. At the receiving end, the 65-megacycle frequency-modulated carrier is obtained from a receiving converter and intermediate frequency amplifier similar to the corresponding units of a repeater. This modulated carrier is delivered to the receiving terminal equipment where the original multiplex telephone or television signal is recovered. Further information on the system will be covered in forthcoming issues.

THE AUTHOR: A. L. DURKEE received the degree of B.S. in Engineering from Harvard University in 1930 and joined the Department of Development & Research of the American Telephone and Telegraph Company in July of that year. There, and as a member of the Laboratories following the consolidation in 1934, his work has been largely on radio transmission problems associated with the development of transoceanic and other radio telephone circuits. Recently he has been engaged in studies relating to microwave radio relaying.

Revised Values for Electrical Units

On January 1, 1948, new values of the electrical units will be introduced by the Bureau of Standards. These changes have become necessary because in the years since the various standards were originally established, it has become possible to measure them with greater precision. Changes have been under consideration by an international committee for the last twenty years, and were scheduled to go into effect in 1940, but were postponed by the war.

The values of the new, or absolute, units in terms of the old, or international, units are given in the accompanying table, which is based on figures published by the Bureau of Standards in Circular C-459. Since the changes are small, in only three instances approaching 0.05 per cent, they will affect for the most part only high precision measurements. Since September 15, our Electrical Measurements Laboratory has furnished calibrations of reference standards in the new units unless specifically requested to do otherwise.

NEW VALUES FOR ELECTRICAL UNITS

1 absolute ohm	=	0.999505 international ohm (U.S.)
1 absolute volt	=	0.99967 international volt (U.S.)
1 absolute ampere	=	1.000165 international ampere
1 absolute coulomb	=	1.000165 international coulomb
1 absolute henry	=	0.999505 international henry
1 absolute farad	=	1.000495 international farad
1 absolute watt	=	0.999835 international watt
1 absolute joule	=	0.999835 international joule

FREQUENCY-SHIFT RADIO TELETYPE IN WORLD WAR II

R. A. VANDERLIPPE
Telegraph
Development

At the beginning of the war, most of the Army and Navy single-channel radio telegraph systems were operated by manual or automatic keying of such a nature that radio-frequency energy was radiated while the keying circuit was closed and no signal was radiated while it was open. Although having the advantage of simplicity, such a system is sensitive to the effects of fading, which is common at medium and high frequencies used over long-range radio paths. Automatic volume control can offer only partial compensation, since it must be very slow acting to avoid amplifying the noise to full signal level during the "key open" portion of the signals, and thus losing the distinction between signal and no signal. By using highly skilled operators, communication is possible even with moderately bad fading, however, since a well-trained ear can recognize codes even when some of the pulses are barely distinguishable from the noise. With teletypewriter transmission, on the other hand, a lost or false pulse results in printing a wrong character, and if the fading is frequent, entire messages may be lost.

What was desired by the Armed Services

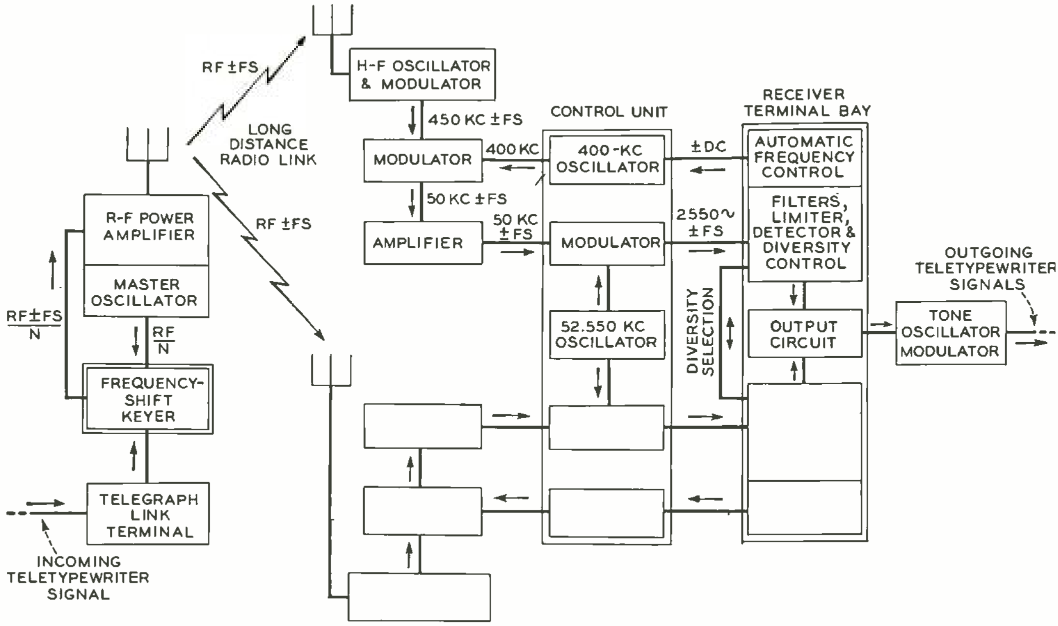


Fig. 1—Block schematic of the Navy's AN/FGC radio teletypewriter system. The frequency-shift keyer developed for this system is shown in Figure 2

was terminal apparatus that would permit teletypewriter operation over existing radio telegraph circuits so as to take advantage of the existing radio transmitters and receivers as well as to permit operation by less highly trained personnel. To avoid the effects of fading by taking advantage of fast-acting volume control, it would be necessary to radiate signal continuously. For this reason, the frequency-shift or FS method of operation was adopted. With this method, the continuous radiation from the transmitter is shifted slightly in one direction from its mean frequency for the "mark" pulses and slightly in the other direction for the "space" pulses. With continuously radiated signal, volume control may be made as fast acting as desired, using the principle of peak current limiting, and in addition, the capability of the transmitter signals to override noise is approximately doubled because of the frequency modulation.

The existing radio telegraph systems used space diversity reception; that is, two or more radio receivers were at different locations so that while fading was occurring over the path to one, it probably would not be occurring over the path to the other. With such a system, usable signals are generally available from one of the receivers even under conditions of severe fading. By taking full advantage of space diversity reception and of a number of other factors in addition to FS transmission, highly satisfactory teletypewriter channels were obtained by means of using only two-path or "dual" diversity reception.

Terminal equipment for converting radio transmitters and radio receivers to FS teletypewriter operation was developed for both the Army and Navy. In general features, the equipment developed for both services was alike, but differences in the existing radio transmitters and receivers of the two services and somewhat different requirements resulted in minor differences in the individual pieces of equipment. The first FS system developed by the Laboratories was the AN/FGC. The Navy version of this system is shown in block schematic form in Figure 1. For the transmitter, the unit developed by the Laboratories was the frequency-shift keyer shown

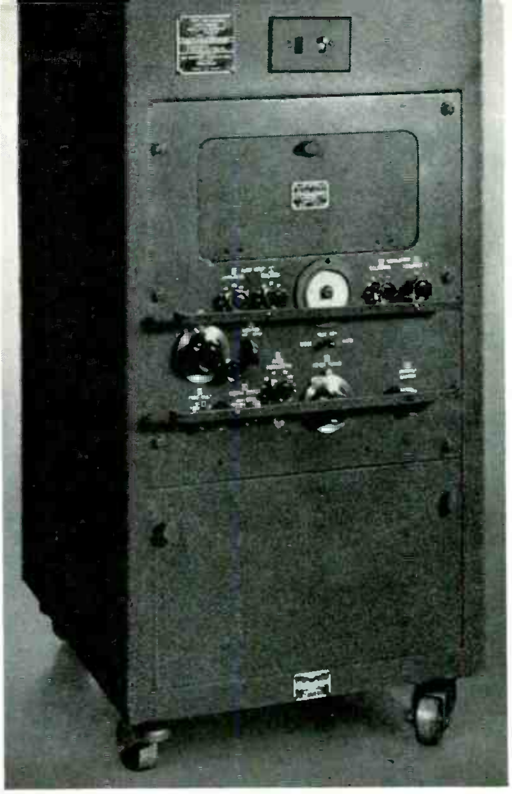
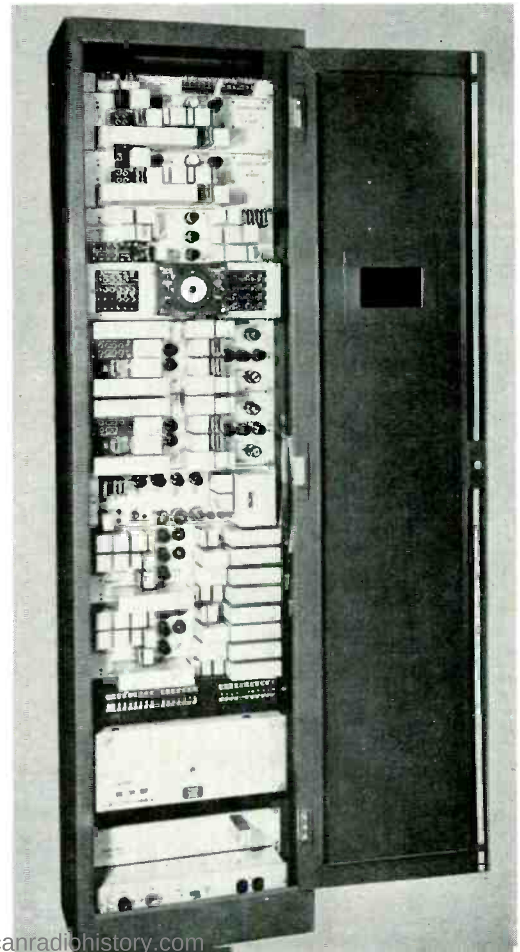


Fig. 2—The frequency-shift keyer developed by Bell Telephone Laboratories

Fig. 3—Receiving terminal for the AN/FGC radio teletypewriter system



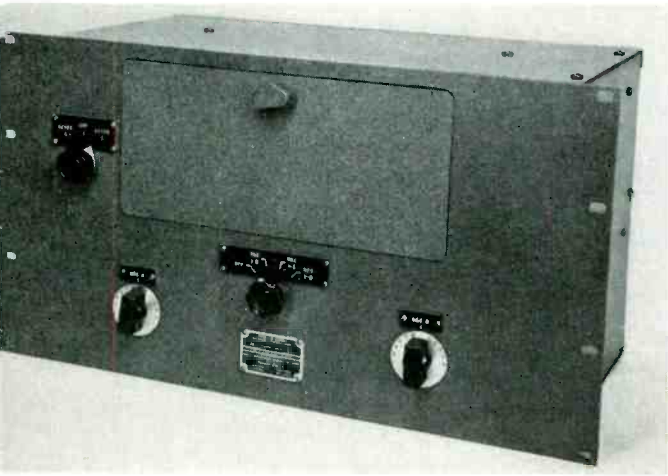


Fig. 4—Control unit for the AN/FGC system

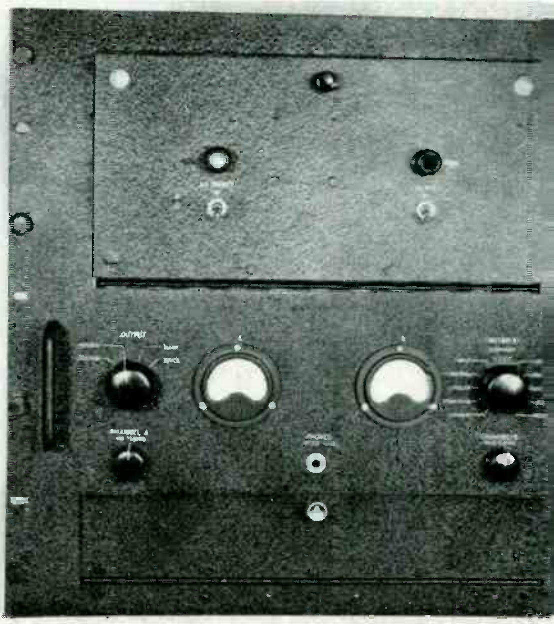


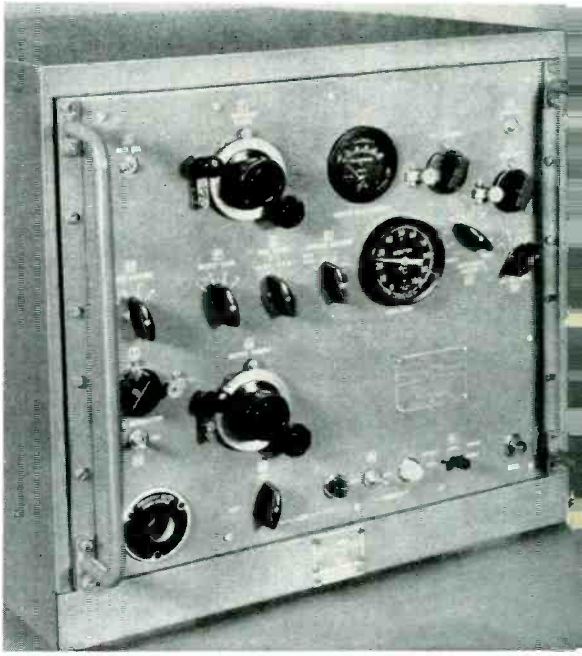
Fig. 5 (right)—Receiving converter for the FRF system whose performance is superior to the FGC system

in Figure 2. Both the d-c teletypewriter signals and a sub-multiple of the transmitter frequency are supplied to this unit. Electronic circuits within the keyer shift the sub-multiple of the radiated frequency above or below its mean value, depending on whether the incoming telegraph pulses are mark or space. In the radio transmitter, the output of the keyer is multiplied up to the radiated frequency and is also amplified.

Two units were supplied for the receiving end: a receiving terminal bay shown in Figure 3 and a control unit shown in Figure 4. Although these equipments were developed under high pressure and with very little operating experience to guide the designers, they gave very satisfactory service, and many of them were used throughout the war. Within a short time after they were put in service, a large part of long-haul military communications was being handled by radio teletype.

The success of the new teletypewriter system made it desirable to apply the teletype method of operation to radio telegraph channels that had not been considered in the design of the FGC system. Moreover, experience gained by the Laboratories in designing the latter system and experience from its operation indicated that a number of improvements could be made. As a result, the FRF and FRH frequency-shift receiving converters were developed at the request of the Bureau of Ships of the Navy. Requirements, both as to the size and performance of these units were more severe

Fig. 6—The model FSA frequency-shift keyer



than for the FGC system. Instead of the two units shown in Figures 3 and 4 for the FGC receiver, all the receiving apparatus of the FRF or FRH is mounted in a single unit about one-third the size of the AN/FGC bay. The FRF equipment is shown in Figure 5. The FRH unit is almost identical, differing only in required input frequency. Field tests with experimental models of the FRF and FRH equipment indicated that in spite of greatly reduced size and weight, their performance was superior to that of the FGC.

Besides this new receiver converter, the Bureau of Ships also asked the Laboratories to design a new frequency-shift keyer that would have nearly universal application to radio transmitters in the Navy radio telegraph plant, including shipboard as well as land stations. The Model FSA Frequency-Shift Keyer developed to meet this need is shown in Figure 6. In this equipment, the frequency of a 200-kc temperature controlled oscillator is shifted by electronic means in accordance with the telegraph signals to be transmitted. This output of 200 kc ± the frequency shift is used to modulate a radio frequency obtained from either a crystal controlled r.f. oscillator circuit contained in the keyer or from an external r.f. oscillator, thus producing at the modulator output a side-band component having a frequency of the r.f. plus 200 kc ± the frequency shift. This signal component is selected and amplified to a level sufficient to drive the input amplifier stage of the associated radio transmitter. Controls on the keyer provide for rapid adjustment of the circuit when a change in radio transmission conditions necessitates changing the radio frequency of the radio transmitter. Three different crystals are provided in the keyer to provide for three optional selections of this frequency.

To make the advantages of frequency-shift radio teletype available to the tactical forces of the Army, a mobile radio teletype terminal was required. In coöperation with the Coles Signal Laboratory of the Signal Corps, the AN/MRC-2 modification of Radio Set SCR-399 was designed for this purpose. The transmitting, receiver, and operations center portions of the terminal are mounted in separate transportable shelters. This makes it possible to place the transmitting and receiving units in the most suitable strategic locations with respect to the operations center.

