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A PREVIEW OF RADIO RELAYING

Most of the Laboratories people at Murray Hill have seen a tower standing on the high ground east of the water tanks and supporting what is obviously a pair of microwave antennas. The more observant of the commuters who ride the Christopher Street ferry have noticed that two of the windows on the 13th floor of the West Street building have been obscured by white panels. Behind the panels are two shielded lens antennas* similar to the pair on the Murray Hill tower. These antennas together with the 21-mile line-of-sight path between them form part of a broad-band microwave radio relay system: a sort of "bread-board" model of the system to be put in operation between New York and Boston in the near future.

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

Fig. 1—The 100-foot antenna tower and repeater house at Murray Hill

This latter radio relay system will link Boston and New York with two two-way circuits operating in the range between 3900 and 4200 mc, and capable of handling the present standard television signals or alternatively a substantial number of telephone channels. Construction and installation has been completed and over-all tests are under way. Although differing somewhat from the experimental system between New York and Murray Hill in apparatus and circuits, the link between New York and Boston is similar to it in all essential features.

In early June of 1945, when it became apparent that the war could not last much longer, and that manpower for the job would shortly become available, it was decided that a proper first step in the project would be the construction of a relay system between New York and Murray Hill, where the equipment designs could be shaken down before shop production was started on the final models. This experimental system was completely in operation in May, 1946, and has been demonstrated to a number of interested groups, including members of the A T & T, the engineers of the FCC, and delegates to the International

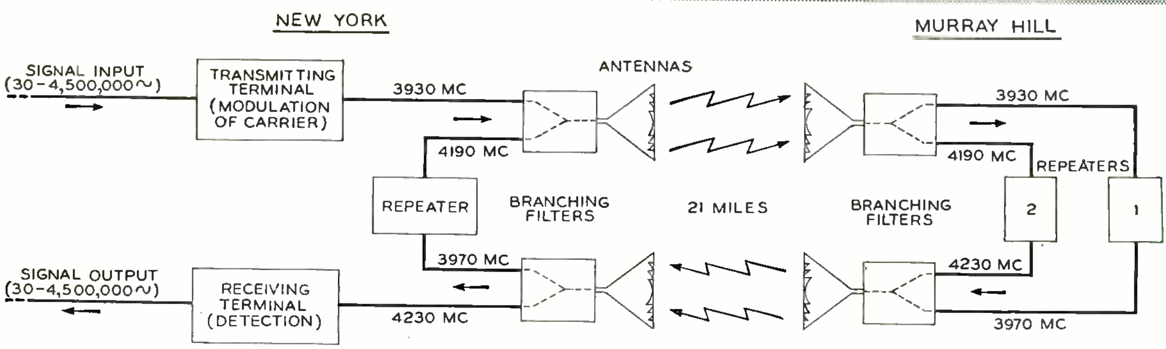
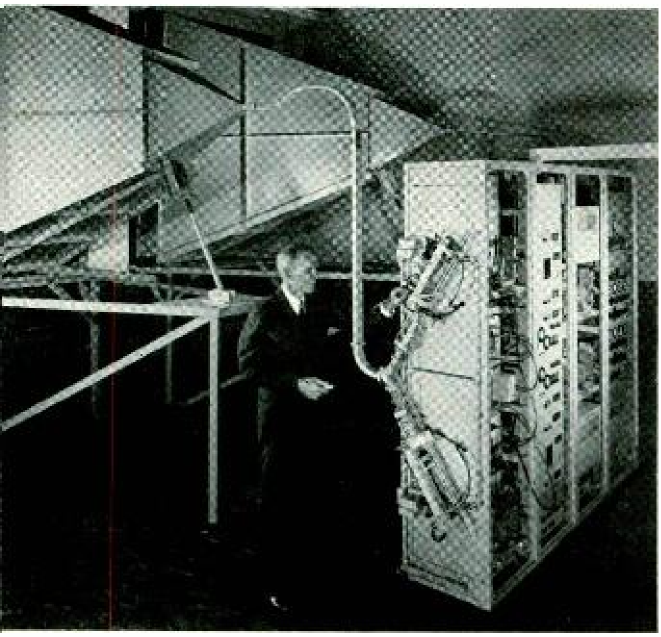


Fig. 2—Block schematic of the double loop radio relay system between Murray Hill and New York

Telecommunications Conference. It was also used in connection with the A T & T exhibit for the Television Broadcasters Convention in October, 1946.

The system shown in outline in Figure 2 will accept signals in the so-called "video" frequency range from 30 to 4,500,000 cycles, send them twice around the 42-mile loop, and then deliver a faithful reproduction of the input signals. If unwound, this system would serve to link New York and Philadelphia one way.

Fig. 3—F. F. Merriam adjusting a receiving modulator at the West Street building



Some of the advantages of microwave radio relay systems have already been described in the RECORD.* One of them is the desirable transmission characteristics obtainable by the use of directive antennas which, by confining the transmission paths to narrow beams, reduce the loss and minimize interference problems. On the Murray Hill tower, each of the two 10x10-foot shielded-lens antennas provides a beam width of less than two degrees, which corresponds to 40 db gain over a non-directional antenna. To fit the window frames in Room 1309, at West Street, the antennas had to be made 5x7 feet with a corresponding gain of 35 db. By using these directional antennas, the normal loss in each 21-mile link is 75 db less than it would have been with non-directional antennas, and is only about 60 db.

Extensive propagation tests over the past years have disclosed that the loss is not constant, but on the contrary on still and humid summer nights may be expected to range occasionally from about 55 to 80 db with a maximum fading rate of something like 5 db per second. From this transmission information, it is easy to see that the repeater must provide a maximum gain of 80 db, and that automatic gain regulation to 25 db below this figure is required. Although the average spacing of repeaters on the New York-Boston system is 27.5 miles, the full 10x10-foot antennas are used throughout, and the average trans-

*RECORD, *October*, 1945, *page* 365.

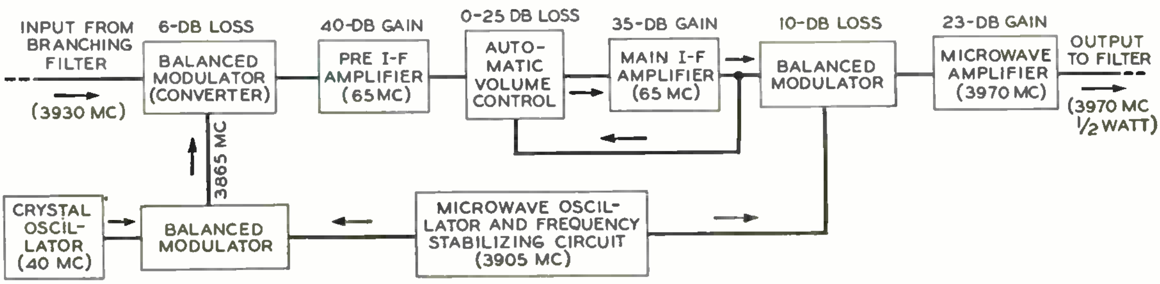


Fig. 4—Block diagram of a repeater such as those at Murray Hill. To make the diagram definite, the frequencies shown are those of repeater No. 1

mission loss per link is about the same as for the 21-mile circuit between New York and Murray Hill.

As may be seen from Figure 2, the first step in the process, as is usual in radio transmission, is to modulate the carrier with the signal intelligence. Frequency modulation has been chosen for the New York to Boston system on the basis of tests on the New York to Murray Hill circuit, which now is operating with this type of modulation. Although the repeaters are suitable for either frequency modulation or amplitude modulation, tests have shown that frequency modulation, with a low index, can be transmitted within a comparable band width, and offers real advantages over amplitude modulation. These advantages result because with frequency modulation the intelligence is conveyed as a function of the frequency of the radio signal, not its amplitude. It is therefore possible to run high-level amplifier stages near their overload points, thus making more output power available. Because the receiving terminal includes an instantaneous amplitude limiter, the requirements on automatic gain regulators may also be relaxed.

A carrier of 3930 mc frequency-modulated by the signal intelligence is trans-

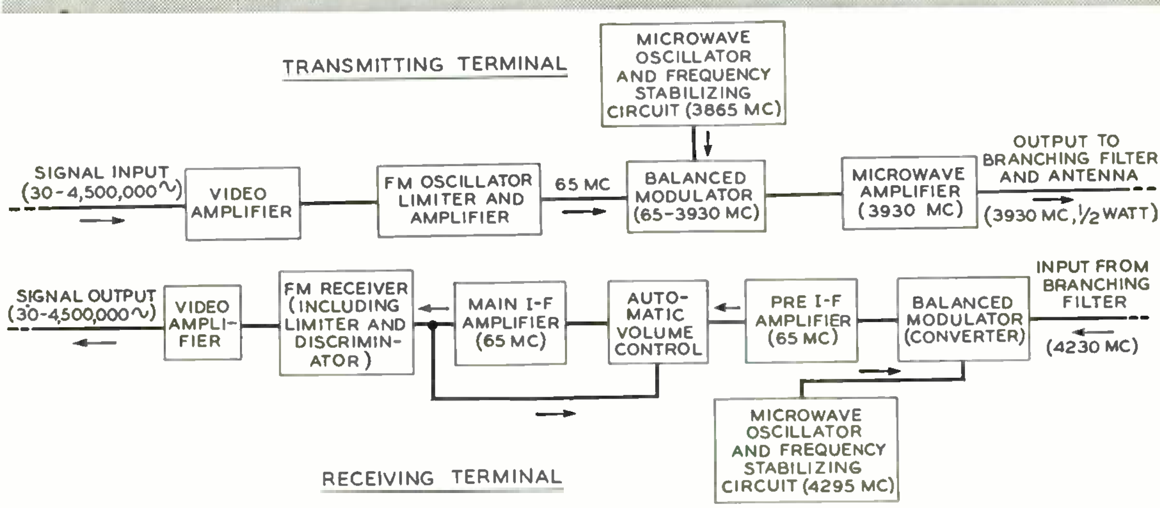


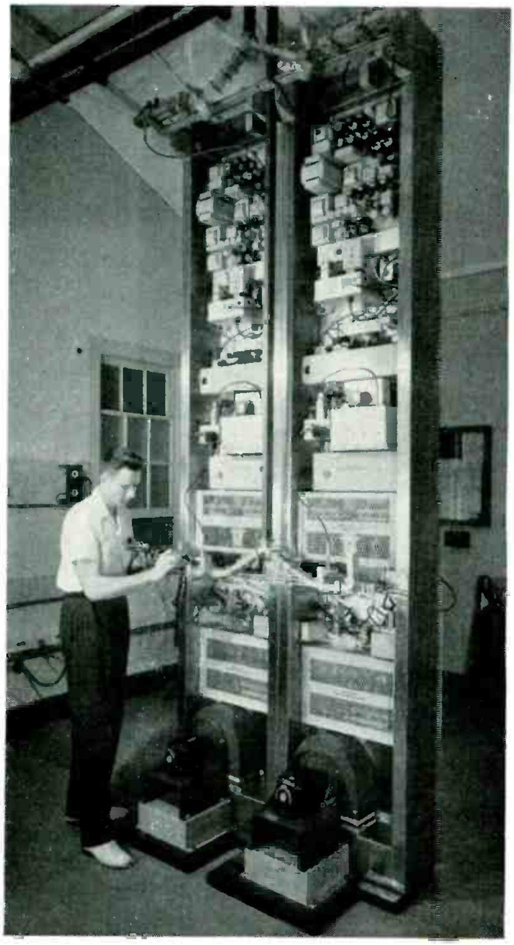
Fig. 5—Block diagram of transmitting terminal, above; and receiving terminal, below

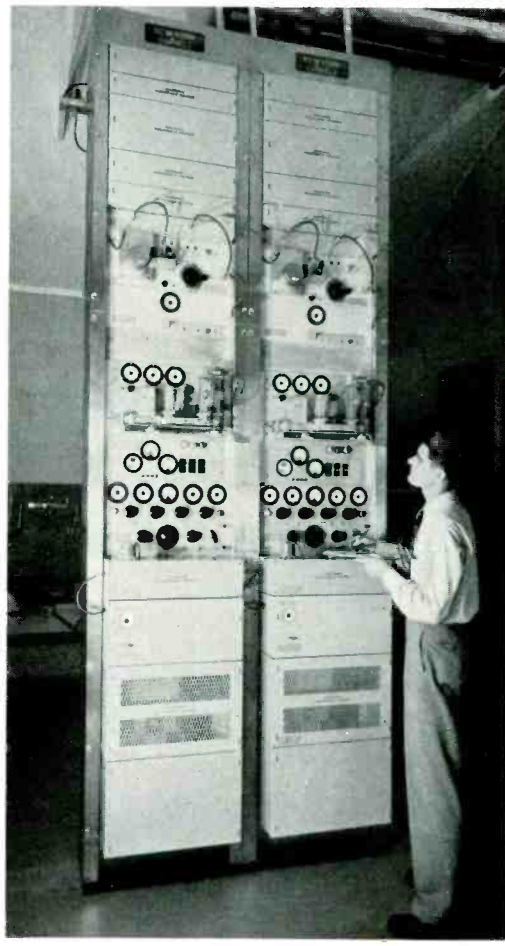
mitted to Murray Hill. Here it is received in repeater No. 1, amplified, and transmitted back to New York, but shifted in frequency by 40 mc to 3970 mc. This frequency translation is made to prevent interference between incoming and outgoing signals due to crosstalk from the transmitting antenna to the receiving antenna. It will be noticed from Figure 2 that the repeater at New York shifts frequency by 260 mc instead of 40, but this is not typical and is required only because the circuit is looped.