The Dual Diversity Converter CV-31/-TRA-7, used in the receiving shelter, is a modification of the basic design used for the Navy Model FRF Frequency-

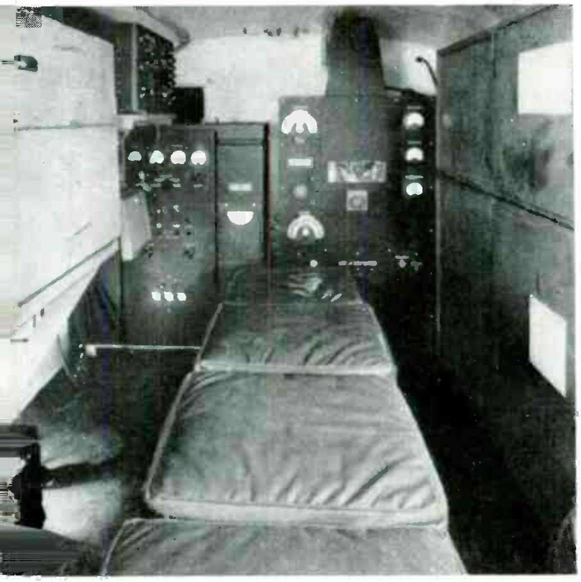


Fig. 7—Transmitting shelter for the AN/MRC-2 mobile radio teletype system

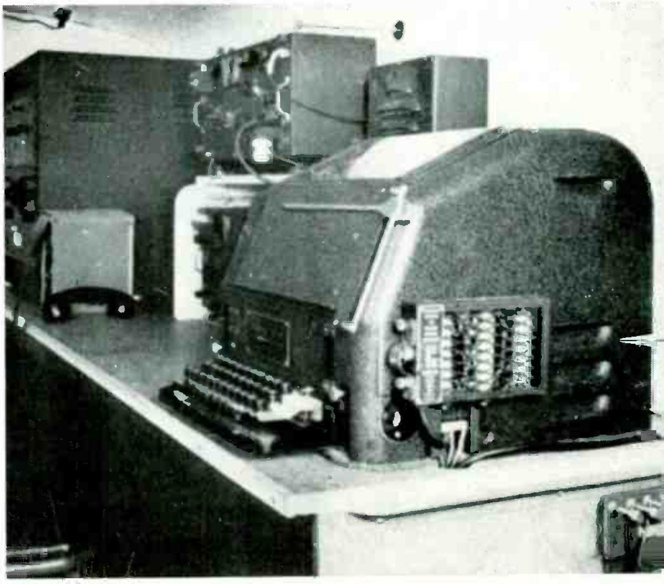


Fig. 8—Receiving shelter for the AN/MRC-2 mobile radio teletype system

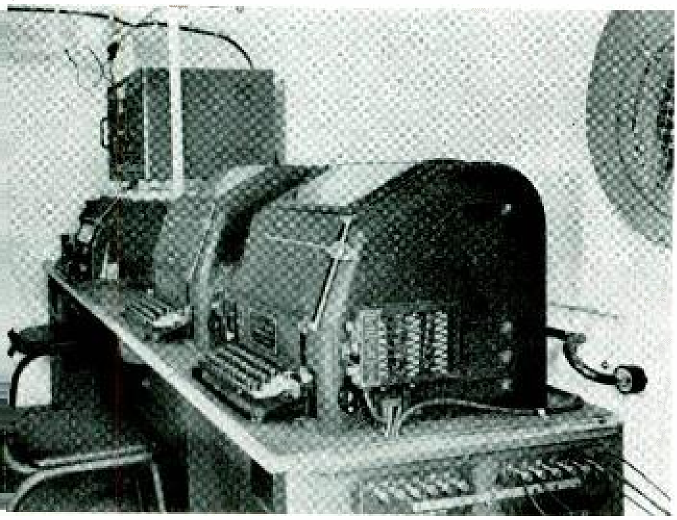


Fig. 9—Operating shelter for the AN/MRC-2 system

Shift Receiver Converter. Control Unit C-292/TRA-7, used in the operations center, provides for interconnecting the transmitting, receiving, and operations center equipment to provide three types of telegraph operation, as well as for emergency control of the radio transmitter on an on-off or frequency-shift basis from the receiving shelter. Frequency-shift exciter O-39/TRA-7, located in the transmitter shelter, is a temperature controlled electronic master oscillator for supplying radio frequency input to the power amplifier stages of the radio transmitter and has provision for either on-off or frequency-shift keying. This group of three units, which were the Laboratories' contributions to the MRC-2 system, has the over-all designation Radio Teletype Equipment AN/TRA-7.

Interior views of the three shelters are shown in Figures 7, 8 and 9. Field reports from military forces using the AN/MRC-2 terminals indicate that, as compared with older designs of frequency-shift equipment, the performance is at least as good and in some cases better. Furthermore, the mobile terminal can be placed in operation in hours, as compared with five or six days for the fixed plant equipment.

By 1944, the radio teletypewriter network had been extended to every part of the world under Allied control. Teletypewriter conference connections between groups of people separated by thousands of miles became common, and the work of Government officials as well as military leaders was greatly benefited.

THE AUTHOR: R. A. VANDERLIPPE attended the University of Omaha and the University of Nebraska from 1925 to 1930, receiving the degree of B.Sc. in E.E. from the latter. While attending Nebraska he also worked as toll-test boardman and equipment engineer. He joined the Laboratories in 1930, and worked on voice-frequency carrier telegraph and d-c telegraph circuit design problems. Later he supervised laboratory testing of telegraph transmission circuits and laboratory and field testing of private line telegraph switching systems. During World War II he was concerned with the development of voice-frequency carrier telegraph systems used by the Army and of long-haul radio teletype apparatus and systems used by the Army and Navy. At present Mr. Vanderlippe is a supervisor responsible for the development of the No. 2 telegraph office in which extensive use will be made of electronic circuits.

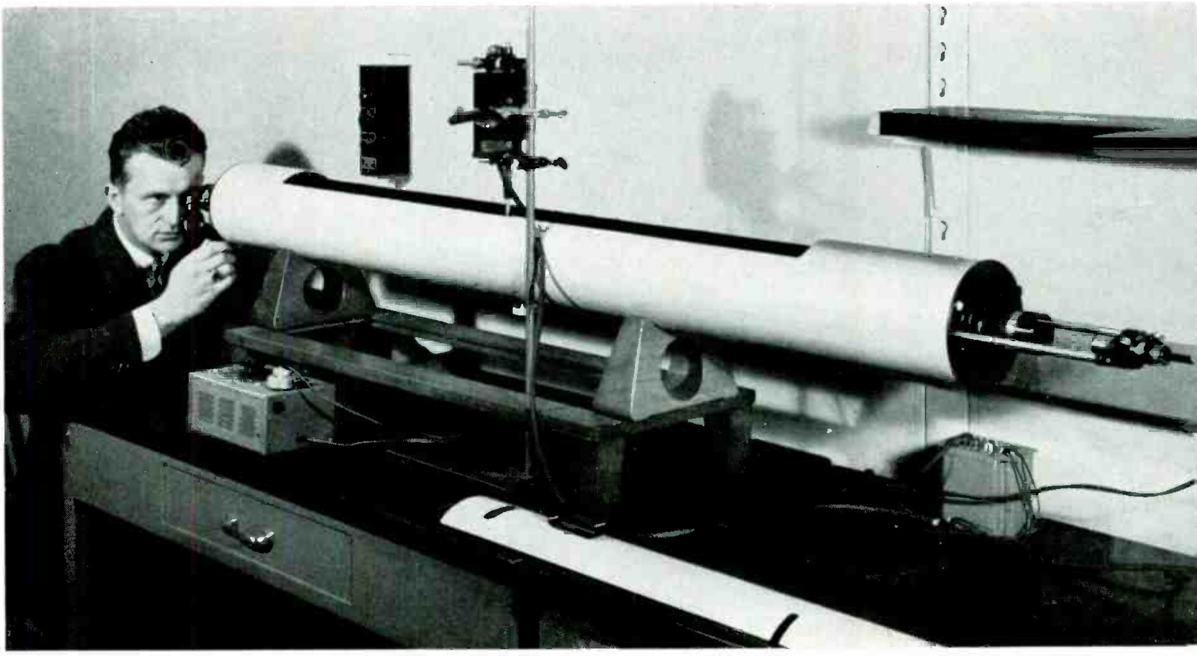
W. O. BAKER
Chemical
Laboratories

CONTROL OF COMPOSITION OF SYNTHETIC RUBBER

The wartime crisis in Allied rubber supply was decided by selecting as the general purpose synthetic substitute a compound made largely from butadiene. To this hydrocarbon was added a smaller percentage of another, styrene, which had been previously found to yield a copolymer that was stronger and easier to process than polymerized butadiene alone. It had also been established abroad and confirmed by coöperative studies of the American rubber industries, that a fairly narrow range of styrene content in the final copolymer gave the best synthetic rubber. Thus, a principal factor in executing the national rubber program was adequate control of the uniformity and hence composition of this synthetic copolymer. Uniform mass production would otherwise have been impossible with a material even more variable than natural rubber.

When a few of the giant plants in which the rubber was made had begun to produce in 1943, the proportions of butadiene and styrene combined in the product were estimated by comparing the weights of the two raw materials put into the reaction chamber with that of the copolymer produced plus the unreacted raw materials recovered. This scheme had the disadvantages that all control had to be done at the reaction equipment and that the measurements were of limited and unproved accuracy. The behavior of one in-

Fig. 1—Quality control of Government synthetic rubber was maintained at first by determining each week, with an interferometer, the refraction of samples of the product in dilute solution. J. H. Heiss, Jr., is shown making a measurement



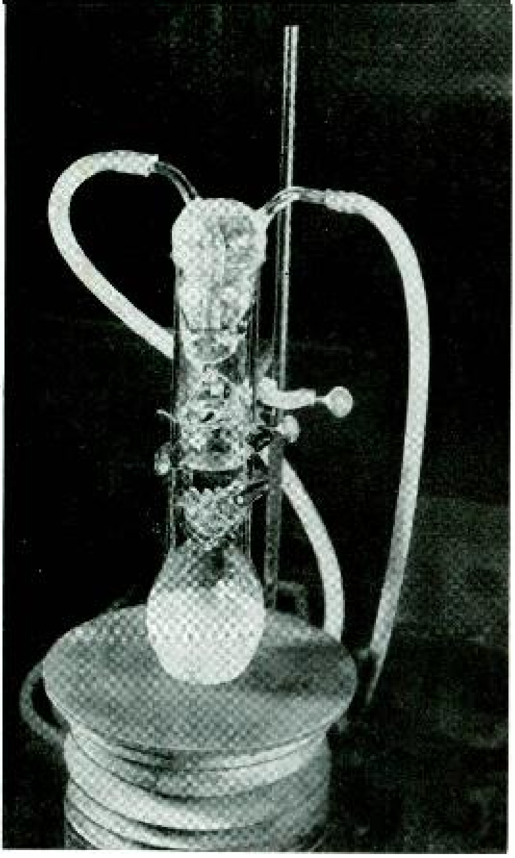


Fig. 2—Synthetic rubber copolymer was separated from other ingredients by extracting it with a constant boiling mixture of toluene and ethyl alcohol

stallation compared with that of another was also obscured in subsequent blending operations and the scheme was cumbersome and inaccurate for following composition during the actual progress of polymerization. In another approach, considered by at least one rubber company, the refractive index of the copolymer was measured and related to the fact that butadiene molecular units have, for equal weight, markedly lower refractive indexes than those of styrene. This method was apparently abandoned, however, because impurities in the sample and other uncertainties caused scattered and inconsistent results.

With the need of large scale production of synthetic rubber in prospect, R. R. Williams of these Laboratories was asked to undertake the organization of a research program. The requirement for more exact control of the chemical composition of the Government-sponsored product, GR-S, became urgent and several possible methods were considered by the Laboratories. These included: the measurement in a spectrophotometer of the selective absorption of light of short wave-lengths by the styrene groups; the measurement of the high magnetic susceptibility of the phenyl groups in the styrene; the chemical measurements of reagents preferentially absorbed by the double bonds in the butadiene molecular units; and the measurement of the hardening at low temperatures of the copolymers, which is greater the higher the styrene content. Also examined were determination of the total atomic composition of the copolymer by combustion and chemical analysis of the gases evolved, and by estimating the specific refraction determined from the refractive index and the density of the pure copolymer.

All of these schemes had virtues and faults, although some were readily discarded on the basis of inaccuracy and slowness. Measurement of the refraction,

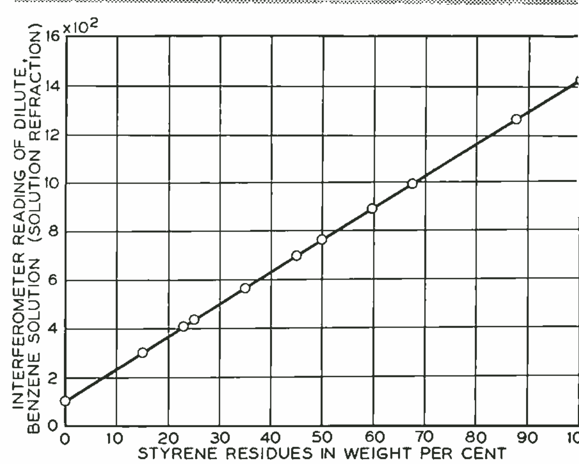


Fig. 3—The relation between interferometer readings and styrene content was determined by measuring solutions that contained known amounts of styrene units

which takes advantage of the fact that light is slowed down more in passing through the electron atmosphere of styrene groups than through that of butadiene, appeared most promising. This basic characteristic of matter is relatively unaffected whether the test sample is in the solid, liquid or gaseous state. It reflects primarily the atomic configuration peculiar to a particular molecule and is only secondarily altered by the proximity of other molecules. This was the kind of property wanted to control GR-S.

Studies of the specific refraction of comparatively dilute solutions or dispersions of synthetic rubber in pure solvents were accordingly made, Figure 1. This avoided difficulties of optical measurements on gummy, discolored polymers. It also eliminated the uncertainty of how varying chemical composition, and especially differences of molecular shape, would affect the density of solid rubber, which is a considerable factor in measurement of refractive index alone. By the use of dilute solutions, the copolymer molecules were put far apart from each other and questions of how they would pack together in a solid were avoided. Liquids were selected so that the density of these solutions was nearly that of the pure solvents.

The necessary determinations then became simply (1) purification of the copolymer so that soaps and salts necessary in emulsion polymerization, and stabilizers added later, were quantitatively removed; (2) weighing the purified copolymer into an exact volume of pure solvent; and (3) accurate measurement of the refractive index of the solutions or dispersions thus prepared.

Purification of the copolymer presented difficulties, including that of separating numerous organic molecules without changing the composition of the polymer itself. It had to involve simple reagents and to be rapid but essentially complete. Advantage was taken of the peculiar properties of mixtures of organic liquids called azeotropes. Such a mixture of toluene and ethyl alcohol represents a balance in molecular forces between those of the toluene, which would dissolve all of the synthetic rubber and its foreign components, and the ethyl alcohol which would dissolve the foreign components but would have great difficulty in swelling and penetrating the copolymer to reach them. This mixture was used to separate the synthetic rubber copolymer from other ingredients of the GR-S system

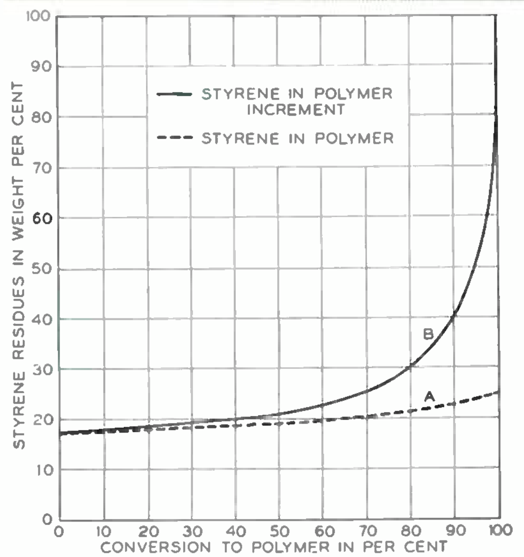


Fig. 4—Line A depends on the extent to which the raw materials have been converted to copolymer. Line B shows that chains forming at 90 per cent conversion would have 40 per cent styrene

by extraction of the solid material, Figure 2. Specifications for all of the GR-S rubber produced during and since the war require that it have a proportion by weight extractable with ethanol-toluene azeotrope that falls within certain limits.

A purified hydrocarbon copolymer was thus provided, but it had to be in solution before the optical measurements could be made to establish its composition. Hence the purified copolymers were dispersed in pure benzene and their relative refractivity was compared in an interferometer, Figure 1, with that of the benzene. This instrument has a precision among the highest of any physical apparatus. It measures, by means of the displacement of interference fringes, the speed of light through a cell containing, in this test, pure benzene compared with that of a beam through a cell filled with the copolymer and benzene.

Measurements were made to standardize the apparatus on pure polybutadiene and on polystyrene. In terms of the molecular groups involved, all the copolymers of styrene and butadiene in synthetic rubber had to lie between these limits. Confirmation of this was obtained by measuring copolymers in which the styrene content was carefully estimated by the unreacted raw materials left and, less effectively, by combustion, Figure 3.

A third scheme for this standardization was also employed in which a chlorine atom was attached to each of the styrene molecules before polymerization. Then the absolute proportion of this chloro-styrene group in the final copolymer was established by accurate chemical analysis for chlorine and compared with the value obtained by refraction. All these calibrations showed that the refraction method gave adequate and convenient measurement of copolymer composition.

The first application of this technique improved synthetic rubber by changing the composition rather than by controlling it. When the method was established, a few scattered plants had actually begun to produce GR-S, and the styrene content of a variety of samples from these plants was examined. In the spring and summer of 1943, most GR-S contained about 20 per cent of styrene although in a few exceptions it ran as high as 25 per cent. Since 25 per cent of styrene was actually added in the reaction chamber, and was also considered to be a desirable amount to have in the final copolymer, it appeared that our

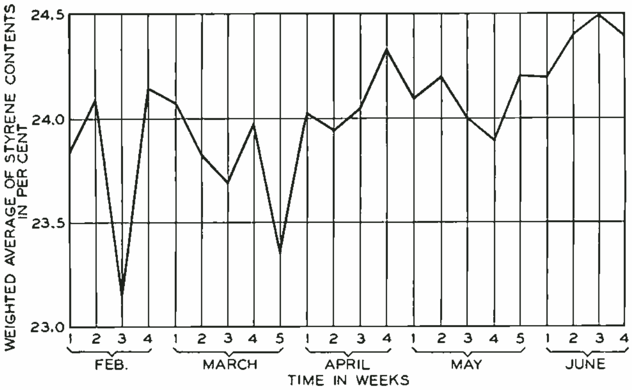


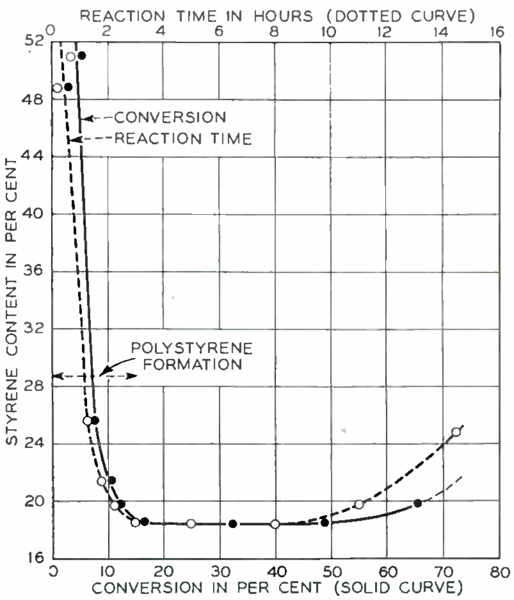
Fig. 5—Weighted average of the styrene content in Government rubber production from February through June, 1943. *The wide early fluctuations disappeared and the styrene content increased, showing the improvement due to quality control*

American product was not coming out at optimum composition. Also, some samples of German Buna S, captured at that time, were examined and found to have 24.3 and 24.8 per cent of styrene.

Studies showed that styrene incorporated in the copolymer while it was being formed was considerably less than that with which the reaction chamber was initially charged, Figure 4. Thus, it was strongly urged that more styrene be added initially so that the value in the final copolymer would be nearer 25 per cent. This was an expeditious plan also because the production of styrene compared to butadiene would favor use of more of the former. Accordingly, at the end of 1943, the Office of the Rubber Director increased the styrene charge to 28 per cent, somewhat short of the 30 per cent recommended but adequate to cause marked advantages. Recently, it has been found that the Germans actually charged at the 30 per cent ratio for some of their newer copolymers.

In 1943, fifteen huge plants in this country and one in Canada began to turn out the new synthetic product, in tonnage exceeding that of any comparable material in history. By arrangement with the Rubber Reserve Company, small samples representing selected blends of the whole production were sent weekly to these Laboratories from each plant. The samples arrived by air express and were promptly purified, chiefly by C. L. Luke and F. C. Koch. Their styrene content was then determined in solution by refraction by J. H. Heiss, Jr., and reported to the Rubber Reserve Company in Washington. Soon the wide week-to-week fluctuations of particular plants disappeared, Figure 5. This control of the composition of the copolymer also assured less variation from the optimum styrene content from batch to batch.

In Figure 4, the composition of the synthetic rubber is seen to change quite steeply, even in the range of 60-80 per cent conversion. The quality of the product is affected by fluctuations in the per cent conversion, even beyond those induced by change in styrene content itself. Hence, accurate measurement of styrene content and control of it within narrow limits provided an automatic gauge of the process.



ig. 6—The initial production of polystyrene in small uantities with some undesirable charging proce- ures weakened the synthetic rubber product

In a mixed system, where quite different chemical units like styrene and butadiene are being charged into a reaction chamber for copolymerization, there is a chance that one may start converting before the other. This was actually found in a few cases, Figure 6, where the styrene was converted to polystyrene in small proportion when certain charging procedures were used. The hard, resinous, inelastic polystyrene was subsequently incompletely dispersed in the true synthetic rubber by ordinary processing, and caused tearing and flaws in some instances intolerable in military and civilian use. Composition studies permitted the development of procedures that eliminated the independent polymerization of styrene.

It had been planned from the beginning to develop a method for copolymer control which could be readily used in plant laboratories. This required simpler apparatus than the interferometer. Hence, the feasibility of refractive index measurements, as contrasted with solution refraction, was explored further. It was recognized that such measurements on solid polymers, as distinguished from solutions, had to be done above the temperature at which their coefficient of thermal expansion changed. The critical points were, again, thorough purification of the copolymer and preparation of the sample so that good optical contact between it and the prism in the refractometer was assured. Cross-check programs with the National Bureau of Standards and some of the rubber companies soon established that adequate and useful quality control could be achieved in this way. In the autumn of 1944, all of the tests of currently produced synthetic rubber were transferred to the National Bureau of Standards in Washington and were thereafter measured there by this means. It was urged that the procedure be advanced to the next step of making the tests in the control laboratories of the various rubber plants and this was later accomplished.

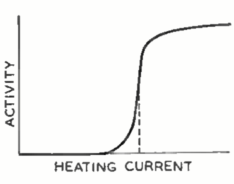
This investigation was carried out under the sponsorship of the Office of Rubber Reserve, Reconstruction Finance Corporation, in connection with the Government's synthetic rubber program.

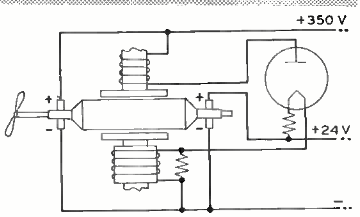
THE AUTHOR: W. O. Baker was graduated from Washington College in 1935 with a B.S. degree and then went to Princeton University for graduate study. He held the Harvard and Proctor fellowships at Princeton and received his Ph.D. there in 1938. In 1939 Dr. Baker joined the Laboratories to carry on investigations of the molecular structure of polymers. Recently, this has led to studies of the fundamental constitution of synthetic rubbers.

HISTORIC FIRSTS: ELECTRONIC VOLTAGE REGULATOR

In providing airplane radio telephone apparatus for the Army during World War I,* one of the important needs was a quiet power supply for the vacuum tubes. Weight, in these early years of the airplane, was of particular importance, and thus storage batteries, which would otherwise have been satisfactory, were ruled out. Instead, a small wind-driven generator was employed. It consisted of a direct-current generator in a streamlined housing with a two-blade propeller on its driving shaft. The speed of such a generator varies with that of the airplane, and thus it was necessary in addition to provide some form of regulator to maintain the voltage constant regardless of speed. Tirrill type regulators, the most satisfactory in use at that time, employed a relay that operated and released at well-defined values of voltage only a small percentage apart. When the relay operated, it opened a pair of contacts in a short-circuit path across a resistance in series with the field winding of the generator. As a result, the field current was reduced and the voltage generated was decreased. When the relay released, on the other hand, it would short-circuit this series resistance and thus increase the generated voltage. By this means, the voltage swung between the two values at which the relay operated and released, the rate of vibration of the relay contacts depending upon the time constant of the generator field circuit.

*Record, *January*, 1944, *page* 221.





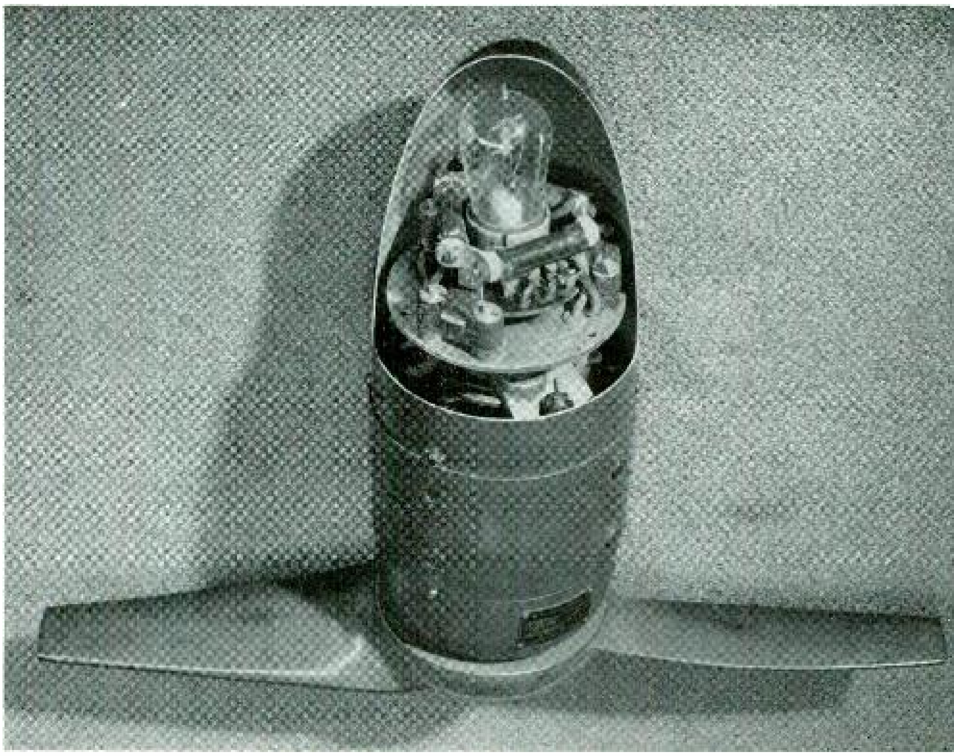
So far as the voltage limits of regulation were concerned, a regulator of this type would have been satisfactory for a wind-driven generator. A graph of the output voltage regulated in this manner, however, follows a saw-tooth pattern, and analysis reveals the presence of a very wide range of frequencies running upward from the frequency of the relay operation. It was at once found that these frequencies in the supply voltage played havoc with the operation of the radio apparatus. Either elaborate filtering and shielding precautions would have to be taken, or a more satisfactory regulator provided.

To meet this need, H. M. Stoller invented an electronic regulator that proved highly satisfactory. His work in this field laid the foundation and set the pattern for a whole family of regulators,* not only for controlling voltage, but for controlling speed as well. His first patent application was filed on April 22, 1918, but subsequent applications, covering modifications and other uses, were filed on July 12, 1918, June 11, 1919, and July 24, 1919. The design finally employed for the wind-driven generator was outlined in his second application, which was issued as Patent No. 1,930,911 in October, 1933. All of the proposed arrangements employ a vacuum tube—either a diode or a triode—as the major controlling element. One form of the circuit outlined in this patent is shown at the left. The generator has a low-voltage and a high-voltage armature winding, and one of the two generator field windings is connected in series with the filament of a diode across the low-voltage commutator. The filament is preferably made of tungsten to secure a stable relationship between plate and fila-

**Journal of the Society of Motion Picture Engineers*, September, 1926, page 696.

ment currents. The second field winding is connected in series with the plate of the diode across the high-voltage commutator, but in a sense to oppose the field of the first. At the left of the circuit diagram is shown the relationship between plate current and filament or heater current, and the circuit was designed so that with the desired output voltage, the tube was operating on the steep section of curve where a very small change in filament current causes a very large change in plate current. Should the voltage increase above the desired value, more current would flow through the filament and cause a relatively large increase in plate current. Since this latter current flows in an opposing field winding and its increase is greater than

Besides eliminating the relay contacts required with the previous regulators, and thus avoiding changing characteristics as the contacts wore, this arrangement gives added sensitivity because of the steepness of the curve relating plate and filament currents. Its chief advantage in controlling the supply to radio apparatus, however, is that it eliminates the saw-tooth pattern of the voltage output. The control action is continuous instead of intermittent, as with the relay type controller, and the voltage remains substantially constant in spite of variations in speed, load or temperature. To avoid "hunting," a heavy copper damping sleeve was placed over the pole carrying the main winding, while no damping was used on the control-winding pole.



that of the current in the main winding, its effect is a net decrease in magnetic flux, and the generated voltage will decrease. A decrease in voltage, on the other hand, causes a decrease in filament current, a cooling of the filament, and thus a much greater decrease in opposing field current. As a result, the net flux increases, and the voltage generated becomes greater.

Another great advantage was that the entire controlling circuit consisted only of a small vacuum tube and a few resistances, which were mounted in one end of the motor housing, as shown in the photograph above. This electronic voltage controller made the wind-driven generator practicable, and thus made substantial contribution to airplane radio telephony.

A RELAY SENSITIVITY TEST SET

E. T. BURTON
Switching
Research

Relay test sets, which have long been standard Bell System equipment, usually operate on one of two principles. Either pre-set currents are used on a go-no-go basis or hand-controlled currents are applied to actuate the relay. In studying relay performance during laboratory tests, however, a more precise device is called for, since important data may be obtained by measuring sensitivity from time to time and analyzing the changes that may appear. A satisfactory instrument for this purpose must be accurate and stable. Its performance must be, so far as possible, free from influence of the operator, and at the same time it must be convenient to use, and readily adaptable to measurement of any type of relay. To meet these requirements, the D-176431 relay sensitivity test set was developed by the Laboratories.

The basic circuit of the test set is illustrated in Figure 1. The winding of a relay to be tested is connected in series with the meter, a battery, and the plate circuit of a triode. Between the grid and cathode of the triode is a large capacitor C, which may be slowly charged or discharged through a high resistance R, thus changing the grid voltage. This, in turn, controls the plate current, which passes through the relay winding. The contacts of the relay are connected through controlling key contacts to effect charging and discharging of the capacitor. Suppose the capacitor is initially at a negative voltage, holding the grid at cut-off. No plate current flows, and the relay armature rests on the back contact. When the hand key marked OPERATE is closed, current flows through the back contact of the relay, slowly discharging the capacitor. The grid becomes less negative, and the plate current in the relay winding slowly increases until the relay operates. This opens the back contact of the relay, which is in series with the operate key. The capacitor charge, the grid voltage and the plate current instantly cease changing, and the value of the current at which operation occurred is shown on the meter.

If the RELEASE key is now closed, current flows from the negative battery through the front contact of the relay, and slowly charges the capacitor. This carries the grid negative and reduces the plate current.

Katharine Prival making relay tests with the D-176431 relay sensitivity test set. A glass-sealed relay is plugged in at the left of the set for test

When the relay releases, the breaking of the front contact terminates the change in plate current. The meter now displays the value of release current.

The arrangement of this circuit is such that the operator has no control over the functioning of the test circuit, except in setting up the desired conditions. The rate of current change is slow and smooth. When the relay contact responds, the change ceases instantly, and the current remains steady long enough for an unhurried and accurate meter reading to be made. The characteristics of the triode are not of primary importance, since the tube functions only to vary the relay current as called for by the conditions of the test.

The circuit of Figure 1 shows only the basic principles of operation. Since it would measure only operate current by the opening of the back contact, and release current by the opening of the front contact, the information it gives is too limited for complete studies. However, by adding a fast-acting, glass-sealed relay* for controlling the capacitor charging circuit and other keys and switches to give a greater variety of connections, it is possible to measure the sensitivity characteristics of any type of relay. In simplified form, such a complete circuit may be represented as shown in Figure 2. Four condition-selecting switches are used: switch A provides a choice of voltage for charging or discharging the grid capacitor, thus controlling the direction of change of relay winding current; B selects the front or back contact of the relay under test to indicate its action; C chooses the opening or closing of the contact to give this indication: and D controls the polarity of the current in the winding of the relay under test, since the characteristic may be different under the two conditions.

Using this circuit, the desired test conditions are first set up on the selector switches. In Figure 2, these are shown in a position to measure the operate current as indicated by the closing of the front contact for the NORMAL polarity of current in the relay winding. After these switches have been properly set, the test key is operated, thus applying voltage to the winding (b) of the grid relay. This relay closes the capacitor discharge circuit, and the plate current in the winding of the relay under test increases. When the relay under test operates and closes the front contact, it applies voltage to winding (a) of the grid relay. The currents in the two windings of the grid relay oppose each other, and the relay releases, isolating the grid capacitor. This results in instant stoppage of grid voltage change. In consequence, the plate current remains at the value at which the relay under test operated. If the opening of a contact is to be used to indicate operation or release, switch C is set in the OPENING position, and winding (b) is not used; winding (a) holds the grid relay closed as long as the contact under test remains closed.

The selector switches of Figure 2 provide all arrangements useful for testing any con-

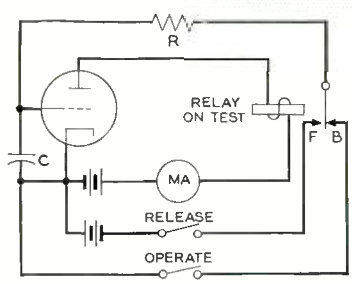


Fig. 1 — Simplified schematic indicating basic operating principles of the relay sensitivity test set

tact combination on either neutral or polar relays. However, in use, the switching would be inconvenient. The test circuit as actually built, although not differing fundamentally from the circuit of Figure 2, is greatly simplified from the operational standpoint by having the test conditions set up and controlled by keys and auxiliary relays. Including a power pack and all apparatus except a meter, it is housed in a small portable cabinet. This circuit, shown in Figure 3, is known as the D-176431 relay sensitivity test set.

A condition-selector switch, at the right of the lower panel, gives four possible combinations pertaining to operate and release functions: front contact only (closing on operate, opening on release); back contact only (opening on operate, closing on re-

*RECORD, *September*, 1947, *page* 342.

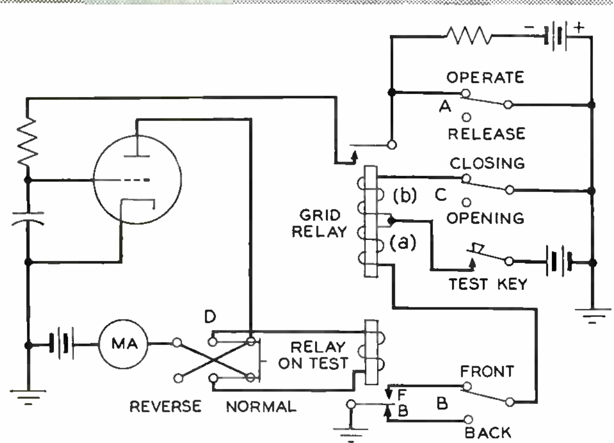


Fig. 2—Simplified schematic of the circuit indicating switching means employed in the equipment to secure a wide variety of tests

lease); closing contacts in a transfer (closing front on operate, closing back on release); and opening contacts in a transfer (opening back on operate, opening front on release). A fifth, central, position of this switch disables the automatic control and allows adjustment of the winding current by the current control knob at the lower left. This permits setting up a maximum or SOAK current. If called for in the progress of tests, the relay may be subjected to this value of current at any time by returning the selector switch to the SOAK position.

A two-position NEUTRAL-POLAR key, just to the left of the selector switch, is set according to the type of relay to be tested. A three-position operate-release key, lower center, is used for initiating the operate and release process. For neutral relays, the central position gives release and the extreme positions give, respectively, operate on PLUS current and operate on MINUS current. With a polar relay, the positive and negative operate positions correspond to MARK and SPACE relay responses.

The power pack includes a mercury relay rectifier, and draws all its power from the 115-volt, 60-cycle supply. Any winding current up to 300 milliamperes may be obtained. The OFF-START-ON switch near the center of the horizontal part of the set is for connecting the mercury relay rectifier to the 60-cycle supply. To the left of this switch are two receptacles. That at the extreme left is for connection to the relay under test. The other receptacle takes a plug-in meter shunt. A number of these shunts are available to provide suitable meter scales for a wide range of currents.