Figure 4 shows the make-up of a repeater such as those at Murray Hill, and to make the plan definite, the frequencies shown are those of repeater No. 1. Although all of the functions shown on the diagram are familiar, much of the apparatus used is novel and interesting. The tuned circuits in the microwave portions of the equipment—used in filters, in interstage coupling transformers, in the oscillator tubes, and as a frequency control element—consist of cavities bounded by metal walls with openings to provide coupling. For the cavity that controls the frequency of the microwave oscillator, the walls are of silver-plated invar; the openings are sealed with mica windows; the water vapor in the space within is removed with a desiccant, and the complete unit is housed in a temperature controlled box.

The balanced modulators shown in the diagram employ sensitive silicon crystals as their non-linear elements, and the wave-

Fig. 6—Equipment racks at Murray Hill. At the left, H. A. Stein is checking the operation of a monitoring connection that measures the power output of Channel No. 1. At the right, J. H. Durrett of Long Lines is checking Channel No. 2





guide equivalent of a hybrid coil* is used to feed the signal and oscillator power to the crystals.

The intermediate frequency amplifiers are of conventional design, using 6AK5 tubes in the low-level stages. Until recently, the 6AK5 has been regarded as tops for low noise and high figure of merit, yet the Laboratories have just developed for the New York to Boston project a tube known by the number WE 404-A that offers lower noise and about twice the figure of merit of the 6AK5.

Four stages of WE 402-A type tubes coupled by cavity resonators comprise the microwave amplifier of Figure 4. Each unit in the repeater through which the modulated signal must pass is required to have a transmission band wide enough and flat enough so that the over-all repeater gain will be constant within 0.1 db over a 10-mc band. It is believed that the 402-A is the first commercially available tube capable of amplifying these wide bands at a frequency as high as 4,000 mc.

Figure 5 shows the functions performed by the transmitting and receiving terminals. It will be noticed that the part of the transmitting terminal that transforms the modulated 65-mc signal up to the microwave frequency range is identical to the final part of a repeater, and that the receiving terminal up to the block labeled frequency modulation receiver corresponds to the first part of a repeater.

*Record, *November*, 1944, *page* 605.

During 1946, the system between Murray Hill and New York was tested to determine the suitability of the basic design for long distance transmission of television signals. These tests, conducted with test patterns and with live studio programs supplied by NBC, CBS, and Dumont, show that present commercial television programs suffer no perceptible degradation in traversing the four-hop system.

Tests intended to evaluate possible methods of transmitting multiplex voice signals were started this year. To date the most comprehensive tests have been made with a new type of pulse signaling called pulse code modulation.* For these experiments, the New York terminal was converted to a repeater station and the Murray Hill equipment connected by coaxial lines to a skeletonized 96-channel PCM terminal in a laboratory room at Murray Hill. The New York-Murray Hill system provides a convenient facility for evaluating these and other possibilities in the transmission of multiplex voice signals. The results will be directly applicable to the system between New York and Boston as well as to future systems of the same general type.

*Record, *July*, 1947, *page* 265. See also page 422 for the I.R.E. demonstration of this system.

THE AUTHOR: G. N. Thayer worked during the summer of 1929 in the Department of Development and Research of the A T & T before completing a course in mechanical engineering at Stevens Institute of Technology. In 1930 he joined the Technical Staff of the Laboratories. Here, with the radio development group, he first engaged in the development of aircraft receivers for both beacon and two-way communication service. In 1937 he became supervisor of a group engaged in the circuit design of ultra-high frequency receivers for police, marine, aviation, and point-to-point service. In 1941, with the Specialty Products Development Department, he supervised a group designing circuits for radar systems, and in 1944 became Radar Development Engineer in charge of air-borne radar. Since 1945, as Radio Projects Engineer, he has been in charge of the microwave radio relay system that will go into operation shortly between Boston and New York.

AN AUTOMATIC TELEGRAPH SERVICE MONITORING SET

S. I. CORY
Telegraph Transmission

Radio-teletypewriter circuits usually have sufficient operating margin to afford good transmission in spite of the signal-distorting effects to which they are exposed, but error-free transmission for long periods, particularly over long distances, is not possible in the present state of the art. In other words, it is recognized in practice that over a long period a certain number of errors in the transmitted intelligence must be expected. These errors usually do not occur in such a way that they can be neglected; they usually are bunched so that a certain amount of the message is lost, as happens when severe fading occurs.

Installation of automatic telegraph service monitoring sets in the Long Lines Building of the American Telephone and Telegraph Company

Unsatisfactory transmission is readily detected on the printed copy of customers' teletypewriters where the copy is in plain English, as in most commercial services of the Bell System. During World War II, however, the Armed Services handled a large volume of traffic, much of which consisted of enciphered messages, and since under these conditions the received copy is unintelligible whether or not it has been mutilated in transmission, it does not furnish an indication of unsatisfactory transmission. The enciphered material must first be deciphered, and then the part in error must be repeated by the distant terminal. Sometimes this requires repeating considerable material, possibly one or more complete messages and, of course, delays traffic.

Much of the long-haul traffic of the Armed Services was handled by high-frequency radio telegraph, which is subject to severe fading and static at times, although generally the transmission is good. It was felt that the service over these circuits would be improved materially if they could be monitored continuously by an automatic monitoring device that would give an alarm if transmission became impaired to the extent that corrective steps should be taken to maintain satisfactory service. Preliminary models of such apparatus had been developed before the war and tried out on Bell System wire circuits. They functioned satisfactorily, but it was found that the frequency of transmission difficulties on land lines was not sufficient to justify the use of these continuous monitors. This situation does not hold for radio channels, and trials indicated that monitors of the type already available would be of considerable help in transmission maintenance work on the circuits. Accordingly, a set known as the X-66421A automatic telegraph service monitoring set was developed especially for the use of the Armed Services and a number of these, as well as the trial models, were used on Army and Navy radio channels.

The monitoring circuit is connected into the receiving telegraph loop circuit just as a receiving teletypewriter would be. It observes incoming signals continuously, and if a certain number of these in a predetermined time is excessively distorted, an alarm is automatically sounded. If the settings of the device are suitably made, that is, if settings of the percentage distortion, the counter for registering the number of excessive distortions, and the observation-interval timer are proper, a good indication is afforded of the times when the signal quality has deteriorated to such an extent that errors are likely to be made on a receiving teletypewriter. Thus, proper steps can be taken to remedy the condition before the channels have become unusable.

Operation of the X-66421 automatic telegraph service monitoring set is indicated by Figure 1, which shows the four major components of the monitor. The duration of each spacing and marking pulse is measured by the hit detector, and an indication of each pulse that is shorter than a predetermined value is passed on to the hit counter. If the number of these short pulses appearing within an interval set up in the delay timer is greater than a specified number, an alarm is given.

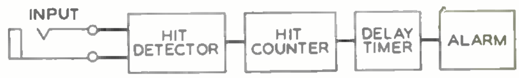


Fig. 1—Block schematic of the monitoring set

Operation of the hit detector circuit can be followed from Figure 2. Each incoming pulse operates the s1 relay to either mark or space, and this in turn operates the four relays s2, s3, s4, and s5 to mark or space, but s4 and s5 operate slightly after s2 and s3 because of the condensers shunted around their windings. The durations of the mark and space pulses are determined from the quantities of the discharges of capacitors c1 and c2 (which have previously been fully charged) during the mark or space pulses—c1 being used for timing mark pulses and c2 for spacing. During a spacing pulse, c1 is charged from a +130-volt source through the space contacts of relays s3 and s5. At the beginning of the

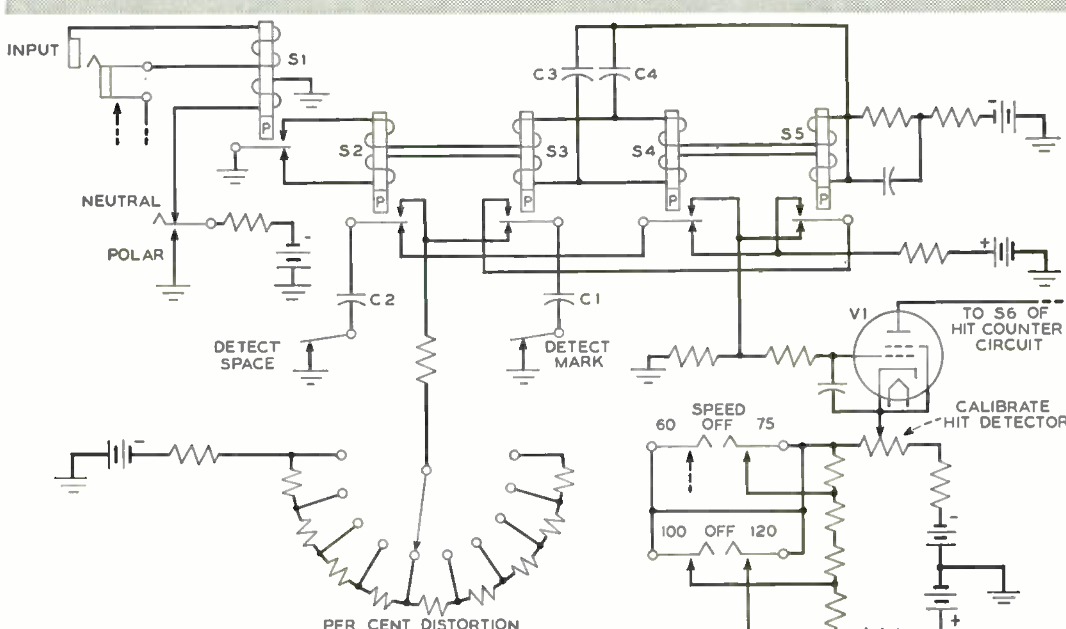


Fig. 2—Simplified schematic of the hit detector circuit

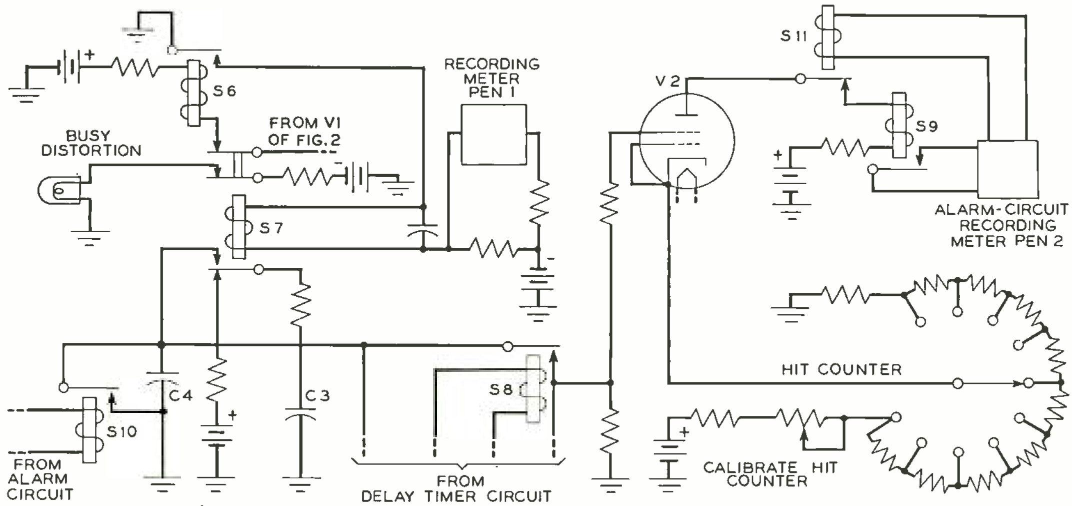


Fig. 3—Simplified schematic of the hit counter circuit

next mark pulse, C1 will be connected to a −130-volt potential through an adjustable resistance and the mark contact of S3. At the termination of the mark pulse, C1 will be connected to the grid of gas tube V1 through the space contact of S3 and the mark contact of S5—which has not yet operated to space because of the delay caused by the condenser shunting its winding.