The value of the D-176431 relay test set

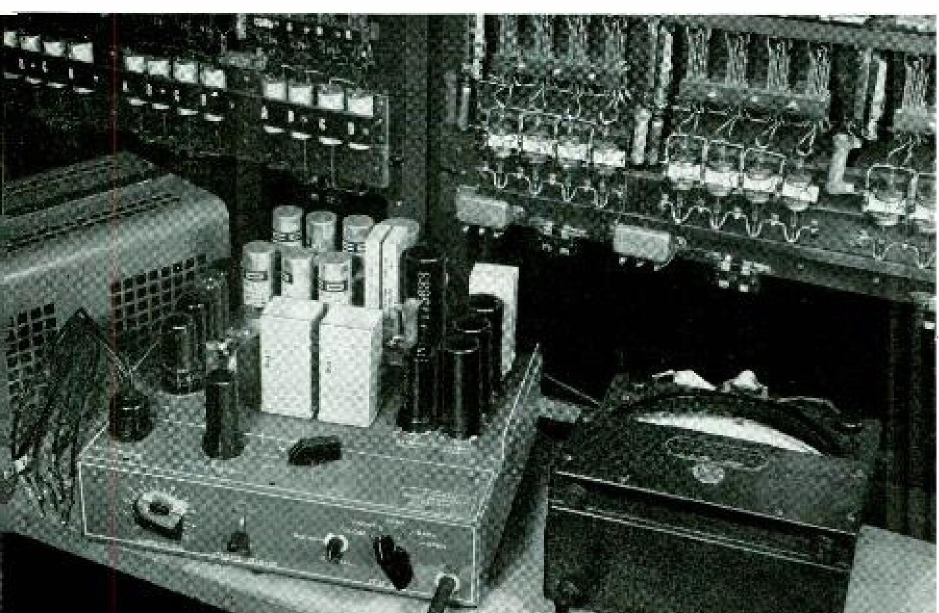


Fig. 3 — The relay sensitivity test set with cover removed to show the circuit elements. Inserted in the test position at the left is a plug with a number of cords which permit connection to be made to any relay to be tested

resides largely in its convenience and accuracy. Experience has shown that inaccuracies due to variation in power voltage, vacuum-tube drift, and operating time of the grid relay are ordinarily so small as to be negligible. As a result, the current read on the meter depicts the response of the relay contact to an accuracy dependent mainly on the meter excellence and the reading skill of the operator. This means that variations of current readings in repetitive operation, or from day to day, or from relay to relay, are true variations with a meaning behind them.

The D-176431 test set has been used mainly on glass-sealed relays, where its accuracy is of prime importance. It has lately come into use in experiments on many other types of relay, demonstrating its general utility as a test instrument.

THE AUTHOR: E. T. Burton majored in Physics at Indiana University, receiving the A.B. in 1920 and the M.A. in 1924. During World War I he served as a second lieutenant in the U. S. Army Engineering Corps and in June, 1920, joined the Laboratories. At first he carried on carrier telegraph research, but in subsequent years worked on magnetic modulation, loaded submarine cables, studies of audio frequency atmospherics, magnetic amplifiers, and relay contact studies—including the development of a high-speed oscilloscope for transient observations. During World War II he worked on the development of power equipment for radar and similar equipment. Since then, he has continued the study of contact protection, particularly with respect to sealed relays.

Thermopane, that sandwich of glass and air, was recognized for its qualities at the Murray Hill Laboratories by being chosen for the weather enclosure along the entire façade of the foyer. The new restaurant will also make similar use of thermopane.

Quite apart from such large installations of thermopane at Murray Hill is the one shown. Through the observation window, which contains five layers of thermopane, C. E. Mitchell installs apparatus for a stratosphere chamber test. The part being tested is a war-developed microphone used in an aviator's oxygen mask. With the door sealed and the pressure, temperature and humidity regulated to the conditions of test, for example, a 30,000-foot altitude run, the thermopane doors on two adjacent sides of the chamber allow complete observation. The chamber itself is a product of Tenney Company of Montclair, New Jersey.

WHAT MAKES SOME CRYSTALS PIEZOELECTRIC

A. N. HOLDEN
Physical
Research

Recent publicity given to these Laboratories' development of ethylene diamine tartrate, known as EDT, has focused increased attention on the use of artificial piezoelectric crystals; how they are chosen, how they are grown, and how they are processed for use. Like almost every technical innovation having elements of radical novelty, this one had its beginnings with research investigations, proceeded through stages of apparatus and manufacturing methods development, and is culminating in the adaptation of telephone systems to apparatus and the reverse, with the aid of trial installations.

The recent war marked a turning point in the attitude of engineers toward piezoelectric materials. Before that time, they were acquainted with the rugged and stable quartz on the one hand, and the fugitive and erratic Rochelle Salt on the other. Unhappy experiences with the instability of that salt gave them a gloomy outlook on any crystal grown from water solution: what good could come of designing with materials of so little integrity that they dissolved in such a bland medium as water? An exhaustive survey of insoluble natural minerals revealed little of promise.

The use of ammonium dihydrogen phosphate, abbreviated to ADP, in Sonar equipment* changed that viewpoint. Drilled, sawed, milled, struck with high-voltage pulses, the material stood up better than anybody expected. In the meantime, the treatment of the "rugged" quartz had become more and more gentle.† No longer did one solder to it with an iron, but rather with little hot-air jets. No longer, for the most part, did it sustain heavy clamping at nodes of motion; it was supported at the tips of wires in a glass envelope. A more optimistic atmosphere surrounded the search for synthetic substitutes for the large pieces of quartz, whose supply has always been uncertain. Eight months after the war ended, two of the materials whose investigation had been interrupted by the war were shown in the Physical Research Department to have promise as crystal filter elements, and of those, EDT is now being made by the Western Electric Company. The search for further synthetic crystals continues, and the reasoning and procedures leading to the discovery of such materials as EDT are becoming of more general interest.

*Record, *February*, 1947, *page* 55, and *October*, 1947, *page* 357. †Record, *April*, 1945, *page* 140.

Fig. 1—The growth rate of a crystal is a directional property, and hence the external form of a freely grown crystal must be consistent with its structural symmetry. In some materials, however, not enough faces are developed to make possible a complete structural symmetry diagnosis from the external form alone. The crystals on the left (front, EDT; back, sodium bromate) show their lack of a symmetry center; those on the right (front, ADP; back, sodium chlorate) do not

A satisfactory quartz substitute must meet many requirements, some quite subtle. Foremost, of course, it must be piezoelectric, and to many persons that property remains the most mysterious. But

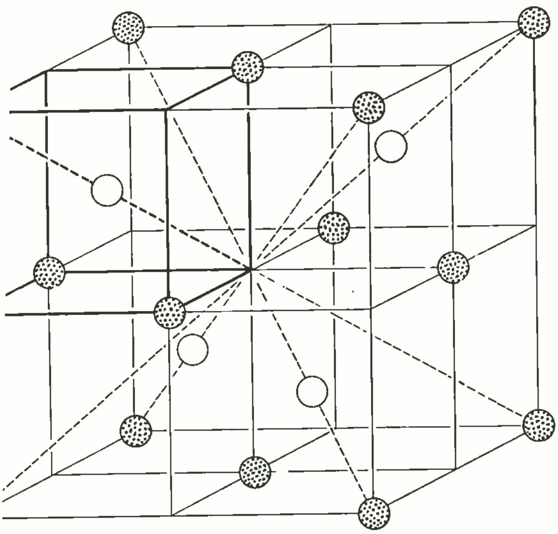
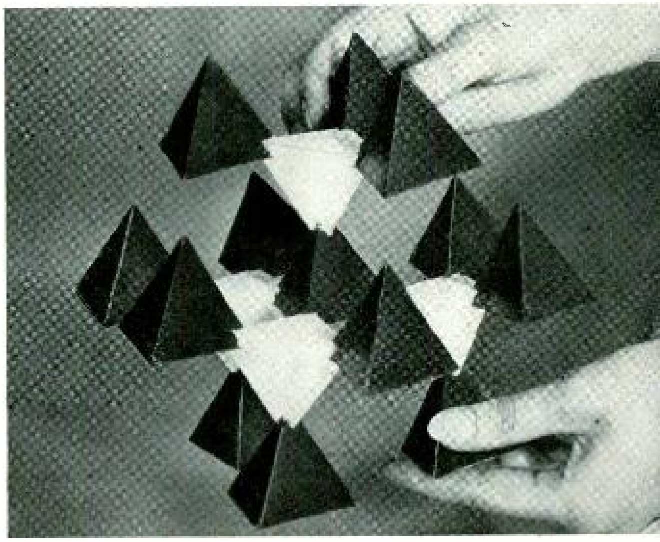


Fig. 2—Zinc blende (ZnS) is constructed of two interpenetrating face-centered cubic lattices. When sheared by the stresses indicated in Figure 5, the sulfur lattice moves downward relatively to the zinc lattice; and since the two types of atoms bear opposite charges, the crystal is polarized

there really is no cause for surprise that a material develops an electric polarization when it is stressed. Every material consists of particles which bear electric charges; and when the material is stressed, it changes its shape and the particles move, carrying their charges with them. If the negative charges were to shift so that their "center of charge" no longer coincided with that of the positive charges, a polarization would appear. There is no general reason why those centers of charge must coincide, and hence one should ask not, "why is crystal x piezoelectric?" but rather, "why is crystal y *not* piezoelectric?"

The argument can be illustrated by taking zinc blende for x and rock salt for y: Figures 2, 3 and 4 show their very simple crystal structures, which as usual are to be regarded as indefinitely continued. When sheared in any of the planes parallel to cube faces, zinc blende polarizes in the direction perpendicular to the plane. Evidently from Figure 5 such a shear, changing the square face into an oblique parallelogram, carries the positively charged zinc atoms closer together along one set of face diagonals and farther apart along the other set. Now the immediate environment of each negatively charged sulfur atom, Figure 6, consists of four zinc atoms, of which during the shear the upper two are pushed together, squeezing the sulfur atom downward, and the lower two are pulled apart, providing space for the sulfur atom's descent. Here the structural origin of the polarization is especially clear: by the shear, the lattice of negatively charged sulfur atoms is shifted as a whole relatively to the lattice of positively charged zinc atoms. To speak more generally, the shear changes the environment of the sulfur atoms from one which was symmetrical up and down to one which is unsymmetrical up and down, and does the same for the zinc atoms, but in the reverse sense. By contrast, it can then be observed from Figure 4 that a shear in rock salt will not occasion that change of symmetry: the environment of

Fig. 3—By building up the zinc blende lattice out of tetrahedra, each representing an atom, the tetrahedral interconnection of both sorts of atoms is made clear



the sodium atoms and of the chlorine atoms is just as symmetrical up and down after the shear as before.

It is tempting to visualize the extension of such arguments to more complicated crystal structures as a guide to constructing piezoelectric materials, but determining the structures of proposed materials would be a very long and elaborate investigation. Fortunately, there is another approach, in which it is necessary to take account only of the over-all symmetry properties of crystals, stresses and polarizations.

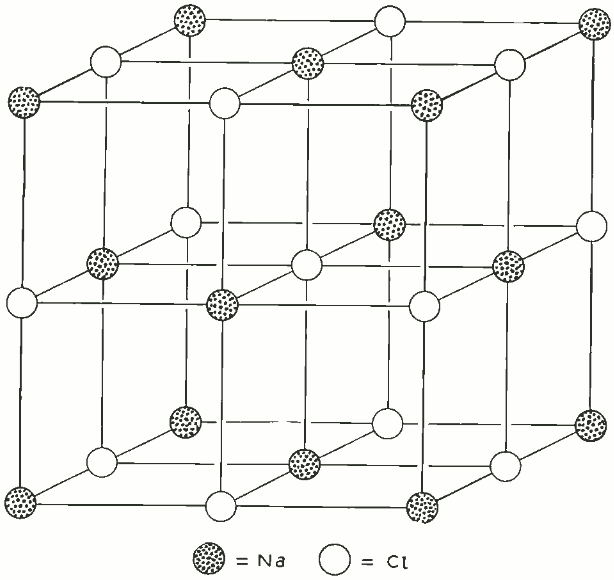
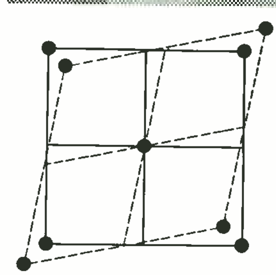


Fig. 4—The two interpenetrating face-centered cubic lattices of rock salt (NaCl) are differently disposed from those of zinc blende, and exhibit no relative shift when sheared

Most crystals have symmetry, Figure 1, to a greater or less degree: a structural symmetry evidenced in all their directional properties, optical, mechanical, electrical and the like. The elements of symmetry which a crystal may possess, in some combination, include (1) axes of symmetry, such that if one rotates the crystal, through ninety degrees, for example, it looks and behaves the same as it did before; (2) planes of symmetry, such that it would exhibit identity if every point in front of the plane were moved or "reflected" to a corresponding point behind the plane and vice versa; and (3) a center of symmetry, such that identity would result from moving every point an equal distance the other side of the center.

Now it can be shown that only if a crystal lacks a center of symmetry can it be piezoelectric. And it can further be shown that a crystal cannot have a symmetry center if it is made of molecules which themselves lack both centers and planes of symmetry. These facts provide a guide for the construction of piezoelectric crystals without reference to detailed crystal structure.

Fig. 5 – Looking down on the cube of Figure 2, one would see it transformed by a shear into a prism with the cross-section of a parallelogram



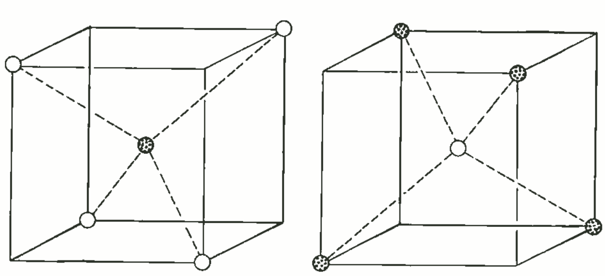


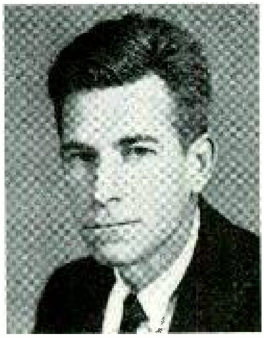
Fig. 6—In zinc blende, each sulfur (or zinc) atom has four nearest-neighboring zinc (or sulfur) atoms, at the corners of a regular tetrahedron

EDT is an example of the employment of this principle. In accordance with this principle, the crystallographer could be almost certain that it would be piezoelectric.

To say that a thing will be piezoelectric, however, is not to say how strongly, nor that it will be a suitable quartz substitute. Apart from reasonable chemical and physical stability, the material must afford modes of vibration whose frequencies are substantially invariable with change of temperature* and which can be piezoelectrically driven with fairly high "electromechanical coupling coefficients."† By the reasoning set forth, we have accomplished only the first of many steps on the path to a filter circuit element. To proceed further, crystals must be grown for measurement of their properties. Initial studies of growth then become the first part of a long chain of experimental investigations leading to plant manufacture and use.

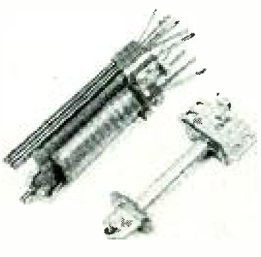
*Record, *March*, 1945, *page* 70.
†Record, *July*, 1946, *page* 257.

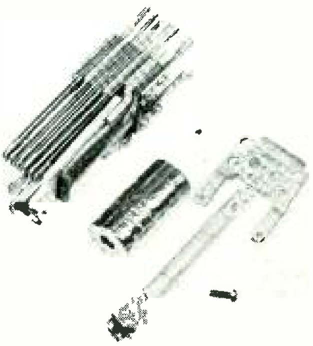
THE AUTHOR: A. N. Holden received a B.S. from Harvard University in 1925 and came with the Laboratories in autumn of that same year. After five years in the staff organization of the General Methods Department he was a member of the then Bureau of Publication until 1936 when he transferred to the Research Department; from 1936 to 1945 he was in the Chemical Department and, after 1945, in the solid state group of Physical Research. His work since 1936, with some interruptions for other projects, has been primarily that of originating new piezoelectric materials and perfecting methods to grow their crystals for research investigations.



WHAT'S IN A RELAY?

Pictured below are two relays—the older Type R at the left and the currently produced UA at the right. Magnetic core of the R relay is punched from sheet stock; corners of the core are swaged, the fibre spool heads are added and staked in place, and a sheet of clear cellulose acetate is wrapped around the core. Then the core is clamped in a chuck and the wire wound on by hand—one at a time. By contrast, seven coils for the UA are wound in one operation by an automatic machine, and then cut apart. One coil, with its associated spool heads, is slipped over the core, which is then fastened to the butt plate. Then the spring pile-up is assembled and clamped while the four screws are run in; and the relay is ready for adjustment and test.





LECTURE AIDS

For many years the Operating Companies have given lectures from time to time to bring to the attention of their subscribers various advances in the telephone art, thus making them more familiar with the facilities available and with the best ways of using them. New devices and methods are continually being applied to the telephone plant as a result of research and development at Bell Telephone Laboratories, and it was felt that the value and utility of the lectures would be enhanced by demonstration of recent scientific discoveries and inventions. Besides improving telephone service, many of the developments are of interest in their own right, and there seemed little doubt that subscribers would be interested in them.