Whether or not tube V1 will pass current depends on the voltage of C3 applied to its grid. It will pass current only if the voltage is at or above a preëstablished value. The fully charged voltage of C1 is +130, and during discharge its voltage falls steadily—ultimately reaching −130 volts. The voltage existing on C1 when it is transferred to the grid of V1 is thus a measure of the period during which it was discharging, which is the duration of the preceding mark pulse. If this pulse has been shorter than the prescribed limits, the voltage on C1 will cause the tube to fire and operate relay S6 in the counter circuit. The operation of S5 to mark after a short delay to permit tube V1 to operate will connect C1 to the +130-volt battery so that it may be charged in readiness for the next pulse. Spacing pulses are measured in exactly the same way by condenser C2 in conjunction with relays S2 and S4. The cathode voltage of V1 is made adjustable by four keys for 60, 75, 100, and 120 words per minute.

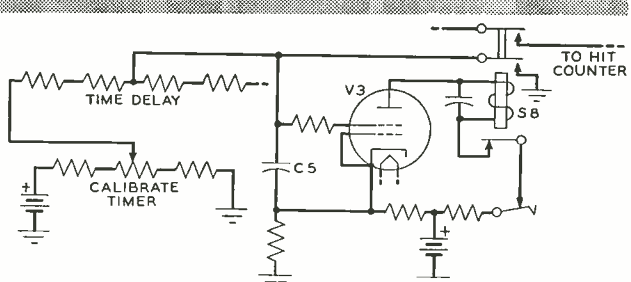


Fig. 4—Simplified schematic of the delay timer circuit

Relay S6, which is operated momentarily by V1 whenever a pulse shorter than the required length is received, is the input relay for the counter circuit shown in Figure 3. Each operation of S6 causes S7 to operate, which transfers small capacitor C3 from its charging supply to large capacitor C4. The charge on C4 is thus a measure of the number of excessive distortions. After a predetermined interval, determined by the delay timer circuit, C4 is connected to the grid of tube V2. If by this time the charge on C4 has built up to a specified value, V2 will pass current that will operate S9 and cause an alarm to be given. Voltages on the cathode of v2 may be varied to permit adjustment of the number of excessive distortions or hits required to give an alarm.

One pen of a recording meter may be connected in the winding of s7 as shown to record the number of hits received regardless of their frequency of occurrence. A second pen of the recording meter may be operated by the alarm circuit to record each alarm turned in.

The period over which the number of hits is integrated is determined by the timer circuit shown in Figure 4. A capacitor c5 is charged slowly through a high resistance which is adjustable to secure different times of integration. This capacitor is also connected to the control grid of a gas-filled tube, and after the voltage reaches a predetermined value, the tube fires and operates s8 of the counter circuit. Operation of s8 also discharges c5 so that a new cycle may be begun.

All the equipment for the automatic monitoring circuit is contained in a 3-foot 6-inch metal cabinet and arranged for operation directly from commercial power supply. It responds to neutral 60-milliampere or polar ±30-milliampere teletypewriter signals transmitted at speeds of 60, 75, 100, and 120 words per minute. A front view of the cabinet is shown in Figure 5. The top panel is the telegraph service monitoring panel. The smaller panel immediately beneath is the X-66421C fuse and alarm panel. A self-contained power supply for operation from 50 or 60 cycles power and located in the lower part of the cabinet includes two rectifiers—one for providing +130 volts and the other for providing −130 volts d-c power. A ten-foot rubber-covered power cord is provided for connection to the a-c power supply, and a twelve-foot patching cord for the input connection between the telegraph circuit and the input jack of the monitoring panel. Apparatus and wiring is moisture-proofed.

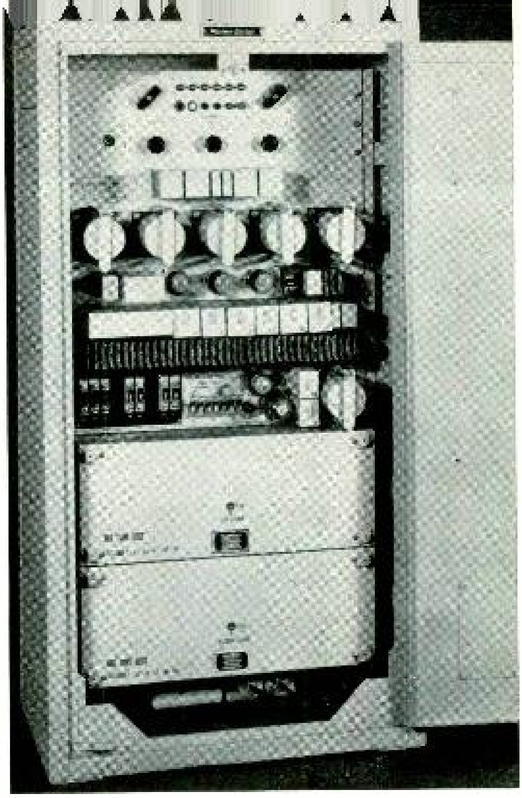


Fig. 5—The automatic telegraph monitoring set

These monitoring sets were used on important radio teletype circuits that formed the backbone of the vital world-wide communications systems of the Army and Navy during World War II. They performed satisfactorily and were found to be of considerable value in maintaining these services.

THE AUTHOR: Samuel I. Cory graduated from Ohio State University in 1916 with the degree of B.E.E. He joined the American Telephone and Telegraph Company immediately, and continued there in the Engineering and Development Departments until 1934, when he transferred to the Laboratories. Mr. Cory's work has been exclusively on transmission development problems, chiefly relating to telegraph systems and transmission measuring methods. During the war he was engaged almost exclusively in telegraph developments for the Armed Services, chiefly in the application of teletypewriter techniques to radio circuits.

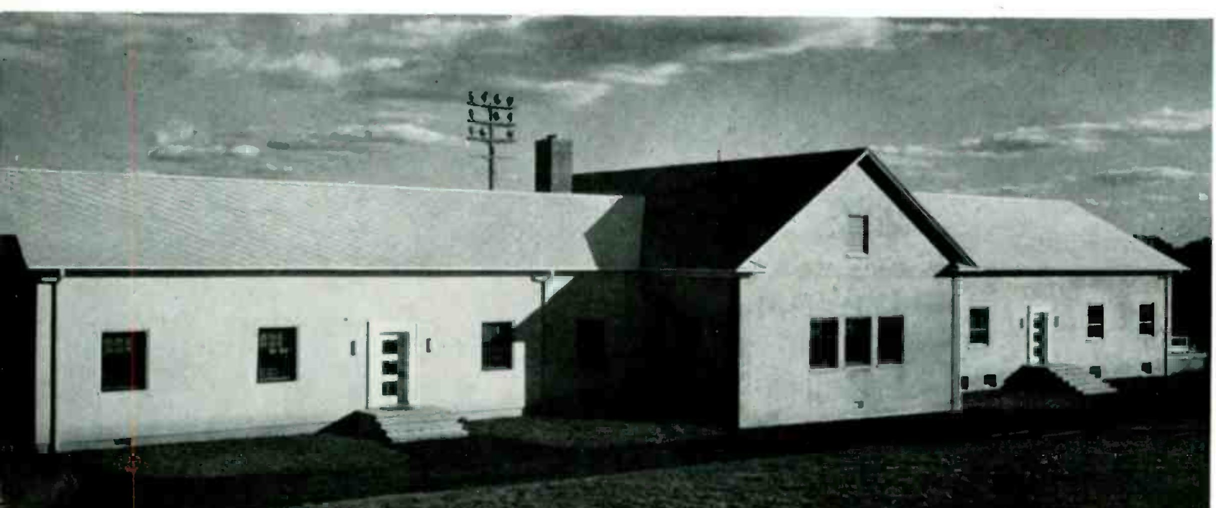
TESTING LABORATORY AT WHIPPANY

J. C. BAYLES
Commercial Products Development

When the Laboratories was called upon to design equipment for the Armed Services at the beginning of World War II, our personnel already possessed not only a well-founded testing philosophy but a considerable amount of testing equipment and experience both in using it and in interpreting results obtained. This phase of apparatus development has always been stressed in the everyday job of developing equipment for continued and highly reliable service throughout the telephone system. The range of conditions encountered in world-wide warfare, however, varying from tropical to arctic, from the surface of the earth to almost stratospheric heights, and including vibration and shock ranging from those of transportation to near-hits of high-explosive shells and bombs was of a different order of magnitude than that applying to peacetime communication equipment. Larger and more extensive equipment was needed, and from a survey of the testing methods and apparatus of the several "type-approval" agencies of the Armed Services came the decisions to establish a special Testing Laboratory at Whippany.

Apparatus installed in the Testing Laboratory is largely of a type not found in other testing areas in the Laboratories, since it is primarily designed to test for characteristics required by combat and service equipment. Furthermore, although the facilities can be and are used for component testing, emphasis was placed on the procurement of testing equipment capable of handling complete systems for synthesized trial installations.

In many aspects, the Testing Laboratory at Whippany parallels similar laboratories maintained by the several agencies of the Army and Navy; in particular, the machines upon which are made final acceptance tests of production equipments are duplicated as exactly as practicable. In this way, it was possible to obtain results of



tests in the Government laboratories closely duplicating those made in the Testing Laboratory on pre-production models, thus eliminating possible loss in production since, under the war program, production necessarily started before final type or acceptance tests were made. Further, the Testing Laboratory collaborated with the

Government laboratories in designing and manufacturing certain testing facilities, and in checking others.

Facilities installed in the Testing Laboratory, and placed in operation in the summer of 1943, included three "stratosphere" chambers, a vibration machine, roll-shock-vibration machine, two impact-type shock testing machines, and a salt-spray cabinet. Early in 1945, a larger vibration machine and a salt-fog cabinet were installed, and later the same year, the installation of two more stratosphere chambers was begun. These chambers are now undergoing acceptance tests.

Of the three stratosphere chambers, one was the large unit shown in Figure 2. This is a heat-insulated steel structure reinforced by steel members to withstand the enormous total pressure on its outside walls, which may exceed four hundred tons when the air pressure inside the chamber is reduced to simulate high altitude conditions. Three multi-pane insulating windows permit visual observation of the operation of the equipment under test. Inside, the work space is six by seven feet in floor area and seven feet high, while outside dimensions are approximately eight by fifteen by nine feet. A large door permits free access to the full width and height of the work space. The chamber is divided into two sections, separated by a partition with upper and lower tilting dampers. One section is the work space; the other contains the blowers for air circulation, the air-cooling coils, and the electric heaters. Air temperatures as low as −70 degrees F. can be attained when the electrical load of the equipment under test is as high as four kilowatts, and −94 degrees F. has been reached during some tests with light loads. Temperatures in excess of +160 degrees F. can be attained. Humidifying apparatus provides relative humidities up to 95 per cent at temperatures up to 160 degrees F. To "flight test" equipment, the air pressure in the chamber can be reduced to simulate altitudes up to about 60,000 feet. Under normal testing conditions, the "rate of climb" averages 6,000 feet per minute up to 50,000 feet. This chamber has also been used to test special packaging methods designed to prevent the infiltration of moisture into containers while the equipment is stored in the holds of ships for trans-ocean shipment or in warehouses in the tropics.

A second stratosphere chamber, Figure 3, providing conditions similar to those of the larger chamber, has a work space about thirty by thirty inches and thirty-six inches high. It has been used primarily for testing component parts and small assemblies of the airborne radar type. Mechanical refrigeration systems, installed in the basement to reduce the noise in the laboratory from the compressors, are employed for both of these chambers.