To make this possible, the Laboratories were asked, in the fall of 1939, to prepare demonstration aids suitable for this purpose. The Laboratories agreed to undertake the assignment, and C. D. Hanscom of the Publication Department was placed in charge of the work. In spite of the intervening war years, when there was neither time nor personnel to devote to this work, over a hundred possible lecture-aid subjects have been studied. Some of these have been rejected as not suitable, for one reason or another, others have been postponed for later study, and still others are

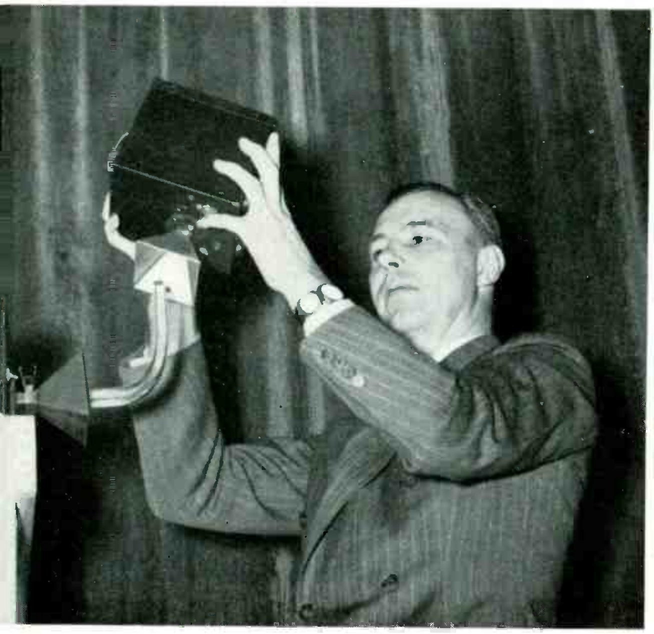


Fig. 1—H. R. Peck, Jr., of the New York Telephone Company, demonstrates the bending of microwaves along a rod of lucite to a group of Telephone Pioneers in the lecture room on the 31st floor of the New York Telephone Company's building in New York City. The polarization of the microwaves may also be shown by rotating the receiver 90 degrees on its axis

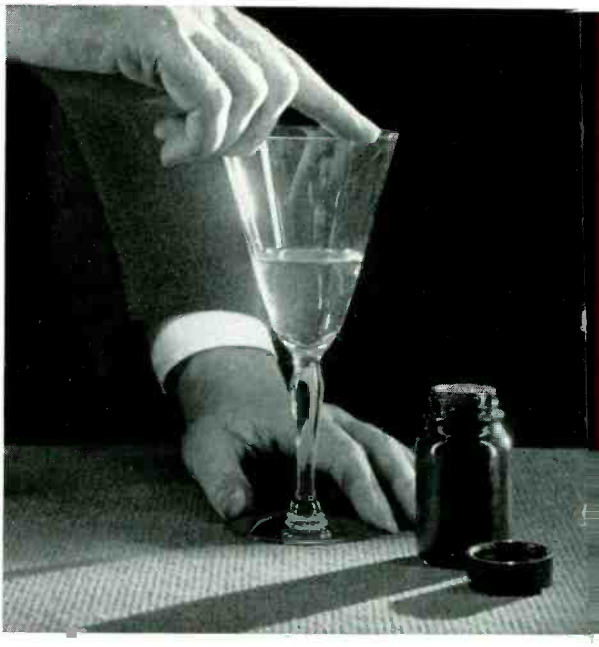


Fig. 2—The singing glass—one of the simplest lecture aids—is used to demonstrate resonance effects essential to electrical filters and many other components of communication circuits. It consists only of a glass that may be filled to varying heights with water, and a jar of rosin in which a finger is dipped before rubbing it around the rim of the glass

Fig. 3—The first lecture aid to be built was for demonstrating the piezoelectric effect. At the left is a large block of piezoelectric crystal which when struck with a small gavel generates a voltage that lights the lamp at the right

now under development. As of January 1, 1947, nearly fifty lecture aids had been developed and made available to the Operating Companies.

The lecture aids vary widely in complexity, ranging from a short section of 2121-pair telephone cable to lecture aid No. 34 for demonstrating microwave phenomena. Some of these aids are shown in the accompanying illustrations. No. 34 is the most elaborate so far produced, but the great use made of microwaves during the war for both radar and communication, and the extensive promise they hold for communication of the future, justified the preparation of apparatus for demonstrating the remarkable characteristics of these waves to the public. The set includes a small microwave laboratory test oscillator and a receiver of the same size. With these two units, and other properties such as metal plates, screens, microwave lenses, and lucite rods, many of the characteristics of microwaves may be demonstrated.

All of the lecture aids are designed with a view of best meeting the needs of the lecture platform. They are then built, often by some outside manufacturer, and assembled to secure easiest portability. An estimate of the probable demand is made before manufacture and they are supplied to the Operating Companies at cost.

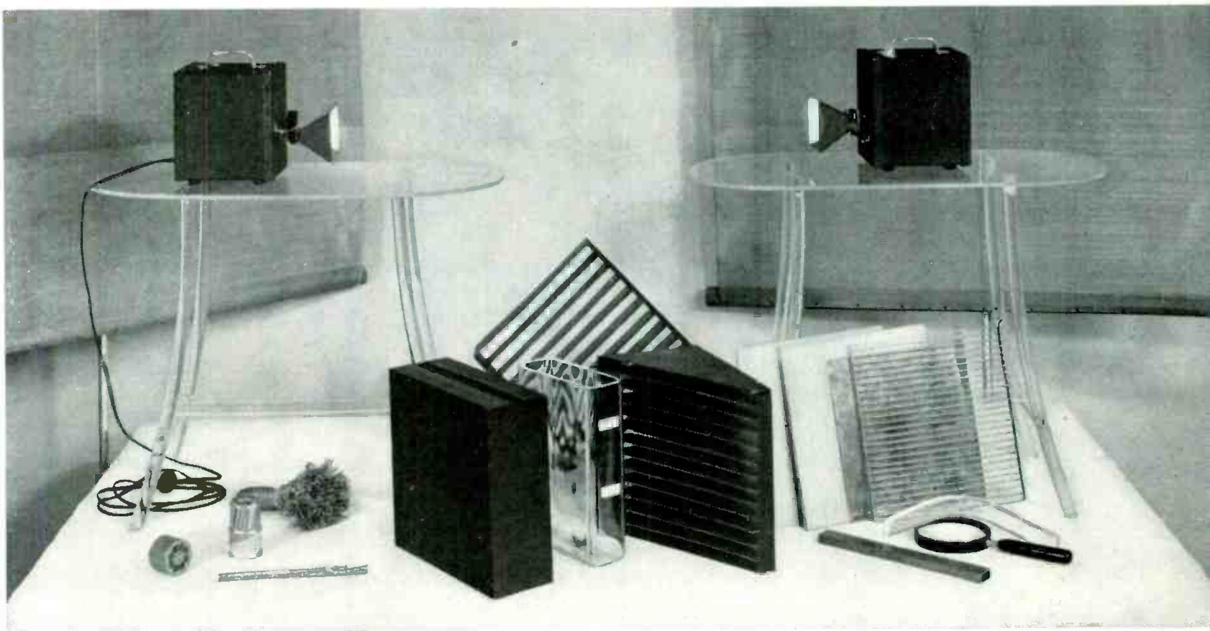


Fig. 4—Lecture Aid No. 34 for demonstrating the properties of microwaves as arranged by the New England Telephone and Telegraph Company

CERAMICS FOR ELECTRICAL APPLICATIONS

M. D. RIGTERINK
Chemical Laboratories

Ceramics are among the most versatile materials used in the communication industry, and their rapidly increasing use during recent years is attributed largely to a growing appreciation of this fact. They include all those products fashioned from inorganic compounds such as silicates, oxides or carbides which are rendered durable in form and composition by a heat treatment applied at some stage of the process. Dinnerware, glass, brick, and porcelain enamel are familiar ceramic products. Not so well known are new products used in war equipment and now being adapted for applications in high frequency communication systems.

Properties attainable in ceramic materials cover a very wide range. Their porosities vary from zero to over seventy-five per cent by volume, permeabilities to the flow of liquids and gases from zero to high values and dielectric constants from five to several thousand. They display from high to extremely low dielectric loss, conductivities from approximately 10^{-1} to 10^{-17} reciprocal ohm centimeters, and resistivities sensitive to voltage and temperature fluctuations in unique ways. These properties are subject to purposeful variation and control within reasonable limits, and in conjunction with their recognized high mechanical strengths, resistance to cold flow, and ability to withstand high and low temperatures ceramics offer the possibility of many useful applications in a number of fields. All of the aforementioned characteristics have already been used to advantage in various communications equipment.

Most familiar of the applications of ceramic materials in telephony, radio and radar is the use of steatites, electrical porcelains, zircon porcelains, and glass for general insulation purposes. Early work at the Laboratories was directed chiefly toward the attainment of low dielectric loss, particularly at elevated temperatures.* During the war, however, the ceramic lab-

*Record, *May,* 1943, *page* 290.

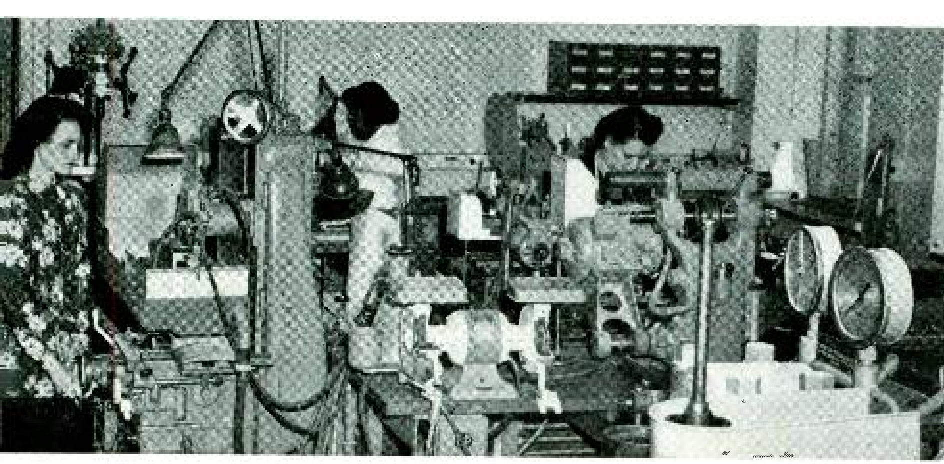


Fig. 1 — Laboratory equipment used to prepare samples of new ceramic materials for electrical appliances

Fig. 2—Some ceramic parts are made on a lathe. They must be oversize, to allow for shrinkage during firing

oratory undertook a new function, that of supplying our own vacuum tube, radio and radar engineers with ceramic details for experimental models. This not only assisted by avoiding long and costly delays but also frequently permitted ceramics to have a fair trial in cases where they would otherwise have received little or no consideration because of unavailability. This need for experimental models and for consultation on design is expected to continue in the post-war programs of development for the Bell System.

Frequently a need arises for a ceramic material which is not commercially available in the quality required for the particular application. An excellent illustration of this is the cylindrical core or base for deposited carbon resistors. This base must not only have the properties usually attributed to ceramic materials but in addition must have high insulation resistance at elevated temperatures, be impervious to gases or liquids, and possess an extremely high degree of surface perfection typified by freedom from pinholes, cracks, pimples, iron spots, scratches, die marks, and heterogeneities of any sort. Finally, it must provide firm adherence for the carbon deposited thereon from a hydrocarbon gas.

Since no known material existed which was completely satisfactory in all respects, the Laboratories developed a new type of body for this specific application. It is called an alkaline earth porcelain because of the similarity of its composition to those of the porcelains long used for dinnerware and low frequency electrical insulation. Both contain a plastic ingredient, clay, to provide workability and easy forming and a non-plastic ingredient, finely ground quartz sand, to furnish mechanical stability during the drying process prior to firing. However, fluxes containing the sodium and potassium ions, such as the feldspars, which are added to dinnerware raw materials to form the glass bond and the means for shrinkage into a hard, dense mass, were replaced with a synthetic flux developed by the Laboratories and which contained

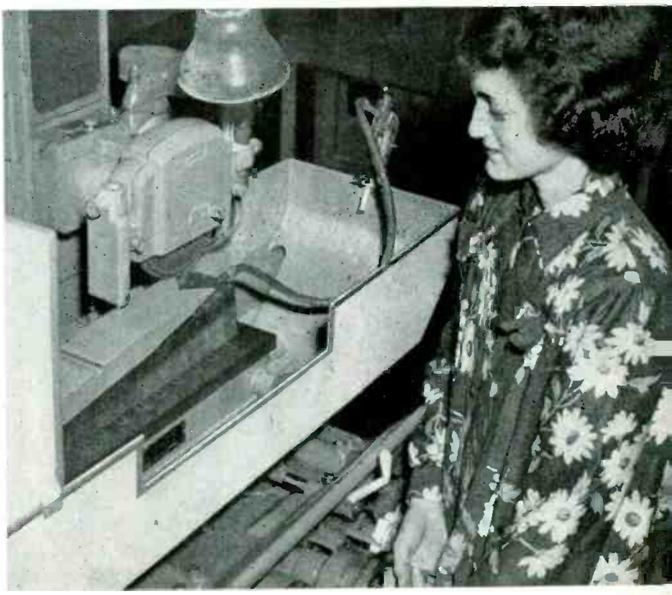


Fig. 3—Ceramic attenuators are ground to close dimensional tolerance on a wet surface grinder with a metal-bonded diamond wheel

the less electrically conducting alkaline earth ions, magnesium, calcium, strontium and barium. This was not simply a matter of direct substitution, as adjustments had to be made to obtain all of the desired characteristics combined with facility of manufacture. The fired body, in the form of extruded rods, fulfills all of the essential requirements. It is white, has a coefficient of thermal expansion of approximately 4.1×10^{-6} per degree Centigrade from 20 to 600 degrees Centigrade, and possesses excellent dielectric properties. A ceramic with all these commendable characteristics will probably be adaptable to other important applications. Several million rods of this composition have already been produced by two commercial suppliers.

A class of ceramics not very familiar to engineers, other than those in the electrical industry, is that of the semiconducting materials hereafter referred to as thermistors, symmetrical varistors, or attenuators. Thermistors are made from mixtures of semiconducting metallic oxides which are characterized by high negative temperature coefficients. The temperature of such elements and thus their resistance may be changed by ambient conditions, by direct heating caused by the passage of current, or by indirect heating from a small heater coil. More detailed description and some of the ingenious uses to which these resistive elements have been put are already familiar to many readers of the RECORD.*

Symmetrical varistors are made of a mixture of silicon carbide and a ceramic bond fired in a reducing atmosphere. The product is of electrical use because its resistance varies with voltage; that is, it has a comparatively high resistance at low voltage but a low resistance at high voltage. Specifically, the current value obeys the equation $I = AV^n$ in which I is the current, A is a constant, V is the voltage and n has values from 4 to 4.7. Again, many ingenious means have been devised for using these elements in electrical circuits and their properties have been more completely described previously.†

Ceramic attenuators are very unusual, in that new compositions were developed by the Laboratories to produce high but definite dielectric loss as contrasted to the usual efforts directed at decreasing this to a minimum. One type consists of a semiconducting material such as silicon carbide bonded with a low temperature porcelain. Attenuators are used extensively in microwave measuring and detecting equipment, but the most interesting application of the ceramic type is as dummy antennae for radar equipment to avoid unintentional broadcasting of signals. In this application, they may be called upon to convert continuous or periodical high frequency power into heat in an amount sufficient to raise the temperature of the ceramic to several hundred degrees Centigrade.

The use of semiconducting ceramic materials lies largely in the domain of electrical engineering and physical research, but ceramic techniques are used in the processing and forming of the raw materials. Furthermore, all of these inorganic

Fig. 4—Gas-fired pot furnaces used for test firings

Fig. 5—Small tunnel furnace used to metalliz ceramic parts prior to the preparation of metal an ceramic hermetic seals

*RECORD, *December*, 1940, *page* 106.

†RECORD, *October*, 1940, *page* 46.

materials undergo a firing treatment to render them durable in form as well as to produce the desired electrical characteristics. Ceramic technology has made significant contributions to the development and improvement of useful semiconducting devices.

Ceramic articles made from refractory oxides such as aluminum oxide, beryllium oxide and magnesium oxide also have unique properties that are useful. Two well-known applications are as insulators for heater filaments in vacuum tubes and as crucibles for the study of very pure metals. An unusual war application was in "submersion-proof" lip microphones and headset combinations. For this equipment, a ceramic "gland"* was developed which would pass air but exclude water. This permitted successful operation of this communication apparatus under all battle conditions, regardless of whether it was used in landing operations with possible submersion or in planes flying at high altitude where pressure equalization is required.

A relatively new field of ceramics receiving increasing attention at the Laboratories is that of the titanates. Some of these have remarkably high dielectric constants and possess other unusual properties. The dielectric constant of most insulating materials in practical use seldom exceeds ten. Water, usually regarded as having an exceptionally high dielectric constant, has a value of eighty. With the exception of certain piezoelectric crystals, no other known class of inorganic materials has dielectric constants approaching those of the titanates and is at the same time stable electrically and chemically. Large numbers of tubes consisting essentially of barium titanate, and having dielectric constants from 1,200 to 1,500, have already been made into capacitors, which were used in part to relieve the acute mica situation during the war and also to provide new circuit elements. The use of these materials will certainly multiply when additional research here and elsewhere provides means for better control, longer life, lower dielectric loss, higher insulation resistance, and better breakdown strength.

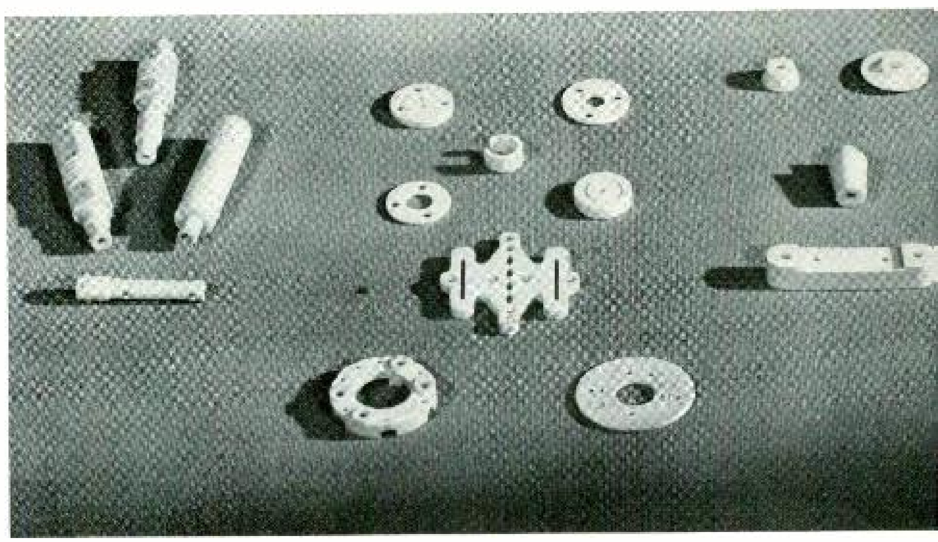


Fig. 6—A representative group of ceramic parts of Laboratories' design

Also of ever-increasing interest are hermetic seals and mechanical assemblies made of metal plus glass and metal plus ceramic combinations. Ceramics are possibly inherently more expensive than organic materials but this disadvantage is frequently outweighed by their greater permanency at elevated temperatures, generally lower moisture diffusion, and freedom from destructive effusions. Furthermore, the desirability in many cases of operating at abnormal temperatures emphasizes the need for inorganic materials. In the metal to

*Record, *June,* 1945, *page* 197.

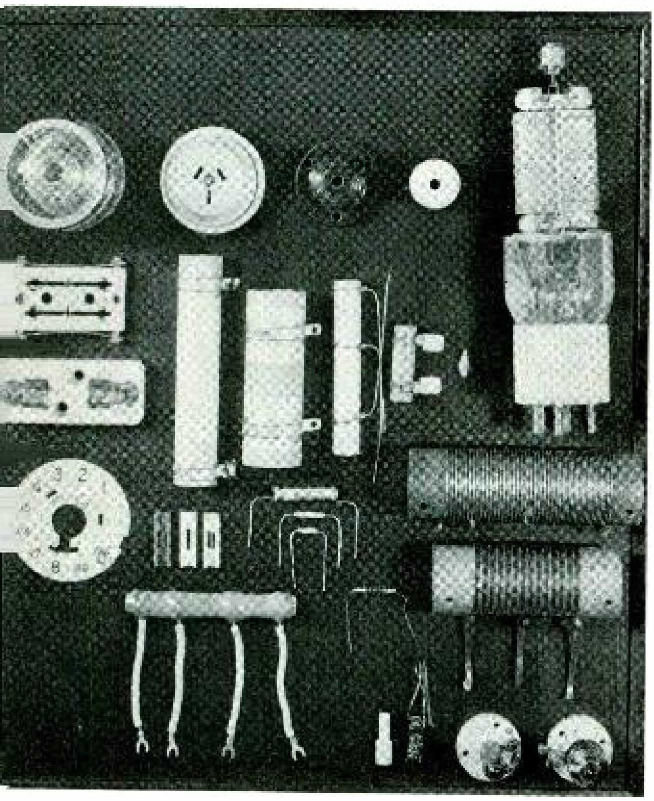


Fig. 7—A group of ceramic parts illustrating their applications in communication systems

ceramic combinations either glass or solder may be used to bond the two together and each method has its own particular advantages and useful applications.

In Figure 6 is shown a representative group of ceramic parts of Laboratories' design which illustrate the fact that many are rather complex. Mechanical ingenuity and compromises are frequently required to arrive at a design which at the same time is adapted to commercial manufacture, and makes the most advantageous use of the desirable properties of the ceramic material. This is further complicated by the fact that the ceramic industry is still based on considerable art, although it is now being converted to a more sound engineering basis.

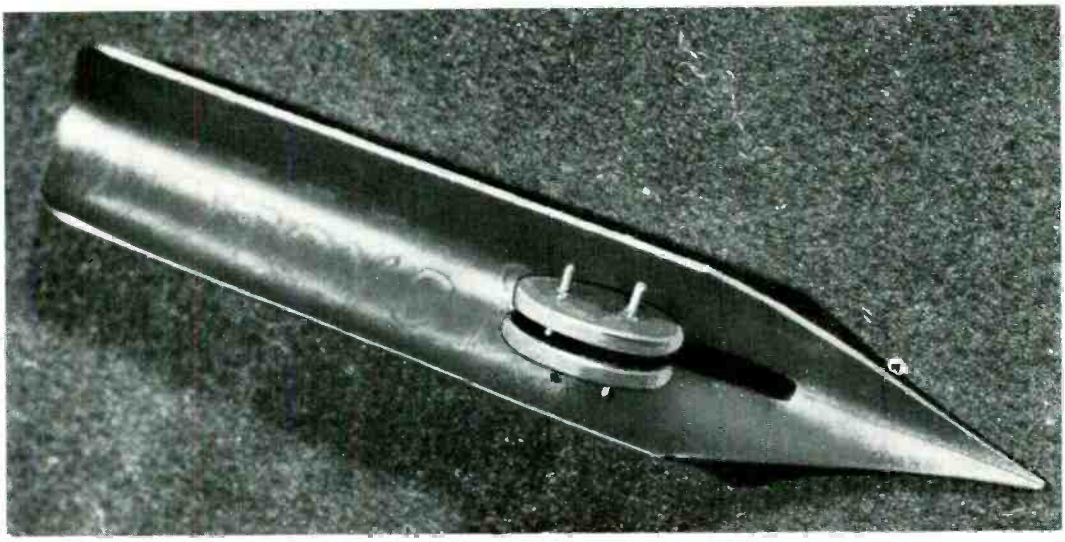
Some of the older applications of ceramic parts in communication systems are illustrated in Figure 7. Bushings, receptacles, vacuum-tube bases and supports for the internal elements, condensers, dial-number plates, resistors, and inductance coils all use ceramic materials because of one or more superior characteristics for the particular application. The total amount of ceramics used in communication equipment is already sizable and the trend toward the use of higher frequencies is not only accelerating the demand for them but is placing increasing emphasis on quality. The possibility of combining both natural and synthetic materials also tremendously increases the number of products, useful in various applications in the communication field, that may be obtained.

THE AUTHOR: M. D. Rigterink received the A.B. degree from Hope College in 1933 and his Ph.D. in Chemistry from Ohio State University in 1937. Immediately after this he joined the technical staff of the Laboratories to engage in research and development projects on ceramic materials for communication uses. He is still active in this field.

WINDING MICRO-COILS

Certain types of cathode-ray tubes are designed to use magnetic fields for deflecting the electron beam. In studying the relatively weak electro-magnetic fields of such a deflection system, it is desirable to obtain accurate data on the three-dimensional distribution of the fields. One method* involves the use of a small search coil in which is induced a voltage proportional to the field strength at the point where the search coil is located. The search coil, shown three times actual size below, requires a large number of turns so that the induced voltage may be readily measurable, though in order to avoid getting an integrated effect over a relatively large volume, the search coil should approach point size. In the other illustration, Catherine Capifali, formerly of Transmission Development, is shown winding such a coil, which is a compromise between the above conflicting requirements. The diameter of the winding is about 0.125 inch and the cross section 0.02 by 0.02 inch. Enameled copper wire of No. 50 gauge (0.001 inch diameter) is used, giving about 400 turns in the space available. This wire is so fine and fragile that it is not only difficult to see but also to determine when it has broken—definitely a case for sensitive female hands. The terminals of the coil are made from No. 30 gauge resistance wire. The accomplishment of winding such a coil was largely due to the coöperation of F. Berger (now retired) of the Development Shop, who designed the machine and also assisted Miss Capifali in the problem arising in the accomplishment of such a delicate task.

*Record, *August*, 1945, *page* 281.



NEWS AND PICTURES OF THE MONTH

PLANNING FOR THE GROWTH OF RADIO COMMUNICATIONS

F. B. LLEWELLYN
Consulting Engineer

Not since 1932 have the nations of the world reviewed the general principles under which they agree to conduct their radio services, and not since 1938 have they reviewed the operating regulations. In the meantime, the need for "space" in the radio-frequency spectrum has increased enormously, not only because of expansion of the older services, such as overseas and ship-to-shore telegraphy and telephony, but also as a result of the development of entirely new services. Prominent among the latter are: navigational aids to airplanes, both for radio location and for dispatching of aircraft engaged in the constantly increasing volume of air travel; navigational aids to ships in the form of radar and loran-type services; and broadcasting over long distances. The last is important to countries with sparse population and mountainous terrain where wire facilities are limited, as well as to countries which wish their programs to be received in distant countries.

To review the situation and make plans for its improvement, the International Telecommunications Union held conferences in Atlantic City during the summer of 1947. Seventy-nine countries were represented with over 700 people participating in various capacities.

If the solution had been attacked in the time-honored way, the procedure would have been to prepare an allocation table in which the various portions of the spectrum were allotted or apportioned to the various services and thereafter to allow the radio stations of the world to try to find an unoccupied space in the spectrum in which to operate. If the matter had been handled in this way and, as in previous agreements and left at that point, it is easy to see that no one would have been satisfied and that the chances of arriving at a satisfactory international agreement would have been very slim indeed.

Consequently, in addition to forming an allocation table, the diplomats turned to the engineers and agreed with them that a good way out of the dilemma was to find means, through the application of engineering principles, of using the radio spectrum more effectively in the expectation that the new services, as well as the old, could all be accommodated within its fixed confines, and in the hope some space could be provided for future expansion.

To carry out this plan, it was well realized that the closest coöperation between all concerned would be required, since engineering principles recognize neither sovereign states nor vested interests. It was also realized that the plan is one of Herculean proportions, and could not possibly be formulated in detail at the Atlantic City Conferences even though they were to last much longer than the four and a half months that actually were consumed. Consequently, the conferences composed a set of basic principles upon which the new assignments of frequencies are to rest, and prepared technical guides to show how the principles would be applied. These guides cover the information that was available among members of special committees of the conferences and deal with the technical aspects of the problem of determining how close together various types of transmission may be given frequency assignments without their interfering with each other. This, in turn, involves questions of the propagation characteristics of radio waves through the ionosphere as well as those dealing with the tolerable signal-to-interference values in conjunction with the transmitter and receiver characteristics and the presence of fading encountered in particular circuits.

A special board, known as the Provisional Frequency Board, was then created, which was charged with the actual preparation of a new frequency list providing assignments for all of the stations of the world now in operation as well as for those whose services were interrupted by the war. It excludes those stations operating in bands which are to be dealt with by regional conferences, and those for which specific assignments are not required, as in the case of amateur and standard-frequency broadcast services. The frequency range to be covered extends from 14 kc to 27.5 mc. It is expected that the work of this board will be completed in time for acceptance by a special international conference in March of 1949 and will go into effect in September, 1949.

In addition to this Provisional Frequency Board, the Atlantic City Conferences established a permanent board, known as the International Frequency Registration Board, which is charged with keeping an up-to-date list of the frequency assignments of all stations, and with making recommendations concerning assignments and changes of assignments to insure the most advantageous use of the radio spectrum. This board will be supplied with the details of operation of all stations and with monitoring information which, eventually, is to include information not only on the frequency stability of the stations, but also concerning the energy distribution of their emissions in the radio spectrum. Reports of interference will likewise be handled through this board.

In addition to these provisions, the Atlantic City Conferences have requested the International Radio Consultative Committee (C.C.I.R.) to study from an engineering standpoint the broad question of how to use available frequencies and to supply the International Frequency Registration Board (I.F.R.B.) with the resulting information. In order to lose no time, Dr. H. C. A. Van Duuren, of the Netherlands, was appointed head of a study group to deal with the subject, and a general meeting of the C.C.I.R. has been scheduled to be held in Stockholm in July, 1948. Among the specific questions to be dealt with are those concerning how close together a telegraph and a telephone-radio emission may be placed in the spectrum when the fields at the receiving stations are not necessarily equal and when fading is present on both circuits. A similar question concerns adjacent single-sideband telephone circuits when the received fields are radically different in intensity.

The Chairman, both of the I.F.R.B. and of the Provisional Frequency Board, will be Captain Paul D. Miles, of the United States, who has been Chief of the Frequency Service-Allocation Division of the Federal Communications Commission. The headquarters of both boards, as well as of the C.C.I.R., will be in Geneva. On the Provisional Frequency Board, the United States will be represented by Commissioner E. K. Jett, of the Federal Communications Commission, and he will be accompanied by advisers from several Government agencies and communication companies. Among these advisers will be R. D. Campbell of the A T & T.

The overseas telephone service of the Bell System requires frequencies throughout the high-frequency spectrum, particularly in the range 4 mc to 22 mc. This service shares the point-to-point frequency bands with the commercial international radio-telegraph services and the long-distance radio services operated by the Government. Sharp reduction of allocations to point-to-point service in this frequency range at a time when the overseas telephone service is growing imposes a serious problem. Only by use of improved techniques by all of the agencies will it be possible to provide adequately for international communication. A quantitative appraisal of the situation cannot be made until the work of the P.F.B. reaches an advanced stage.

Ship telephone on the high seas requires for its operation frequencies in the high-frequency range (4 mc to 22 mc). It is provided for in the specific allocations for maritime mobile service, certain portions of the band being designated for ship telephone and coastal telephone operation. While the maritime mobile bands are to be shared with certain internal fixed services of the U.S.S.R. and are somewhat narrower than would be desirable, they nevertheless offer a good opportunity for the further development and organization of this maritime service.

While the allocations for coastal harbor service adopted at Atlantic City embrace all of the frequency range now employed, they do not provide appreciably for growth. The designation of 2,182 kc for calling and distress purposes for marine telephone service in the 2-mc frequency range may require the reorganization of the coastal harbor service for its utilization in this country, as in most cases no calling frequency is employed at present, the calling being done on the working frequencies.

The Bell System has a number of point-to-point domestic radio systems operating in the VHF range and important relay projects which will operate in the microwave or SHF range. In addition, the Bell System general mobile urban and highway systems operate in the VHF range. The allocations made at Atlantic City for frequencies above 30 mc are, in general, in agreement with the experimental assignments in effect in the United States and provide satisfactorily for the Bell System radio services, in operation and proposed, in this portion of the spectrum. A reasonable degree of flexibility has been provided by marking many of the bands in this range for both fixed and mobile service. Some degree of flexibility has, however, been surrendered by designating

Albert Tradup and R. A. Cushman of the Laboratories and J. G. Jones and M. E. Strieby of Long Lines received the President's Certificate of Merit on October 29 in recognition of their outstanding services as Expert Consultants in the Office of the Secretary of War. Left to right, Mr. Jones, Mr. Strieby, Major General James A. Van Fleet, who presented the certificates, Mr. Tradup and Mr. Cushman

Signal Corps Photo

some of the bands exclusively for broadcasting or amateur service.

The over-all result of this part of the work done at the Atlantic City Conferences is the setting up of coördinated machinery that, with patience and coöperation, may be capable of bringing order out of the increasing chaos that has characterized radio communication in the past. There will be great difficulties in the future, but if a sincere attempt is made to apply engineering principles, there can hardly be other than a net gain for all concerned.

Highway Telephone Service Opened Between Boston and Washington

Motorists in vehicles equipped for highway telephone service can now make and receive telephone calls at any point along the entire route between Boston and Washington. The service is also available for boats operating within range of the transmitters.

Opening of continuous telephone service for mobile units between the New England metropolis and the Nation's capital follows completion of the last link in the 450-mile chain of radio telephone stations, each serving a radius of approximately 25 miles.

The new service is for motor vehicles on the mainly traveled routes and nearby highways within reach of the 250-watt transmitters situated at or near Boston, Providence, New London, New Haven, New York, New Brunswick, Trenton, Philadelphia, Wilmington, Baltimore and Washington.

Microwave Relay System Relieves Long-Distance Traffic in California

A microwave radio relay system has been placed in commercial service by The Pacific Telephone and Telegraph Company between Marysville and Redding, over 100 miles to the north, to help handle heavy long-distance telephone traffic north of San Francisco. The short-wave radio equipment used is of the type employed in the Barnstable-Nantucket and Los Angeles-Santa Catalina Island over-water systems, but modified to provide sixteen circuits instead of eight.

December Service Anniversaries of Members of the Laboratories

40 years
R. W. Harper

35 years
A. G. Chapman
Howard Weinhart

30 years
W. B. Cardell
P. P. Cioffi
H. J. Delchamps
Werner Hartmann
E. H. Hasbrouck
Minnie Marcus
W. E. Marousek
G. A. McNeill
G. E. Reitter
J. E. Ross
R. A. Shetzline
E. Von Der Linden

25 years
M. L. Clarke
O. H. Danielson
R. D. DeKay
A. S. Dubuar
G. M. Eberhardt
Dorothy Mahon
D. R. McLennan
Tim Sullivan
H. K. Warnke

20 years
C. A. Chase
Emory Lakatos
Henry Mach
P. H. Schmitt, Jr.
E. A. Schramm
Kathleen Thompson

15 years
F. D. Fessler

10 years
F. M. Bowman
Ruth Griffith
Charlotte Honeycutt
Jean Lubking
W. B. Sage

BELL SYSTEM OPENS NEW YORK-BOSTON RADIO RELAY

Beaming telephone conversations and television pictures through space via seven intermediate stations on hilltops, the Bell System radio relay system between New York and Boston was opened by Mr. Gifford on November 13 for experimental use. Simultaneous ceremonies in New York, Boston and Washington—including a television program carried on the longest television network in existence—were linked by a circuit combining the new radio relay and the coaxial cable between New York and Washington. The ceremonies in New York were held at Long Lines headquarters.

Radio relay is the newest type of long-distance communication facility to be used by the Bell System. By transmitting sharply focused radio microwaves along a line-of-sight path, it provides an exceptionally large number of long-distance circuits.

The new radio relay system, developed and built* by the Laboratories, was started in 1945. In describing its place in the telephone system, Dr. Buckley said, "Bell System radio relay is not in any sense a communication system merely parallel with, and outside of, the nationwide Bell telephone network. On the contrary, our radio relay is designed to become an integral part of the whole network."