A third stratosphere chamber, shown in Figure 4, also has a work space about thirty by thirty inches and thirty-six inches high, but cooling is accomplished by placing

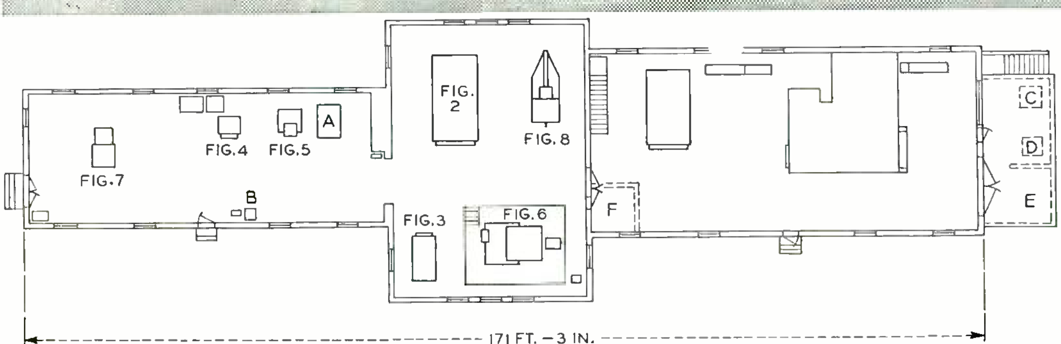


Fig. 1—Floor plan of the Whippany Test Laboratory; A—Portable temperature chamber; B—Electric oven; C—Salt-fog cabinet in basement; D—Salt-spray cabinet in basement; E—Pressure-testing room in basement; F—Dark room in basement

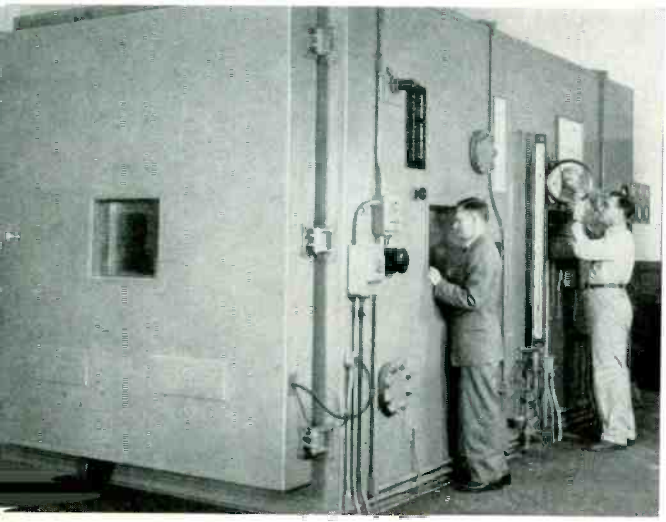


Fig. 2—*The large stratosphere chamber with L. A. Elmer watching the equipment under test through an observation window, and with J. E. Ziccarello at the control panel*

chipped "dry ice" in a tank of Varsol, and then pumping the cold Varsol into a cooling tank in the top of the chamber. It is used for tests requiring temperatures between −40 degrees F. and +180 degrees F. and relative humidities up to 95 per cent at 150 degrees F. This chamber also has found application for tests on components and small assemblies, and long-term relative humidity tests, many of them involving altitude and temperature cycling.

Long before World War II, the Laboratories used vibration machines to test aircraft communication apparatus. They were inadequate, however, for the heavier military units, particularly those designed for shipboard use, and their motion was not sufficiently controlled for the quantitative tests required. The Western Electric Company therefore designed and built several

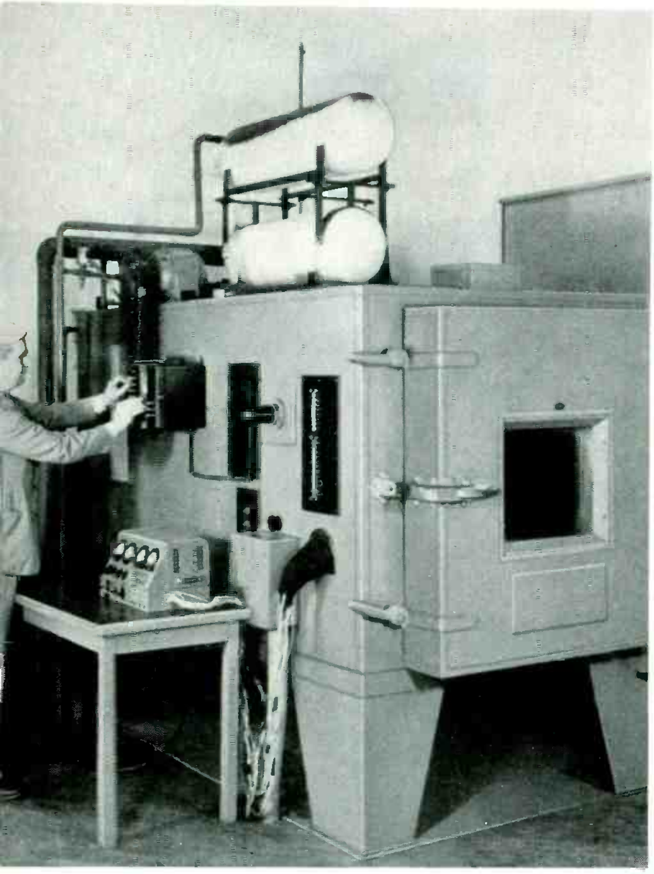


Fig. 3—*For testing medium-sized apparatus and parts, a smaller altitude chamber has been provided. A. Taggerty is shown checking equipment under test*

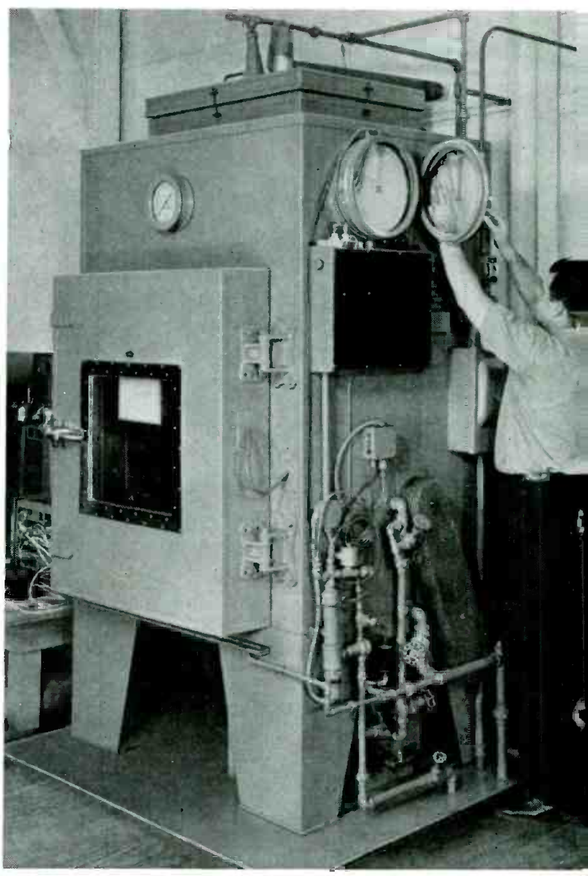


Fig. 4—*A third chamber has been constructed to test small apparatus and parts. D. G. Sanford is shown adjusting the recording altimeter*

machines having a rated load capacity of one hundred pounds for maximum accelerations of ten times that of gravity when operating at vibration frequencies up to sixty cycles per second. The first one of these, which was installed at Whippany, is shown in Figure 5. It has a vibrating table of cast magnesium which is directly driven from eccentric cams that can be rotated with respect to the main shaft to vary the vibration amplitude. Either horizontal vibration in one plane or vertical vibration can be accomplished independently or simultaneously. The main shaft of the machine is driven by an electronically controlled, direct-current motor at speeds between 300 and 3,600 revolutions per minute, which causes between five and sixty vibrations per second. Although rated a 100-pound machine, it has been used for testing units weighing up to 200 pounds when the amplitude has been held to 0.06 inch, and the vibration frequency kept below thirty cycles per second. Either manual or automatic frequency cycling between predetermined limits is provided.

Another unusual machine in the Testing Laboratory is the roll-shock-vibration machine, shown in Figure 6. It is an improved model of an earlier one devised by the Naval Research Laboratory, and has a table about six feet square mounted on horizontal bearings, so it can be "rolled" or tilted back and forth to simulate the pitch or roll of a ship in a heavy sea. The angle of roll from the horizontal can be set at 25 degrees, 35 degrees, or 45 degrees, and the rate varied continuously between three and nine rolls per minute, which is more severe treatment and at a faster rate than any actually experienced in service. For shock tests, a pneumatic ram slams the table top against a wooden bumper. Under the table is mounted a reaction-type vibration generator consisting of a variable-speed, electronically controlled, direct-current motor and a pair of eccentric wheels. These wheels may be rotated up to about 2,100 rpm, producing frequencies up to about 35 cycles per second.

To provide a vibration machine of increased capacity and also to promote standardization of test procedures, the Bureau of Ships, the Naval Research Laboratory,

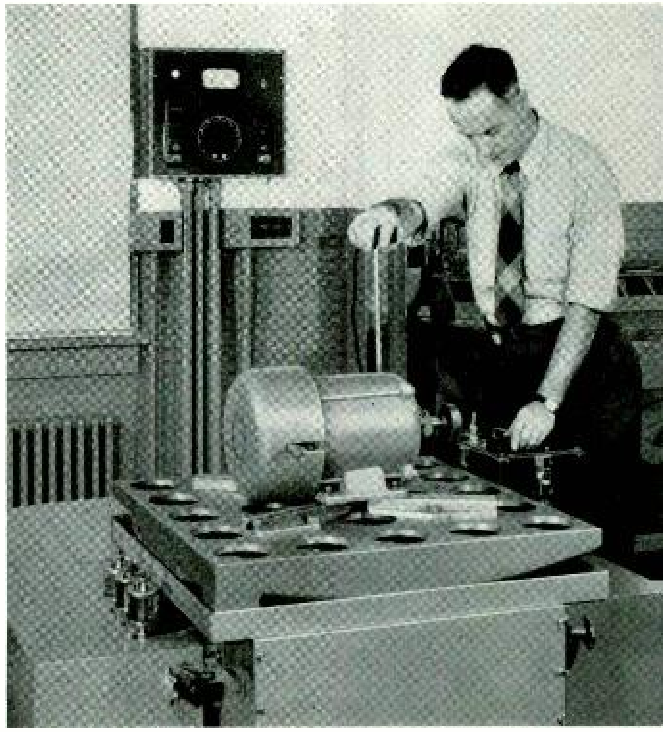


Fig. 5—T. A. Young testing a generator on the 100-*pound vibrating machine*

and the Laboratories coöperated with the Western Electric Company in the development of a new vibration machine. The objective was a machine with a rated load capacity of 1,500 pounds capable of producing accelerations up to 2½ G at 30 cycles per second, and capable of vibrating a 500-pound load at 60 cycles per second at accelerations up to 10 G. It has a maximum amplitude of 0.217 inch and either horizontal vibration in one plane or vertical vibration can be obtained independently or simultaneously. The first of these new machines, shown in Figure 7, was installed at Whippany early in 1945. To withstand the reactive forces created, a reinforced concrete base, weighing about 285 tons, was installed.