Officially opening the radio relay system, the first telephone call was made by Mr. Gifford, who talked with Joe E. Harrell, President of the New England Telephone and Telegraph Company, in Boston. Speaking from Washington, Paul A. Walker, Acting Chairman of the Federal Communications Commission, and H. Randolph Maddox, President of The Chesapeake and Potomac Telephone Companies, joined the conversation. As host to representatives of the press and radio and television executives, at the ceremonies in New York, Frank P. Lawrence, Vice-President of A T & T in charge of the Long Lines Department, then introduced the intercity television broadcast. Mr. Lawrence said, "The network, extending from Washington to Boston, is about 500 miles long and is the longest television network to date, making it possible to bring television programs to a potential viewing audience of about 25 million people. This is, I believe, the largest population group so far brought within the range of network television."

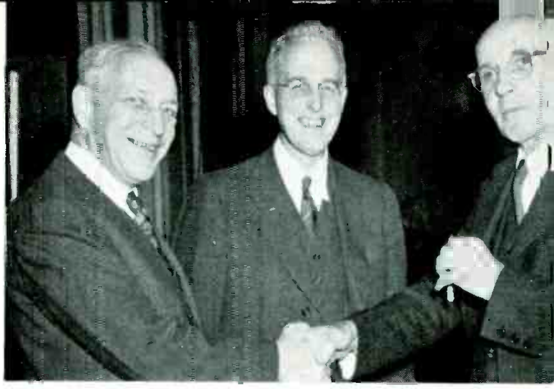
The program was seen by audiences in all cities along the East Coast having television broadcasting stations. Titled *The Story of Seven Hilltops,* the television broadcast began in New York, where Mr. Gifford, Carl Whitmore, President of the New York Telephone Company, and Mr. Lawrence participated in the early part of the program. The scene then shifted to Boston, to Mr. Harrell, whose image travelled by radio relay to New York, and beyond to Philadelphia, Baltimore, and Washington by coaxial cable. Next, Mr. Maddox and Mr. Walker, in Washington, joined the program and were seen on television screens in other cities of the network. Tom Shirley, announcer for the Bell System's *Telephone Hour,* who was master of ceremonies, concluded the television broadcast in New York.

Following the television broadcast, Ralph Bown, Director of Research, conducted a technical demonstration of the radio relay system. This included the use of special test films and charts to show the capabilities of the radio relay system and its method of operation. The signal was looped twice around to travel over 900 miles, passing through 31 repeaters. There was no significant degradation in quality.

At the conclusion of the ceremonies, press and radio representatives made telephone calls over the new radio relay system between the two cities. The guests were also shown the equipment involved in the demonstration. Members of the Laboratories who took active part in the demonstration were: *New York Terminal,* C. N. Anderson, H. H. Hoffman, A. A. Roetken, A. L. Durkee and H. C. Foreman; *Jackie Jones,* C. E. Scheideler, E. E. Helin and C. W. Van Duyne; *Birch Hill,* A. H. Roos and J. K. Mills; *Spindle Hill,* J. L. Wiegand and H. T. Langabeer; *John Tom,* J. L. Wenger and J. L. Larew; *Bald Hill,* H. A. Gifford and H. M. Spicer; *Asnebumskit,* E. H. Duryea and A. F. Burns; *Bear Hill,* W. F. Wolfertz and R. R. Gay; and *Boston Terminal,* J. G. Chaffee and H. A. Stein.

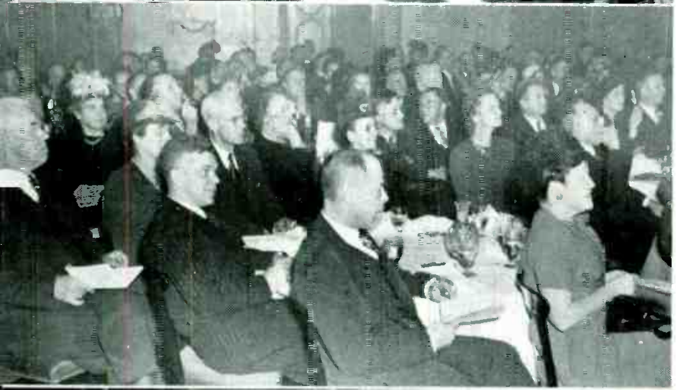
Because of the large number of Laboratories people who had worked on the project, receiving facilities were set up in the auditorium at West Street and in a listening room at Graybar-Varick. At each point were two television receivers, one connected by a video circuit, and the other tuned to the WNBT broadcast. The audio program was monitored by loud-speakers. W. T. Wintringham was master of ceremonies to about 250 people at West Street and J. F. Wentz to 70 at Graybar-Varick.

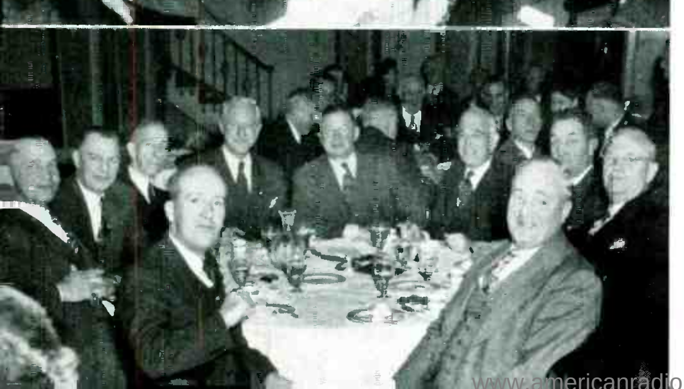
*Buildings were erected by Long Lines.



FRANK B. JEWETT CHAPTE

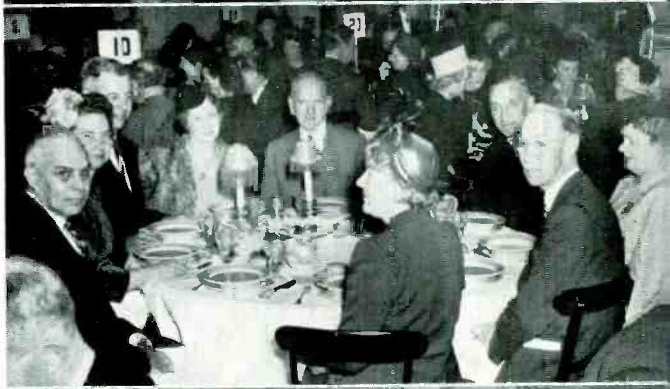
Attended by over 850 members and gues including 63 life members, the annual wint party of the Frank B. Jewett Chapter of tl Telephone Pioneers of America was held in tl Hotel Commodore on November 14. Followir an informal reception and the dinner, Harve Fletcher, president of the Chapter, welcome those attending, and then introduced the pr gram of entertainment.





ELEPHONE PIONEERS OF AMERICA

Arrangements for the dinner and entertain-
ient were made by a Pioneers committee un-
er the chairmanship of L. P. Bartheld. During
ie reception there were demonstrations of tele-
ision, including a camera and two receivers
ı operation, high-fidelity reproduction of music,
simulated model of a three-element vacuum
ube, and an exhibition of paintings by the Bell
.aboratories Art Group.



Telephone Pioneers Pay Tribute to Bell in Boston Convention

The Telephone Pioneers of America went back "home" this fall to honor the 100th birthday anniversary of its first Pioneer, Alexander Graham Bell. Convening in Boston for their annual meeting, delegates representing 117,000 members heard talks by three Bell Company presidents; discussed their program for the coming year; listened to the Boston "Pops" Orchestra; and toured the historic city.

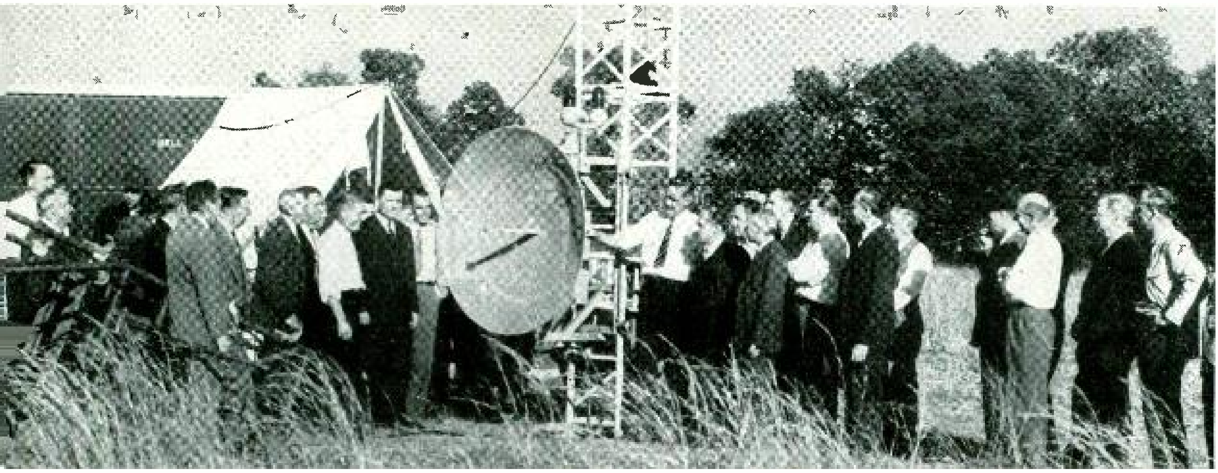
Joe E. Harrell, association head and president of the New England Telephone and Telegraph Company, welcomed the delegates back to the "old family homestead." O. E. Buckley took the delegates on a "tour" of the Laboratories and gave them a fascinating glimpse of present and future developments in communications. M. B. Long, association vice-president; Harvey Fletcher, president of the Frank B. Jewett chapter; and Hattie Bodenstein, secretary of the chapter, attended.

American Institute of Electrical Engineers

Members of the Laboratories serving as officers or members of general and administration committees for the 1947-1948 year include: O. E. Buckley, *District Vice-President,* and *Executive* and *Edison Medal Committees;* M. J. Kelly, *Research Committee;* R. L. Jones, Chairman of *Standards Committee* and a member of *Planning and Coördination* and *Constitution and Bylaws Committees;* D. A. Quarles, *Board of Directors,* Chairman of *Finance Committee* and a member of *Planning and Coördination* and *Headquarters Committees;* R. K. Honaman, chairman of *Institute Publicity Committee* and member of *Publication Committee;* L. P. Ferris, *Safety Committee;* and H. M. Trueblood, *Board of Examiners.*

Memberships on technical committees include: P. A. Jeanne, *Protective Devices;* H. M. Trueblood, *Transmission and Distribution;* O. E. Buckley, *Communication and Science Coordinating Committee;* J. D. Tebo, chairman, O. E. Buckley, *Basic Sciences;* H. A. Affel, A. J. Busch and R. G. McCurdy, *Communications;* and E. I. Green and J. H. Miller, *Instruments and Measurements.*

Institute representatives on other bodies include: R. L. Jones, *Electrical Standards Committee of the A.S.A.* and *United States National Committee of the International Electrotechnical Commission;* and H. A. Affel, *Radio Technical Planning Board.*



On October 7 a group of Bell System engineers inspected the microwave path measuring terminal at Murray Hill. Transmitting end of the path was at the Chester field station

Bell System Held Order Total Reduced

The Bell System total of unfilled applications for telephone service was reduced about 200,000 during the third quarter of 1947, leaving the aggregate at 1,894,000 at the beginning of the tenth month. Telephones in service showed a nine-month gain of more than 1,850,000. New demand for service continued heavy.

Summit Association of Scientists

Last spring several scientists met in Summit for an informal discussion of the social implications of science, and that original group became the nucleus of the Summit Association of Scientists. Six men from Bell Laboratories are members of the present executive committee of the association. They are: G. C. Daniel-

ounty Commander E. J. Clark (right) installs . Bongard as Western Electric Post Commander

son, M. E. Fine, W. C. Herring, H. E. Mendenhall (chairman), J. M. Richardson and C. H. Townes. They had Dr. Philip M. Morse, director of the Brookhaven National Laboratory, as a speaker at an open meeting in June.

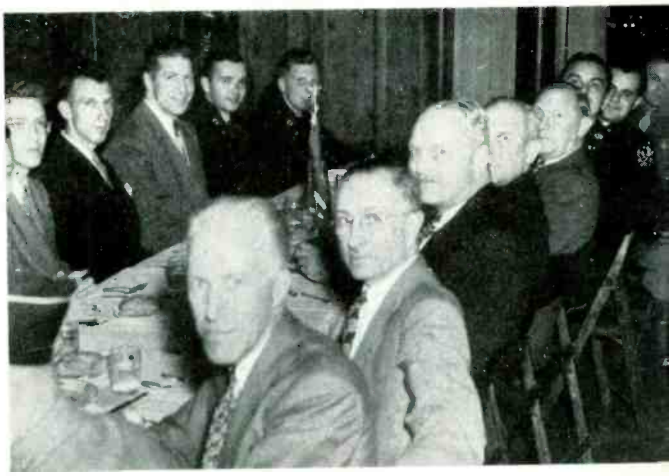
Membership is made up of scientists employed by laboratories in and near Summit. Organized primarily to study and discuss problems related to the social aspects of science, the actual dissemination of scientific information bearing upon social, economic, and political problems is an equally important purpose.

P. J. McGann (left) presents Past Commander's badge to Fred Deputy at the annual meeting of the Western Electric Post, American Legion

Legion Post Installs Officers

New officers of Western Electric Post 497, American Legion, were installed at a dinner held on October 28 at the George Washington Hotel. Fourteen past commanders were included in the sixty-five members and guests who attended.

New York County Commander Edward J. Clark installed the following officers: H. Bongard, Commander; R. C. Kenny, First Vice-Commander; and J. Landi, Second Vice-Commander, all of Western Electric; D. H. MacPherson, Third Vice-Commander, B.T.L.; W. J. Hogan, Adjutant, W. E.; R. C. Nance, Assistant Adjutant; and H. S. Hopkins, Finance Officer, B.T.L.; E. N. Emmons, Service Officer, and A. Draper, Chaplain, W. E.; and J. M. Marko, Sergeant-at-Arms, B.T.L.



Many past commanders attended the annual meeting of Western Electric Post 497, American Legion

The installation was followed by a talk by County Commander Clark outlining the various activities of the Legion. J. W. Lea of Long Lines, Past Adjutant of the John Puroy Post, spoke on changes which might bring more Bell System employees in the Post. P. J. McGann presented the Past Commander's badge to F. T. Deputy, the retiring Commander.

We See by the Papers, That—

American Telephone and Telegraph Company received a heartening vote of confidence in the future of the business from its employees, more than 250,000 of whom have signified their intention of buying capital stock under terms of the employees' stock plan. More than 45 per cent of employees who had six months or more service with A T & T last August 31 signed to purchase more than 50

On a Saturday in October, W. S. Suydam visited Murray Hill to see what his camera could pick up. In this view, at the left is the restaurant, at the right the Arnold Auditorium; in the lower view, autumn leaves accentuate Saturday afternoon quiet

per cent of the 2.8 million shares authorized for the purpose, a higher rate of participation than for previous plans. Each eligible employee had the right until October 31 to subscribe to one share of stock for each $500 of his annual base pay up to 50 shares. Installment payments for the shares are to begin through payroll deductions in December.—*Wall Street Journal, November* 8, 1947.

News Notes

HARVEY FLETCHER and J. C. STEINBERG attended a meeting in Washington of the National Research Council Sub-Committee on Group Hearing Aids of which Dr. Fletcher is chairman. He also presided at the session on Acoustics of the Theatre Engineering Conference of the Society of Motion Picture Engineers on October 24 in New York.

DR. C. E. MARTIN, R. B. GIBNEY, L. A. WOOTEN, J. STRUTHERS, J. A. BURTON and T. J. CROWE attended talks at the Brookhaven Laboratories on the handling of radioactive material.

ELIZABETH A. WOOD spoke on *Optical Methods of Crystal Investigation* at the Squier Signal Laboratory, Fort Monmouth.

C. H. TOWNES addressed the joint Harvard-M.I.T. Colloquium on *Nuclear Quadrupole Effects in Molecules.*

W. P. MASON attended the New York meeting of the Rheological Society.

H. K. BODE selected *Broadband Negative Feedback Amplifiers* as the subject of his lecture on November 17 in the course on Wideband Amplifiers being given jointly by the Communications Division of the New York Section of the American Institute of Electrical Engineers and the Institute of Radio Engineers.

H. D. HAGSTRUM and J. R. HAYNES participated in a conference in Arnold Auditorium at which the work of the physical electronics and solid state research groups was discussed. Mr. Hagstrum spoke on *The Dissociation Energy of Carbon Monoxide and the Heat of Sublimation of Carbon;* Mr. Haynes, *The Behavior of Photoelectrons in Silver Chloride as Exhibited by Colloidal Silver Produced at Electron Traps.*

K. K. DARROW attended the centennial celebration of Sheffield Scientific School of Yale University as a delegate of the American Institute of Physics. He also attended the convention of the New England Section of that society held at Middletown, Connecticut. Dr. Darrow spoke before the Metallurgy Colloquium of Massachusetts Institute of Technology on *The Physicist Looks at Metals.* On November 11 he delivered the first lecture, *Metallic Structure,* in a series of six, before the Basic Science Group of the A.I.E.E.

R. M. BURNS, U. B. THOMAS, JR., H. E. HARING and W. E. CAMPBELL went to Boston for the annual fall meeting of the Electrochemical Society Convention. Mr. Thomas presented a paper, *Corrosion and Growth of Lead-Calcium Alloy Storage Battery Grids as a Function of Calcium Content,* of which he is co-author with F. T. FORSTER and H. E. Haring.

A. C. WALKER visited Ohio State University, Antioch College, University of Missouri School of Mines, University of Utah, and the Brush Development Company in Cleveland to discuss synthetic crystal problems. While on a vacation trip to the Pacific Coast by car during October, he also spoke on growing synthetic crystals before groups of telephone engineers in Los Angeles, San Francisco and Denver. At the annual meeting of the American Association of Textile Chemists and Colorists in Chicago, he presented a paper on *The Textile Drying Process.*

L. A. WOOTEN delivered the first in a series of informative lectures designed to acquaint members of the Laboratories with development work in various areas. Mr. Wooten spoke on *New Tools and Techniques for the Analysis of Materials* on November 17 at 463 West Street and on November 20 at Murray Hill.