To simulate the shocks often experienced in actual combat, the U. S. Navy has devised high-impact testing machines. One of the "light-weight" machines has been installed in the Testing Laboratory, and is shown in Figure 8. A 400-pound hammer is dropped against the anvil plate on which the unit under test is mounted. The ham-

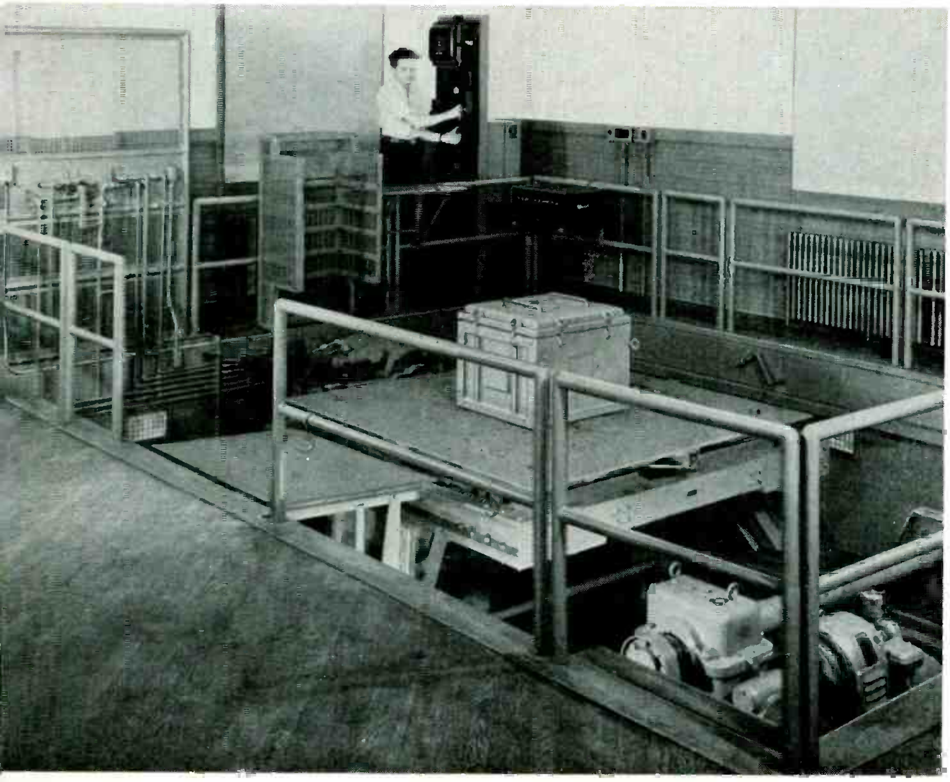


Fig. 6—F. Meyer is adjusting the roll controls of the roll-shock-vibration machine. This machine simulates the pitch or roll of a ship in a heavy sea

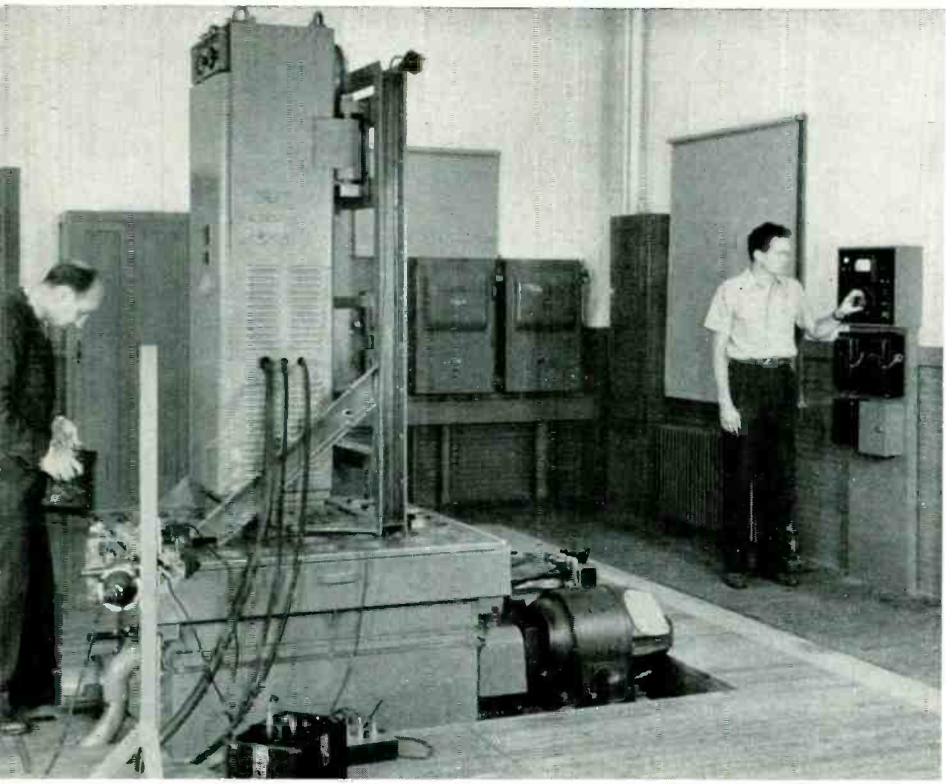


Fig. 7—The large vibration machine; W. R. Goehner at the left and F. Meyer at right. To withstand the reactive forces created, a 285-ton reinforced concrete base was installed

mer can be released from heights up to five feet, to give blows up to 2,000 foot-pounds.

Much of the equipment intended for naval service either is subject to direct spray by salt water or operates in a salt-laden atmosphere. Under these conditions, many metals, unless protected, would disintegrate in a very short time. To check the qualities of corrosion-resistant metals and the effectiveness of protective finishes applied to other metals and materials, a salt-spray testing cabinet was devised by the Navy. One of these is installed in the Testing Laboratory and is often called the "disintegrator" because of the startling results obtained with some materials. It produces in a few days the effect of many months or even years of service at sea. Test samples are usually exposed one hundred hours to alternate three-minute periods of warm air and a spray of 20 per cent salt solution. The temperature of the air and the spray are thermostatically maintained at 120 degrees F. In some cases, ultra-violet light is also directed at the samples.

More accurately controlled salt-exposure test conditions are obtained in a "salt-fog" testing cabinet. It produces a spray, much finer than that of the salt-spray cabinet, that settles uniformly on the test specimen. The salt solution is not recirculated through the sprayer of this cabinet to avoid accelerated corrosion or false results caused by the corrosion products from the specimen.

Temperature plays a very important rôle in the effectiveness of most vibration mountings, since natural and synthetic rubbers become hard at the lower temperatures. To test rubber mounts and plastics, and to study lubrication at varying temperatures and under vibration, a portable chamber with facilities for changing the temperature from −80 degrees F. to +180 degrees F. has been recently provided in the Testing Laboratory. This chamber may be placed over the 100-pound vibration machine when necessary for such tests. Doors with large glass windows are provided on the two sides of the chamber.

Accessories to the testing facilities include direct-reading thermocouple bridges for temperature measurement, accelerometers, a centrifuge for calibrating accelerometer cells, vibration meters, stroboscopes, speed measuring instruments, altimeters, and a station barometer as well as many other special instruments, gauges, and tools. Also available is an acoustically treated dark room with photographic processing facilities. In an associated building are facilities for both arc and gas-welding to permit the fabrication of the special brackets and frames that are required for mounting the various apparatus to be tested.

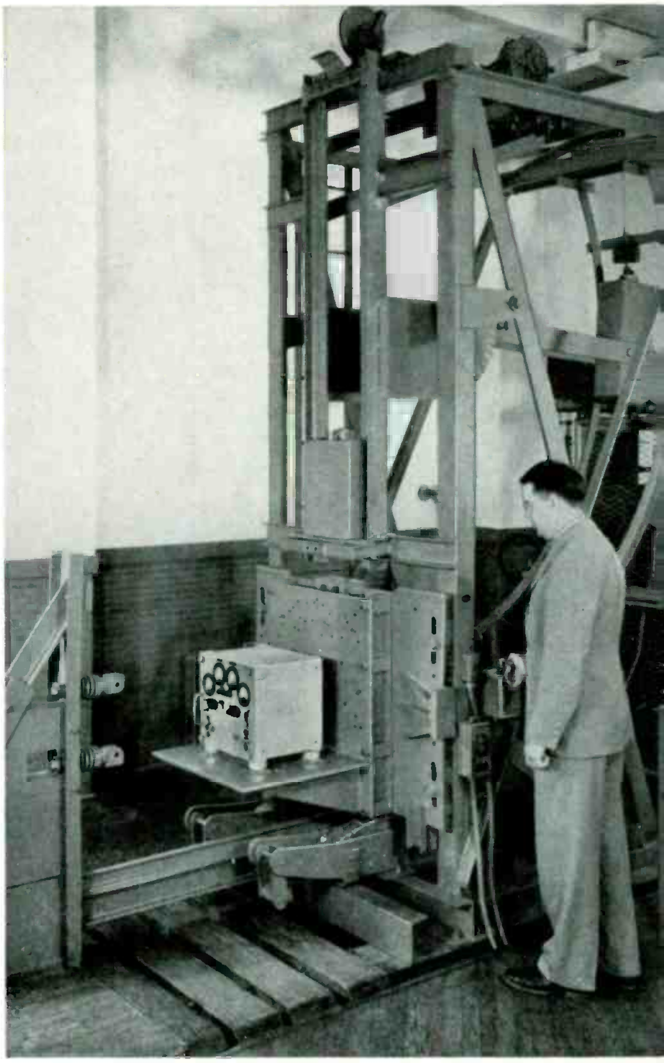
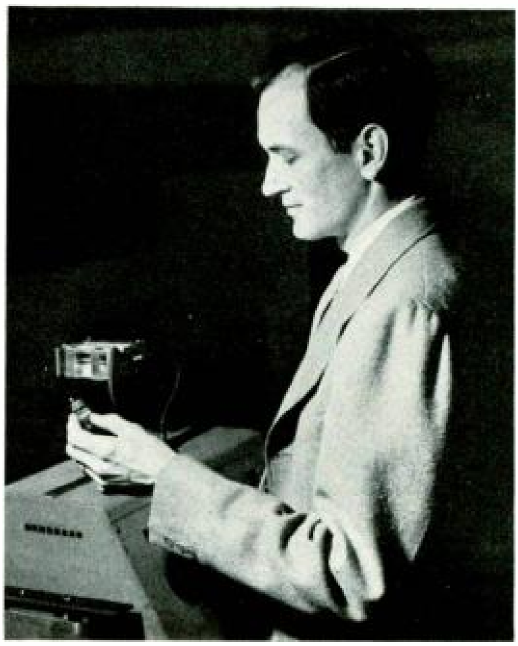


Fig. 8—Light-weight, high-impact shock testing machine being operated by A. Taggerty

In addition to the usual 60-cycle single-phase 120-volt, three-phase 208-volt and 480-volt power supplies, several special supplies are available, primarily for testing aircraft equipments. These include a 24 to 28-volt 200-ampere d-c generator, a five-kva generator for frequencies from 360 to 1,000 cycles per second, and a three-kva generator for frequencies from 800 to 2,400 cycles per second. The two variable-frequency generators are driven by electronically controlled d-c motors.

Many of the tests are carried beyond the requirements for acceptance by the Armed Forces, and sometimes to destruction, which often helps to establish future design trends. These tests assure the project engineers and the Armed Forces that the final apparatus will not show unexpected weaknesses in service.

THE AUTHOR: J. C. BAYLES joined the Radio Development Department of the Laboratories early in 1930 after receiving an E.E. degree from the University of Illinois. After several years in the development groups working on quartz crystal oscillators, broadcast transmitters, speech input equipment, and synchronizing equipment for broadcasting stations, he spent several years in the field supervising the installation of broadcasting equipment of all sizes up to and including the 50-kw equipment. Early in 1940 he transferred to radar projects, and then—late in 1943—he was placed in charge of the Testing Laboratory. Since January, 1946, he has been in charge of the groups in the Specialty Products Development Department preparing technical information, including instruction books on Government equipment. He has also been in charge of the extensive expansion program for the Whippany Testing Laboratory, which is not yet completed. More recently he was placed in charge of the group at Whippany preparing specifications, parts and spare parts information, and Government designation information.



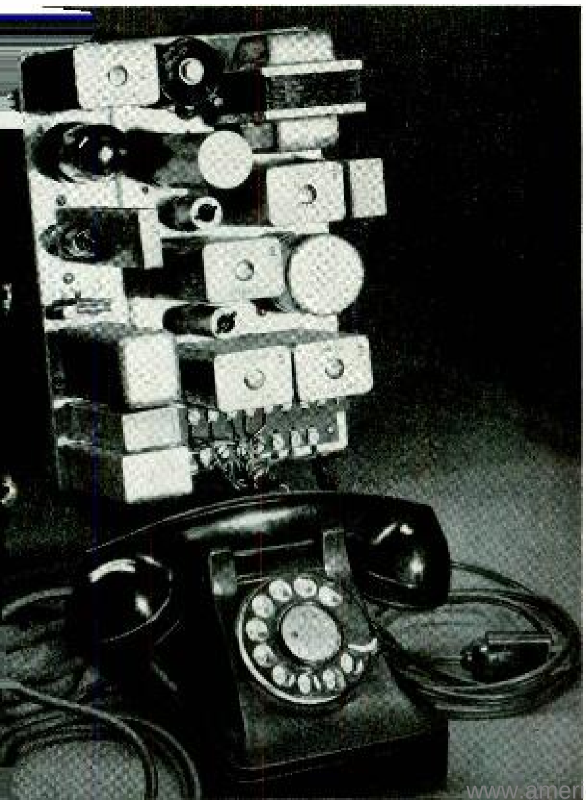
C. T. Goddard, one of the men who design electron tubes for wide band amplifiers, is shown measuring capacitance variations resulting from mechanical changes made in a large scale model of the small tube in his hand. Minute mechanical variations between successive models of the small tube might easily mask the changes caused by modifications in design. Dimensional changes in the large structure, on the other hand, may be made and analyzed with ease. The optimized structure may then be scaled down to apply to the small tube. This method of analysis is representative of one of the many tools devised by engineers of the Electronic Apparatus Development Department to assist in developing electronic devices.

LESTER HOCHGRAF
Transmission
Engineering

THE SUBSCRIBER TERMINAL FOR RURAL POWER-LINE CARRIER

A subscriber who receives telephone service over the M1 carrier system* is scarcely aware that he talks over a power line at carrier frequencies rather than over the usual rural party telephone line. He uses a combined telephone set in the usual manner, and he may be connected either to a manual or to a dial central office. Somewhat more equipment is required in the subscriber's house, however, than for a voice-frequency line. Besides the combined telephone set, there is also a black plastic box mounted on the wall or in a nearby closet which is similar to, but larger than, a bell box. A rather heavy cord connects the telephone set to the carrier terminal mounted in the box. A carrier connection from the power-line pole is also brought to the terminal, and a power lead is plugged into a convenient 110-volt outlet.

*Record, *October*, 1947, *page* 363.



When the subscriber's telephone is not in use, the carrier transmitter circuit is inoperative and the transmitting path is open at the pole by a relay contact. His receiving circuit, however, is connected to the power line, the cathodes of its two tubes are hot, and the entire receiving circuit is in readiness to receive signaling pulses from the line. Signals are received as pulses of carrier power occurring thirty times a second. After passing through the carrier receiver, these pulses are rectified, and each pulse operates a sensitive relay, applying a voltage pulse from the local B supply to the bell, which thus operates in step with the ringing pulses. When the subscriber whose code is rung picks up his handset, contacts of his switchhook energize the carrier transmitter and operate the relay at the pole to connect his transmitting circuit to the power line. An interval of a second or two is required to bring the temperature of the cathodes to their operating value, but this time is made short by the use of filamentary instead of indirect cathodes. Carrier power is then transmitted over the line, and its reception at the common terminal near the central office interrupts the ringing. Conversation may then be carried on in the usual manner. Replacement of the handset at the termination of the call restores the circuits to the condition existing before ringing was received.

A simplified schematic of the transmitter circuit is shown in Figure 1. The first tube is a combined oscillator and modulator. Its filament and the two grids nearest it are connected in a crystal-controlled oscillator circuit, while the third grid associated with the handset modulates the carrier current produced by the oscillator. The second tube acts as a power amplifier, and is connected to the transmission line through an

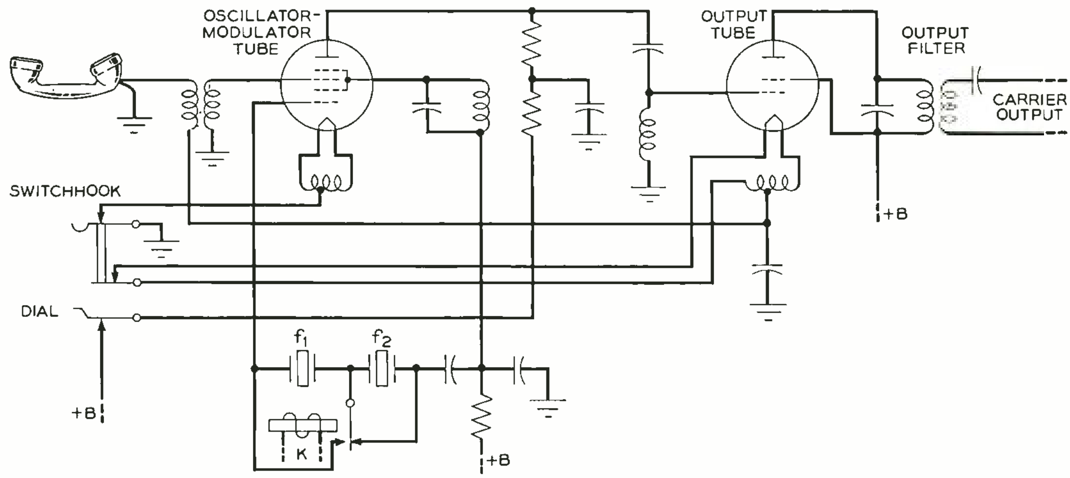


Fig. 1—Simplified schematic of the transmitter circuit at the subscriber's station

output filter. There are two crystals associated with the oscillator, and one or the other is connected into the circuit by the K relay, the operation of which is described in connection with Figure 3. The crystals employed are of the small wire-supported type developed for radio tank sets.* When no carrier is being received at the time the handset is lifted, the crystal providing the f_1 frequency is employed, but when carrier is present on the line when the handset is lifted, the f_2 crystal is employed, as described in the article already referred to. Current for the handset is obtained from the cathode return of the power amplifier.

Figure 1 shows the switchhook connections when the handset is removed. When the handset is in place, representing the idle condition of the transmitter, the filament circuit of the power amplifier is open, and the cathode return of the oscillator-modulator is also open. Moving the switchhook up and down alternately applies and removes carrier and thus signals the operator. Since a short time is required to heat the filaments, however, the operator should be flashed slowly.

This method of applying and removing carrier is not suitable for dialing because the slow building up of the carrier would not give satisfactory dial pulses. The dialing contact is thus arranged to open and close the supply voltage to the plate of the oscillator-modulator without affecting the supply for the oscillating part of the circuit. This gives the sharply defined pulses required for dialing.

A two-stage tuned radio frequency circuit is used for the subscriber's receiving terminal, as shown in Figure 2. Its input, interstage, and output filters are pretuned and adjusted at the factory. Automatic gain control incorporated in the receiver takes care of a range of line losses up to 30 db, while variations beyond this range are taken care of by optional wiring arrangements in the coupler unit mounted on the power pole, which are specified at the time the system is laid out. Thus the installer does not have to adjust the gain of the subscriber terminal, and subscriber terminals may be replaced without the need for subsequent measurement or gain adjustment.

Demodulation is accomplished by a varistor in the output stage, shown at the extreme left of Figure 2. Voice frequency currents passing through the varistor operate the receiver of the handset, while the d-c component operates the R relay used both for ringing and for operating the K relay that determines which of the two transmitting crystals will be used.

Since there may be eight subscribers on

*RECORD, *January*, 1945, *page* 1.

a single carrier system, code ringing is supplied, but it may be either of two types: all the subscribers may hear all the codes, or each subscriber may hear only half the codes. This ringing feature and other circuit arrangements not shown on the preceding diagrams are indicated on Figure 3. Ringing is accomplished through the R relay shown at the lower left and the K relay above it. As described in connection with Figure 2, the d-c component of the rectified received carrier operates the R relay. K is operated from the B-voltage supply through a front contact of R; K is a slow release relay, however, and thus is also somewhat slow to operate, and its operate time is further increased by the capacitor C1 bridged across it, which prevents full voltage from being applied to the relay

When it is desired to have the subscriber hear only half of the codes, one of the switchhook contacts is arranged to apply d-c B-voltage to the screen grid of the second stage while the handset is removed from the hook, and to apply 60-cycle a-c while the handset is in place. The ringing pulses are timed by the 60-cycle current at the common terminal, and consist of spurts of carrier during two successive half cycles of the 60-cycle current, then no carrier for two full cycles, and then carrier for two more successive half cycles, and so on. For half the codes, the positive half cycles of the 60-cycle supply will be used for applying carrier, and for the other codes, the negative half cycles will be used.

At the subscriber's receiver, the second stage tube will transmit only when its

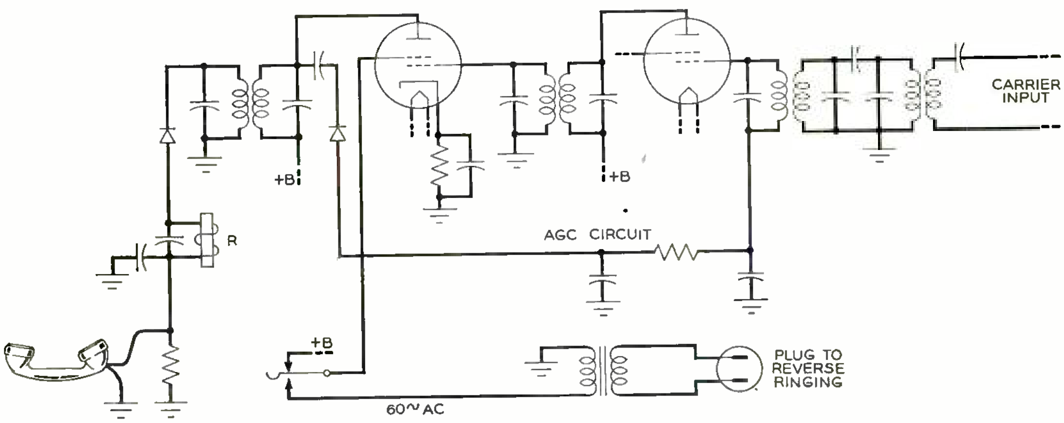


Fig. 2—Simplified schematic of the receiver circuit at the subscriber's station

while C1 is charging. Each pulse of the 30-cycle ringing operates the R relay, but one or two pulses are required before C1 is charged and K operates. As long as K remains unoperated, the bell is short-circuited, but after K operates, each ringing pulse that operates R applies B-voltage to the capacitor C2 through the ringer winding. Between pulses, R releases and discharges C2, and the alternate charging and discharging of C2 rings the bell. The action of relay K in delaying the ringing of the bell prevents bell tapping not only when carrier comes on or goes off the line, but when static discharges are present.

screen grid is positive, and this may be made to be for either the negative or positive half cycles by properly poling the a-c connection to the switchhook contact shown in Figure 2. Those subscribers who are to be rung on positive half cycles would have their power supply poled accordingly, and thus they will hear only those codes sent out on the positive half cycles from the common terminal.

Besides delaying the beginning of ringing, relay K also controls the selection of one or the other of the two transmitting crystals. During silent intervals between ringing, no carrier is being received, and if the subscriber lifts his handset to answer, K is released and frequency f_1 will be selected. When the handset is removed from the hook, a ground connection for the K relay is opened by the switchhook, and if K was not operated at that time, it cannot be operated until after the handset is replaced. If K were operated due to carrier on the line at the time the handset was lifted, it would remain under the control of the R relay through one of its own forward contacts.

When a subscriber lifts his handset to place a call, and the system is not in use by some other subscriber, K also will be released and f_1 will be selected. Should he place a call to another subscriber on the same system, however, he will hang up after giving the number he wants to the operator and will wait until after the cessation of ringing indicates that the other subscriber has answered before lifting his handset. At this time carrier will be on the circuit from the transmitter of the other subscriber, and thus the K relay at the calling station's control unit will be operated and f_2 will be selected.

The arrangement of apparatus on the subscriber's terminal is shown on page 413. The narrow panel at the left is the transmitter, and the wider one at the right, the receiver. At the bottom of the transmitter panel is the input transformer and certain capacitors, and then the X relay followed by the two crystals. Above these is the oscillator-modulator tube, then the power-amplifier tube, and at the top the output filter. At the bottom of the receiver panel is a terminal strip, with the input filters immediately above it. Then at the left is the first stage amplifier tube, and at the right, in the cylindrical case, the R relay. Above the first stage tube is the inter-stage filter and then the second stage tube.

The large transformer at the upper right is for the local power supply. This operates through a selenium rectifier to the left of it to provide the B-voltage.