J. B. HOWARD was at Burlington in connection with hearing-aid cord problems.

J. H. HEISS attended a meeting of the Polymer Research Group of the Office of Rubber Reserve in Washington.

R. C. PLATOW presided over the meeting in Cleveland of the Committee on Adhesives of the American Society for Testing Materials.

K. G. COMPTON presented a paper on *The Selection of Protective Coatings for Metals* at the Southeastern Branch of the American Electroplaters' Society in Birmingham, Alabama. He also gave a talk on *Electronic Matériel and Apparatus in the Tropics* at the U. S. Navy Powder Factory in Indian Head, Maryland.

Army-Navy "E" pennants were flown again throughout the country on Navy Day, October 27, and during the preceding week. E. W. Hubbard raises the flags at the Deal laboratory. E. MacC. Fliedmer is at the right

R. A. EHRHARDT visited the Brush Development Company at Cleveland to discuss the electrodeposition of magnetic recording alloys.

A. H. WHITE, C. HERRING, C. D. HARTMAN, R. W. HULL, W. SHOCKLEY, J. BARDEEN, L. A. WOOTEN, J. A. BURTON and J. D. STRUTHERS participated in a conference at the RCA Laboratories at Princeton.

W. SHOCKLEY has been made a member of the Frank B. Jewett Fellowship Committee.

G. L. PEARSON attended the Cyrogenic Conference at Ohio State University.

RETIREMENTS


L. E. Dickinson


William Belits


C. J. Kuhn

Members of the Laboratories who retired recently include C. J. Kuhn on November 30, with 41 years of service; L. E. Dickinson on November 30, 37 years; and William Belits on November 24, 30 years.

Lewis E. Dickinson

After graduating from the Worcester Polytechnic Institute in 1903 with a B.S. degree, Mr. Dickinson of Switching Apparatus Development spent several years with other electrical concerns and then joined the Western Electric Company in 1910. At West Street his first work was in the Physical Laboratory on the development of heat coils, magnet wire, switchboard cables, and magnetic materials. Seven years later he transferred to the apparatus design group where he was interested primarily in the design features of such apparatus and materials. During World War I he aided in the development and testing of submarine detectors and field telegraph sets. Later he transferred to the general development laboratory where he was concerned with telephone protection problems. In 1927 he joined the Telephone Apparatus Development Department on apparatus analysis of step-by-step and panel apparatus, base-metal contacts, and station handsets.

During World War II Mr. Dickinson aided in the development of components for the electrical gun director and other equipments designed for the Armed Forces. Later he was concerned with studies of dial performance and with the development of protection apparatus. More recently he has carried on extensive studies in connection with the development of improved terminal strips.

William Belits

Mr. Belits started work in the Model Shop at West Street as an instrument maker; among his first assignments was the making of experimental molds for the development of telephone handsets. During the latter part of World War I he was engaged in the making of radio apparatus then being developed for government use. Following the war he was appointed as a supervisor, in which capacity he directed shop work on a variety of assignments which included instrument makers, the construction of loading and retardation coils, heavy machine work, milling machines, punch presses, and cabinet shop operation. In 1937 Mr. Belits was promoted to the position of foreman in the Development Shop.

With the expansion of the Laboratories' activity brought about by World War II, Mr. Belits was assigned to the group then being organized to handle work subcontracted with outside suppliers. In 1944 Mr. Belits was transferred to the Laboratories Preproduction Shop at 157 Chambers Street as foreman in charge of the assembly and wiring group. At the conclusion of this war activity, he assisted in the setting up of the present Assembly and Wiring Shop located at West Street where he was a foreman at the time of his retirement.

Charles J. Kuhn

Mr. Kuhn started in 1905 as a milling machine operator. Five years later he was assigned to telephone repair work and when manufacturing activities were transferred to Hawthorne he became a millwright in the old Model Shop. Later he was assigned to the machine switching development group where he set up equipment and performed other jobs of a mechanical nature for the engineers engaged in this development. Since 1925 Mr. Kuhn has been in charge of the 4E storeroom of the General Services Department.

News Notes

At Hawthorne, J. R. Townsend, G. T. Kohman, H. G. Wehe and D. A. McLean discussed capacitors; H. Peters, rubber flooring for telephone booths and neoprene-coated coin chutes; A. J. Christopher and J. R. Weeks, new metallized condenser for station sets; V. E. Legg, loading coils and cases; J. R. Bardsley, submarine loading coil cases; H. A. Frederick, H. O. Siegmund, A. C. Keller, C. N. Hickman, C. F. Swasey, B. F. Runyon and W. Orvis, new switching apparatus; W. W. Brown, telephone operators' chairs; and V. T. Wallder, plastic insulation.

"Authorization for Work"

For the benefit of engineers now hard at work on Annual Case Authorizations, the following words of advice have been versified by R. C. Mathes:

When a job is added to the pot
The question first to mind is *what*.
As background helps to proper sense,
Throw in a line regarding *whence*.
No time for aimless yon and thither—
Our job should have a definite *whither*.
The future's not within our ken
Yet we must risk a guess at *when*.
For engineers to earn their chow
They must have thoughts regarding *how*.
What profits in this job we spy
We must put down explaining *why*.
Away with surplus verbiage—
Condense the tale upon one page.*
How, when, why, what, whence, whither,
From steno to boss we're all in a dither.

News Notes

J. R. Fisher attended the meeting of the Refractory Division of the American Ceramic Society at Bedford, Pa.

W. A. Munson went to Harvard University for a meeting of the Naval Research Advisory Panel for Psychophysiology.

A. C. Beck presented a paper, co-authored by D. H. Ring, on *Testing Repeaters With Circulated Pulses* before the joint meeting in Washington of the URSI and the Institute of Radio Engineers. At the same meeting, W. E. Kock presented a paper on *Broadband Metallic Lenses*. At Cincinnati he spoke on *Metal Plate Lenses for Microwaves* before the Optical Society of America.

W. R. Lundry collected L1 system delay and attenuation data for a new equalizer at the main repeater station of the Long Lines at Dallas.

F. J. Hallenbeck studied filter manufacture problems at the Haverhill plant of the Western Electric Company.

J. H. Bower attended the sessions of the Electrochemical Society Convention devoted to primary and storage batteries. He also visited the National Carbon Company, Cleveland, to discuss batteries for hearing aids.

R. A. Sykes attended meeting of Sub-Panel on Frequency Control Devices of the Joint Research and Development Branch at the Squier Signal Laboratory, Fort Monmouth.

R. A. Hecht was at the Ucinite Company in Boston to discuss multi-contact connectors.

*Seldom realized!

M. Feder, at Media, checked the adjustment and inspected line relays used in No. 5 crossbar equipment.

D. G. Blattner and A. E. Dietz visited the St. Paul plant of Western Electric in regard to general discussions on fuses.

Douglas Aircraft Photo

J. H. Waddell, extreme right, is shown illustrating the use of the fastax camera during a course in High-Speed Photography given by the Laboratories and Western Electric at the University of Southern California. The course extended from September 15 to October 3 and was given to Air Force, Signal Corps, naval, educational and industrial research personnel training for careers in cinematography

E. P. Felch, G. N. Packard and W. A. Marrison were in Washington in connection with the design of the new Bell System primary frequency standard.

M. H. Cook and R. E. Poole attended conferences at Winston-Salem. Mr. Poole was also at Burlington and at the Navy Department in Washington.

For a second year a vaccination against influenza has been given on a voluntary basis to members of the Laboratories and more than 2,300 have received the serum. Above, Nurse Helen Adams is shown vaccinating a patient at the West Street Medical Department

C. R. Taft, V. I. Cruser, C. H. Williams and N. W. Bryant witnessed the testing of submarine radar equipment at New London.

J. B. D'Albora went to the Gorham Company in Providence regarding balanced converters for radar equipment.

J. W. Smith and F. E. Nimmcke conferred on fire-control equipment at the Bureau of Ordnance in Washington.

W. C. Hunter visited Washington and St. Louis in connection with tests on new equipment used in the urban mobile radio services.

F. C. Willis and E. T. Mottram participated in conferences at Wright Field on the status of testing and producing special radar.

F. Cowan went to Binghamton for the annual sales conference of the Ozalid Division of the General Aniline and Film Corporation.

"The Telephone Hour"

NBC, Monday Nights, 9:00 p.m.

December 15*	*Jascha Heifetz*
December 22	*Blanche Thebom*
December 29	*Robert Casadesus*
January 5	*Maggie Teyte*

*From Hollywood.

H. A. Baxter's trip to the Palmer-Bee Company in Detroit concerned antenna problems.

R. O. Wise and M. N. Yarborough, at Wright Field, discussed specifications and proposals for flight-testing radar equipment.

O. M. Glunt visited both Burlington and Winston-Salem during October.

F. L. Langhammer and R. L. Mattingly investigated antenna production problems at the Brooks and Perkins Company in Detroit.

W. H. Doherty was present at the Vatican for an audience with the Pope given to delegates to the International Radio Congress marking the fiftieth anniversary of the discovery of radio by Guglielmo Marconi.

A. F. Hughes' visit to the Ordnance Department was concerned with radar pamphlets.

E. H. Jones and J. T. Muller observed type tests at the Naval Research Laboratories.

H. Vadersen visited the Fairchild Camera and Instrument Corporation to confer on the production of radio ranging equipment.

J. H. Cook and R. H. Kreuder spent some time at the Douglas Aircraft Company at Santa Monica, California.

R. R. Hough made trips to the Airborne Instrument Laboratories, Mineola, and to the Wheeler Laboratories, Great Neck, New York, in connection with a fire control system.

W. Stumpf reviewed, with Air Force representatives, problems at Wright Field relating to the procurement of spare parts for radars.

R. W. Benfer recently visited the Warner-Swasey Company at Cleveland; H. T. Budenbom, the Naval Research Laboratory, Anacostia; and F. A. Krauth, the Eastman Kodak Company, Rochester.

H. A. White spent October at the Tennessee Aircraft Corporation, Nashville, and at Winston-Salem on radar production work. Others who were at Winston-Salem include E. A. Bescherer, radio telephones; R. C. Newhouse, radar; J. E. Corbin, radar; H. R. Wilsey, instrument books for radio equipment; J. H. Hershey, T. M. Bray and G. D. Johnson, production of radar; and H. A. Baxter and P. H. Thayer, antenna testing.

R. C. Newhouse and R. F. Lane participated in a Navy Aircraft Radio Conference during a recent trip to Washington.

At Burlington, G. T. McCann was concerned with broadcast transmitters; H. C. Braun, the 5A monitor; A. C. Peyman, the design of a new transmitter; and R. E. Coram, the 10-kw transmitter.

S. O. Ekstrand, with C. E. Snow of the Western Electric Radio Division, attended a meeting at the Aeronautical Radio Corporation in Washington. They discussed a preferred list of reliable vacuum tubes with Aeronautical Radio and Association of American Railroads and various tube and electronic apparatus manufacturers. Mr. Ekstrand, D. S. Peck, V. L. Ronci, E. G. Shower, R. L. Vance and J. W. West attended the Western Electric-Graybar Sales conference, held to discuss plans for new codes and field operation problems.

R. C. Edson, F. A. Minks and W. Van Haste, at Crystal Falls, Michigan, investigated troubles in rural power-line telephone systems.

L. F. Moose recently conferred with members of the Bureau of Ships on local oscillators in Government microwave equipments.

D. S. Peck, V. L. Ronci, E. G. Shower, R. L. Vance and J. W. West attended the National Association of Broadcasters' Convention in Atlantic City.

E. G. Shower, with D. S. Frankel of Western Electric Radio Division, visited the Thermex Division of Girdler Corporation, Louisville, in connection with the application of type 5531 tubes to dielectric heating applications.

T. C. Fry attended the United States Independent Telephone Association Convention held October 14 in Chicago.

J. M. Dunham spent several days in Aiken, S. C., and Tarboro, N. C., in connection with M1 carrier on rural power lines.

K. L. Maurer, R. Pope and J. H. Harding investigated cable sheath corrosion at Fond du Lac, Wisconsin.

R. K. Honaman visited Boston and consulted with representatives of the Publicity Department of the New England Telephone and Telegraph Company.

The Laboratories were represented in interference proceedings at the Patent Office by J. W. Schmied before the Board of Interference Examiners.

J. E. Cassidy and E. B. Cave appeared before the Board of Appeals at the Patent Office in Washington relative to applications for patent.

R. R. Riesz was recently awarded an Alumni Citation "in recognition of outstanding ability and distinguished accomplishments in the field of Sound and Acoustics" by Ripon College. On November 3, Mr. Riesz visited Ypsilanti and Ann Arbor in connection with the visible speech installation at University of Michigan and the Michigan State Normal College.

S. P. Shackleton chose *The Engineering Profession—Its Responsibilities and Opportunities in Society* as the topic for his talk before the first meeting of the Manhattan College chapter of the A.I.E.E.

D. R. Brobst, J. W. Woodard, R. G. McCurdy and E. B. Wood visited the Western Electric Cable Plant at Buffalo to discuss requirements for switchboard cables.

N. H. Thron visited Burlington and Winston-Salem in connection with single sideband radio equipment.

H. A. Miloche attended a technical symposium on printed circuits at Washington, D. C.

R. H. Ross tested motors for sonar equipment at New London.

OBITUARIES

G. K. Smith 1883-1947 — J. E. Kenzig 1874-1947

Gordon K. Smith, November 13

A graduate of Pratt Institute, Mr. Smith, who retired in 1942, had joined the Western Electric in 1902 in New York, later going to Hawthorne. Returning to West Street in 1910, he took an active part in development, first tests and, later, trials in Newark of panel-central office equipment. During World War I he worked on PBX's used by the Post Office and the Department of the Interior, and on step-by-step PBX's for railroads. He was later associated with the development of step-by-step and crossbar equipment.

John E. Kenzig, October 28

In his twenty years of Bell System service Mr. Kenzig had been an instrument maker at West Street and had specialized in the wiring of early radio equipment and public address systems. At the time of his retirement in 1939 he was a laboratory mechanic assigned to the test station at 32 Sixth Avenue.

Engagements

*Marjorie Boitel—Robert W. Proctor
*Gladys Brocking—John Kwait
*Claire Deerin—John G. Gill
*Florence Makoske—John Karbowski
*Barbara McGowan—Charles H. Cadmus
*Patricia Munther—*Frederick B. Vreeland
*Kim Mee Ng—Joseph F. Chu
*Barbara Parker—*William Springer
Sally Potter—*William R. Rushmore, Jr.
*Jane Sherry—Stanley J. Witiver
*Ellen Starr—Vincent Blois
*Ruth Vieweger—Vincent Nugent

Weddings

*Carol Bockhoven—Ralph B. Welsh
Margaret Connolley—*Carl Wm. Bachmann
*Helen Duerr—John G. Fernandez
*Margaret Ferrie—Robert Thomas
*Beatrice Maher—Stanley Donovan
*Norma Malecki—Arthur A. Prisby
*Margaret Marlowe—John Higgins
*Mary McLoughlin—*John J. Mosko
*Cecile McNeal—Nicholas Lisante
*Vincina Rizzo—George A. Gabriel
Doris Savistro—*Robert L. Norton
*Mary Suchonik—Frank Labuda
*Joan Thomas—*Harry A. Helm
*Frances Truzzolino—John Kaufmann
Clara Zuccato—*Francis Bruckner

*Members of the Laboratories. Notices of engagements and weddings should be given to Mrs. Helen McLoughlin, Room 803C, 14th St., Extension 296.

News Notes

H. T. LANGABEER discussed power plant questions at The Bell Telephone Company of Pennsylvania and at Western Electric, Chicago.

A. F. BURNS and R. R. GAY tested power plants on the New York-Boston radio relay system.

H. H. SPENCER visited Mineral Wells and Sweetwater, Texas, to test new power supply equipment for L carrier systems.

A. HERCKMANS and H. R. CLARKE discussed at Archer Avenue the manufacture of a new station dial.

T. H. CRABTREE discussed information on batteries for hearing aids with the National Carbon Company in Cleveland.

PAPERS presented before the November 3-7 Mid-West General Meeting of the American Institute of Electrical Engineers at Chicago were *Frequency Division Techniques for a Coaxial Cable Network* by R. E. CRANE, J. T. DIXON and G. H. HUBER; *The Glass Enclosed Reed Relay* by W. B. ELLWOOD; and *Capillary-Fed Mercury-Contact Relay* by J. T. L. BROWN and C. E. POLLARD. A. W. CLEMENT also attended the meeting.

A. C. PETERSON and A. E. RUPPEL discussed mobile radio equipment problems with Motorola engineers at Chicago.

H. W. EVANS and H. S. WINBIGLER on visits to Newark, Philadelphia, Baltimore and Washington reviewed performance of mobile telephone service to passengers on the "Royal Blue" of the Baltimore & Ohio and the "Congressional" of the Pennsylvania Railroad. Mr. Winbigler and J. MALLETT were in Chicago discussing mobile radio problems.

C. C. TAYLOR attended a Sub-Committee meeting of the Radio Technical Commission for Marine Services in Washington.

D. K. MARTIN attended a meeting of the Radio Technical Commission for Aeronautics Special Committee on air traffic control facilities.

W. R. YOUNG attended a meeting in Washington of the RMA Sub-Committee on Systems Standards of Good Engineering Practices.

R. C. SHAW visited Chicago and St. Louis in connection with mobile radio systems problems.

H. H. ABBOTT, A. L. MATTE, R. A. MILLER, NEWTON MONK, R. B. SHANCK and A. L. WHITMAN attended the annual convention of the Association of American Railroads at Miami Beach.

A TWO-DAY conference between representatives of the Laboratories and Western Electric Company was held on October 30 and 31 at Point Breeze. The subjects discussed comprised cable, cords and outside plant and station wires.

H. F. HOPKINS and R. BLACK were in Cleveland to attend Radio Manufacturing Association meetings.

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