The desire to make the method of using the M1 system as nearly like present telephone service as possible, and the requirement of small size, low cost, low power consumption and low maintenance presented an interesting combination of opposing requirements to the designers of the system. One problem is caused by the poor voltage regulation on some of the power lines on which the system will be used. During light load hours, the voltage will be high, but during heavy load periods,

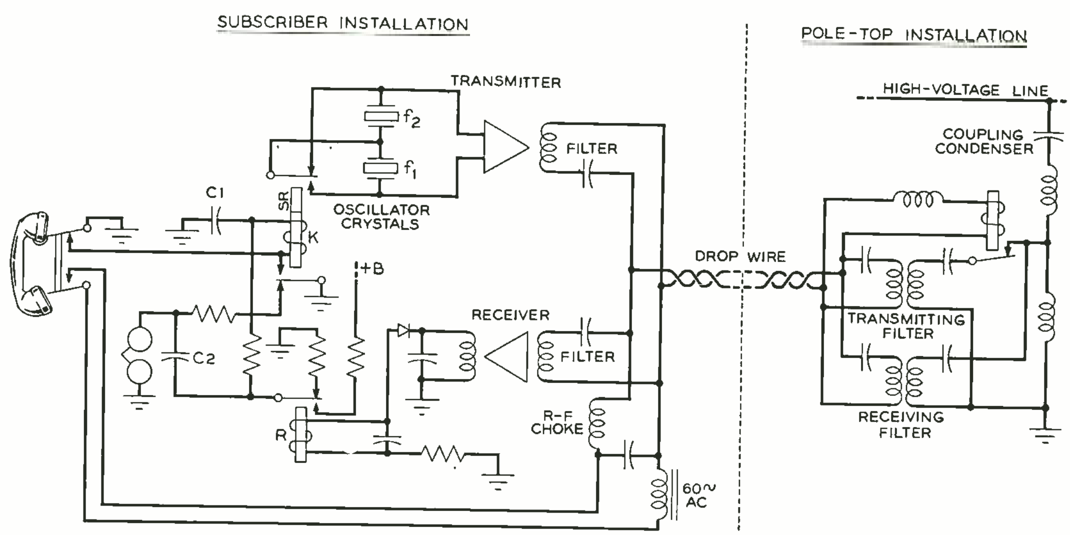
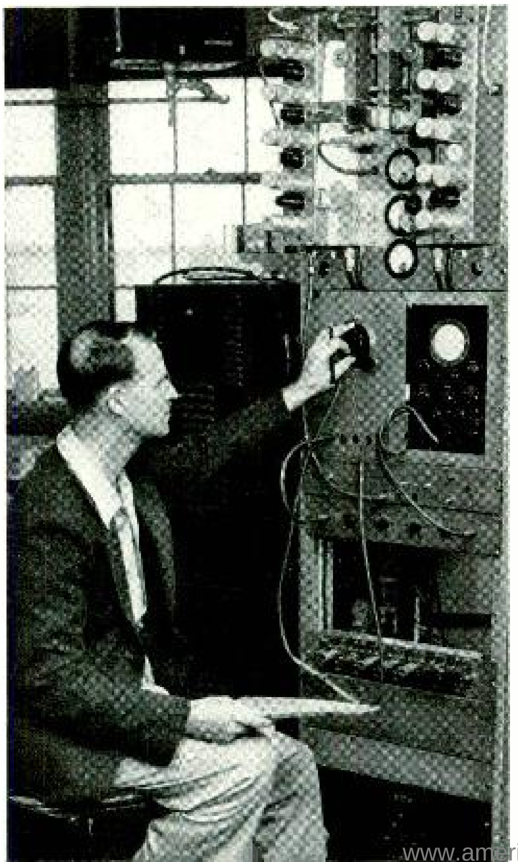


Fig. 3—Simplified schematic of the subscriber's station circuit showing ringing features

such as in the early evening, it may drop below a value which urban customers would consider satisfactory. A voltage regulating device in the subscriber terminal is not desirable because of size, cost, and power consumption. The circuits and tubes must, therefore, operate satisfactorily during low voltage periods, and yet have long life even though the line voltage will be high for a large portion of the total time.

THE AUTHOR: LESTER HOCHGRAF received the E.E. degree from Rensselaer Polytechnic Institute in 1926 and the degree of D.Eng. in 1929. He then joined the Department of Development and Research of the American Telephone and Telegraph Company where, with the toll transmission group, he engaged in studies of crosstalk on open-wire lines. After transferring to the Laboratories with the D. and R. Department in 1934, he continued his crosstalk studies—particularly in connection with crosstalk balancing for the type-K cable carrier system. During the war period he was occupied with special war projects, but since then has transferred his attention to carrier and microwave transmission systems.

A Microwave Generator Arranged to Sweep Through a Range of Several Megacyles



L. E. Hunt of Radio Research, at work in our Deal laboratory. He is using a microwave generator arranged to sweep through a range of several megacycles. By putting a synchronized sweep voltage on one set of plates of an oscilloscope, and the output of a circuit under test on the other set, the experimenter can see on the 'scope a transmission-vs.-frequency curve of the circuit.

Entering the Laboratories in 1929 with a degree in physics from Reed College, Mr. Hunt has always done radio research work. As early as 1938 he carried on radar work, making measurements of 2-meter pulses reflected from airplanes.

Professional papers by Mr. Hunt in the microwave field appear in *I.R.E.* for October and *Teletech* for November.

FREQUENCY CALIBRATION OF QUARTZ CRYSTALS

L. F. KOERNER
Transmission
Apparatus
Development

Early in the war, the Western Electric Company received a contract to manufacture several million quartz crystal units for radio transmitters furnished to the Armored Forces of the U. S. Army. Since the quantity of crystals involved was many times greater than had ever been manufactured before, all steps of the process from the cutting of the quartz from rock crystal to the final adjustment of the crystal for frequency had to be carefully studied. Construction of the crystal unit has already been described in the RECORD.* After the crystals are mounted in their containers, one of the final steps is to adjust them accurately to the desired frequency. By methods heretofore employed, this would have been a slow and tedious process. By an analysis of the frequencies involved and some intensive development work, however, a testing procedure was provided that enabled a single operator to adjust as many as 500 units in an eight-hour day.

Most of the units were for three types of radio transmitters: the BC-604 and the BC-684, which were for installation in tanks and field artillery trucks, and have already been described,† and the AN/TRC-1 for radio relay systems. These transmitters were of the frequency-modulation type. Modulation was accomplished at the crystal frequency, which was then multiplied by doublers and triplers to obtain the final carrier frequency. Each of the transmitters carried from 80 to 300 crystals from which one would be selected to meet conditions existing at the time. In all, 500 different crystals, and thus 500 frequencies, were involved, and all had to be adjusted to better than 0.01 per cent of nominal frequency since the over-all tolerance over the temperature range 25 degrees to 70 degrees C was 0.02 per cent. Heretofore, standard crystals for each of the 500 different units would be calibrated, and crystals under test would be compared against these standards. The frequency of the standard crystals would have to be checked continually and since any one frequency could be called for on demand, the maintenance problem for such a set-up would be enormous. A system was devised to derive the 500 frequencies directly from the company standard.

In each type of transmitter, the crystal frequency was multiplied by a fixed factor m to get the carrier frequency, and each carrier frequency of all the transmitters was a whole number times 100 kc. Letting F stand for the carrier frequency and f for the crystal frequency, these two conditions may be expressed as (1) $F = mf$ and (2) $F = 100n$. Substituting equation (2) into equation (1) gives (3) $F = 100n/m$. For any type of transmitter, therefore, the crystal frequencies required were always some whole number, n, times a sub-multiple, 100/m, of 100 kc. Since a 100-kc reference frequency standard,* maintained to better than one part in ten million, was available at the Hawthorne plant where these crystals were to be manufactured, it was decided to derive three sub-multiple frequencies of the 100-kc standard frequency—the sub-multiple being related to the values of m for the three types of transmitters—and to derive a series of harmonics for each of these sub-multiple frequencies by a harmonic generator.

These sub-multiple generators and harmonic producers were installed in the shop, and were fed by appropriate lines from the

*RECORD, *April*, 1943, *page* 237. *August*, 1947, *page* 295. †RECORD, *January*, 1945, *page* 1.

*RECORD, *November*, 1942, *page* 73.

reference standard. From them the three series of harmonic frequencies were carried by coaxial conductors to all of the test positions, each of which was equipped with a calibrator circuit to select the harmonic

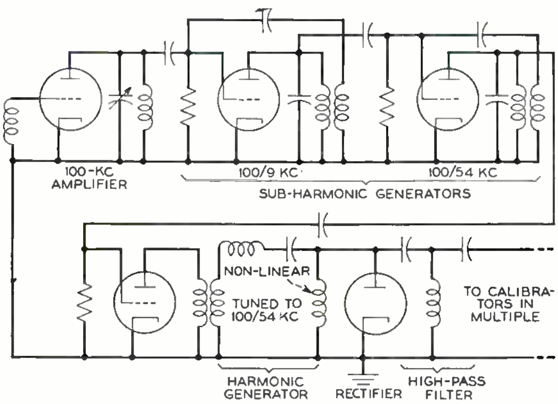


Fig. 1—Simplified schematic of the circuit of the sub-harmonic generator used in deriving a fifty-fourth sub-multiple frequency

desired and to compare it with that of the frequency of the crystal under test.

The values of m determining the sub-harmonics required were 54, 72 and 96, and essentially the same circuit was employed in deriving each sub-multiple frequency. That used for the 54th sub-multiple is shown in Figure 1. It consists of a 100-kc amplifier followed by a simple triode oscillator tuned to a frequency of approximately 100/9 kc. Sufficient voltage from the 100-kc amplifier is fed to the grid of the oscillator tube to lock it in with the standard frequency, and thus the output was exactly one-ninth of 100 kc. The output of this oscillator is fed to the grid of a second oscillator pre-adjusted to approximately 100/54 kc, but locked in to exactly 100/54 kc, which is the sub-harmonic desired. During the development of these locked-in oscillators, it was found that the desired sub-harmonic frequencies could be obtained in one step, but that more reliable operation could be obtained by using two.

The output of the second oscillator was the desired sub-harmonic frequency; it was fed into a power amplifier, the plate circuit of which contained a transformer stepping down to an impedance matching the series resonance impedance of a tuned circuit which included a non-linear coil. By shunting this coil with a rectifier, all the harmonics, both odd and even, are obtained. These coils have already been described.* The harmonic producing circuit is followed by a high pass filter with a cut-off frequency below that of the lowest crystal frequency desired. The impedance of the non-linear coil circuit was such that it matched approximately that of commercial concentric cables, which were used to pipe the crystal frequencies to the calibrators. Fifty calibrators could be fed from one generator.

At each of the test positions is one of these calibrators as shown in Figure 2. Its circuit, in semi-block schematic form, is shown in Figure 3. A filter circuit selects the harmonic desired and passes it on to a detector tube. One of the grids of this tube is supplied by the output of an oscillator

*Record, *March,* 1946, *page* 102.

Fig. 2—The crystals are calibrated in test positions, where calibrators as shown above are connected by coaxial cable to the sub-harmonic generators. The calibrating circuit is shown in Fig. 3

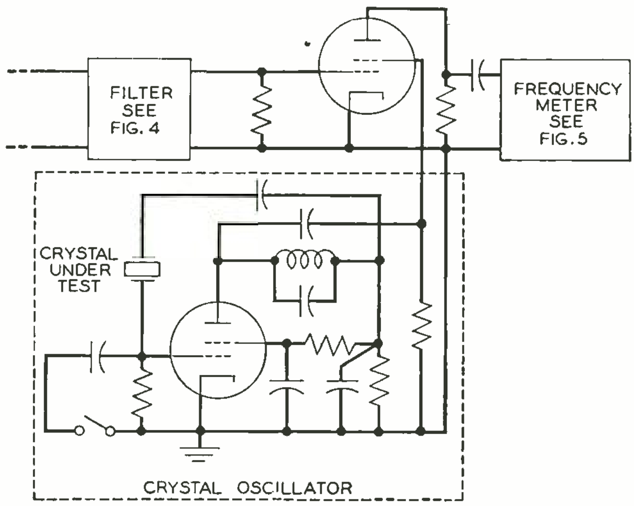


Fig. 3—Simplified schematic of the calibrator circuit

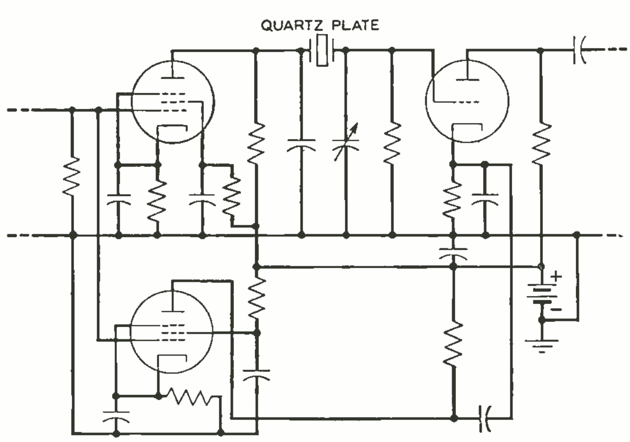


Fig. 4—Schematic of the filter

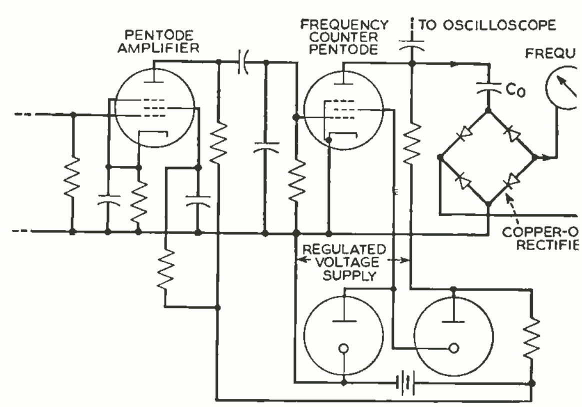


Fig. 5—Schematic of the frequency meter

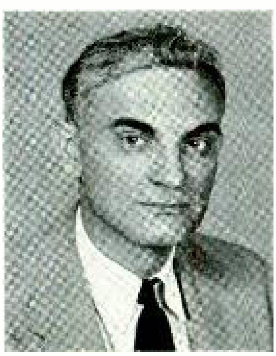
tube controlled by the crystal under test. Under these conditions, the output of the detector is the difference between the two frequencies supplied to it, and thus is the deviation of the frequency of the crystal under test from the desired frequency. This difference, in the audible range, is supplied to a frequency meter calibrated to read frequency difference directly.

Details of the filter section of the calibrating circuit are shown in Figure 4. The input voltage is that from the harmonic producer, and thus includes all harmonics of the base frequency 100/m kc. This is supplied to two pentode amplifiers in parallel. The output from the upper amplifier is carried through a crystal filter that passes principally the desired harmonic, and thence to the second amplifier. Output from the lower amplifier is applied out-of-phase to the cathode resistor of the output amplifier. This gives a feedback-amplifier effect that balances out all frequency components but the one desired. At the output of this latter amplifier, the nearest undesired frequency is down some 30 db relative to the desired frequency.

This frequency is supplied to the detector tube of Figure 3, which derives the difference between it and the frequency under test and passes it on to the metering circuit. Details of this latter circuit are shown in Figure 5. An amplifier first raises the level of the difference frequency to a value sufficient to insure the proper action from the frequency counter tube which follows it. This latter tube, operating well above saturation at the peaks of the wave, gives an output consisting of square top pulses—one for each cycle of the difference frequency. This output is supplied to the condenser C_0 in series with a rectifier and a milliammeter used to indicate the difference frequency. This combination of condenser and rectifier integrates the pulses of current, and thus the current flowing through the meter is proportional to the frequency and the capacitance of C_0. By providing three condensers for use in this position, the full scale reading may be made 120, 1,200 or 12,000 cycles.

To adjust the frequencies of the crystal, one of its edges is ground down slightly by rubbing it with a fine grade abrasive paper fastened to a small stick. To permit rapid calibration and adjustment, the crystal, in its mounting, is connected to the calibrator as shown in Figure 3, and is clamped on two sides to permit abrading one edge. Downward pressure on a small lever associated with the clamping jig releases the crystal, which at once starts to oscillate. The operator reads the deviation on the meter, releases the lever to clamp the crystal, abrades the edge by a small amount, and then again depresses the lever and reads the meter. These steps are rapidly repeated until the crystal is within limits of the desired deviation.

The preliminary model of this equipment, consisting of the sub-harmonic generator, a calibrator and a crystal jig, was assembled at the Laboratories and taken to Chicago early in 1942. Immediately successful, it was incorporated at once in the Hawthorne shop. During the three years the shop was in operation, modifications were made in the equipment, principally in the calibrator circuit and jig, culminating in the apparatus shown in the photograph. Considerable credit for the manufacture of the many millions of crystals produced at the Hawthorne plant should go to the Hawthorne engineers who worked on and maintained this equipment. This was an important factor in reducing the cost of crystal production to about one-sixth of that originally estimated.



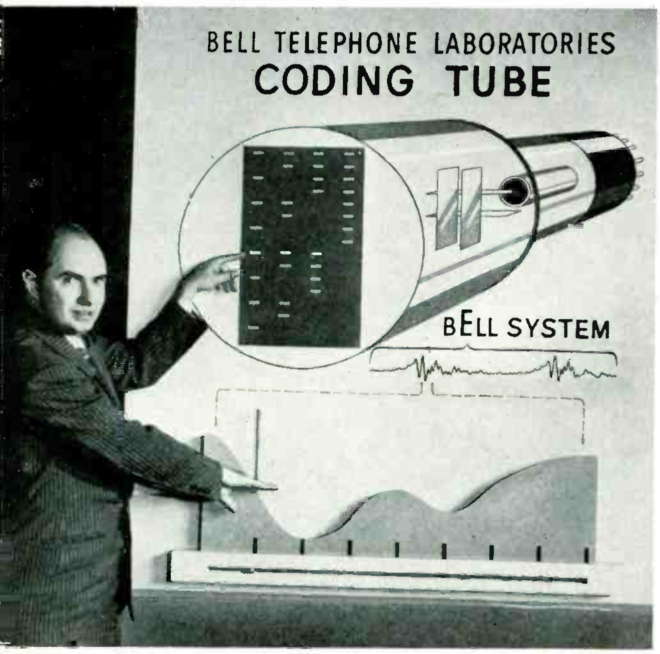
THE AUTHOR: LAWRENCE F. KOERNER received his B.S. degree from Colorado College in 1923, and his M.S. degree from Harvard University in 1924. He joined the Laboratories in the latter year, where his work was concerned primarily with electrical testing equipment involving electric and piezoelectric oscillators. During the war he was chiefly occupied in the production of quartz crystal units at the Hawthorne plant of the Western Electric Company. He is now engaged in the development of crystal oscillator circuits and associated crystal equipment.

W. A. Marrison Honored for Work on Quartz Crystal Clock

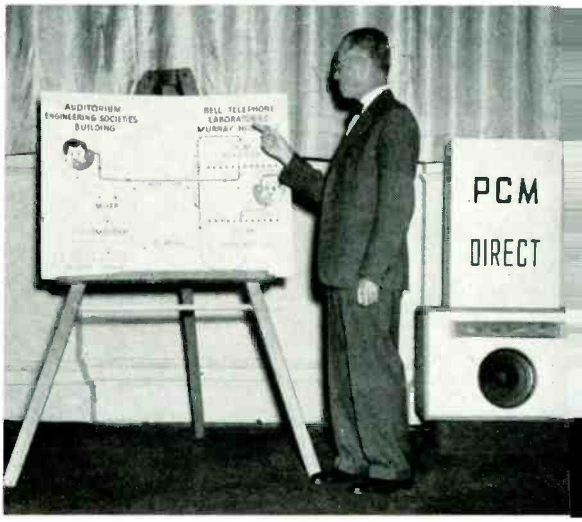
W. A. Marrison of Transmission Research has been awarded the British Horological Institute's Gold Medal for 1947 in recognition of pioneer researches in the development of the quartz crystal clock. Previous recipients of the medal, the Institute's highest award, have included distinguished scientists all over the world.

The Gold Medal was presented to Mr. Marrison by Sir Harold Spencer Jones, Astronomer Royal, and president of the British Horological Institute, at its 89th annual general meeting in London on October 29. Mr. Marrison went to London to accept the medal and on November 6 will lecture before the Institute on *The Evolution of the Quartz Crystal Clock.*

PULSE CODE MODULATION DEMONSTRATED TO I.R.E.



On the I.R.E. stage, L. A. Meacham uses an animated display developed by Publication



Eugene Peterson describes the demonstration set-up with a display illuminated to indicate circuits

A radically new communications technique for long-distance telephone transmission was given its first public demonstration on October 8 by engineers of the Laboratories. Known as PCM, an abbreviation for pulse code modulation, the new technique is entirely different from earlier forms and promises marked freedom from noise and interference.

A special demonstration program illustrating the remarkably clear transmission which the new system affords was brought over telephone lines from Murray Hill, where the equipment is installed, to the auditorium of the Engineering Societies Building.

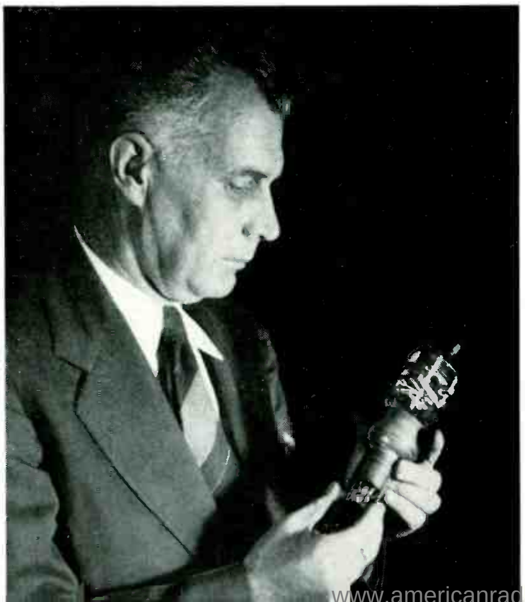
There, at a meeting of the New York Section of the Institute of Radio Engineers, several hundred engineers heard the program and an explanation of the new technique. Both speech and music were sent over the new system and reproduced through loud-speakers in the auditorium.

The new technique is expected to find use on broadband transmission hook-ups, including microwave radio relay systems, such as that now being installed to link New York and Boston. Basically it is a method of transmitting the human voice by various patterns or codes of electrical impulses.

A revolutionary new vacuum tube which electronically converts the human voice into these patterns or codes was also displayed for the first time at the meeting. In a 96-channel model now under development, such tubes will handle code signals at the speed of 5,376,000 pulses per second.

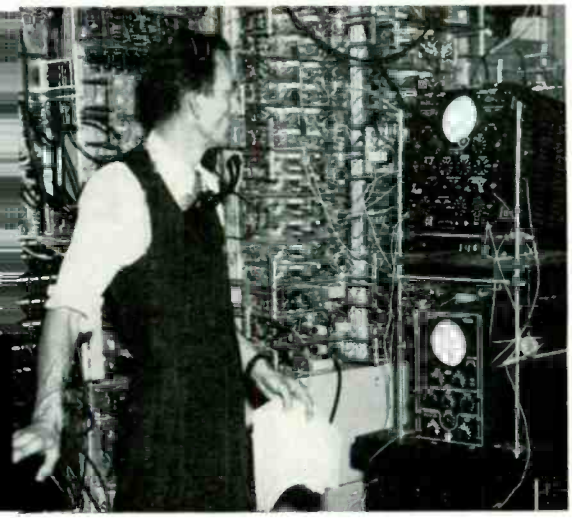
Although the new system is expected to be used primarily as an adjunct to the telephone network, it can also be used to transmit radio programs, pictures, and teletypewriter signals.

The demonstration was given by L. A. Meacham and Eugene Peterson of the technical staff of Bell Telephone Laboratories, both of whom have been active in the de-



R. W. Sears and the coding tube he developed

J. Rach, at Murray Hill, is ready to switch for ; comparison tests to be broadcast within the gineering Societies' auditorium. By observing the :illoscope trace, he monitors the performance



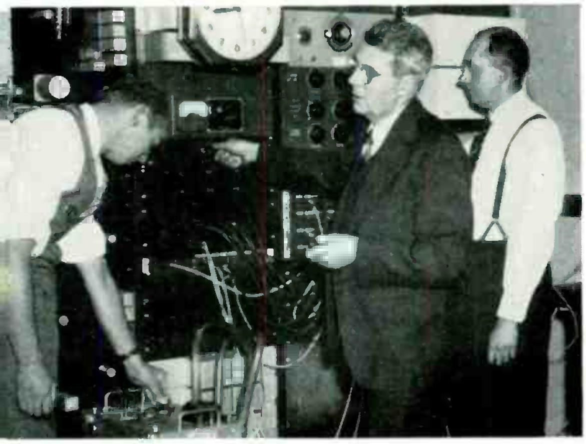
S. E. Michael and G. H. Day at the control point on the stage of the auditorium in the Engineering Societies' building where pulse code modulation was demonstrated to the I.R.E.

velopment of the system. The coding tube was described by R. W. Sears, also of the Laboratories technical staff, who designed and developed it for use in the system.

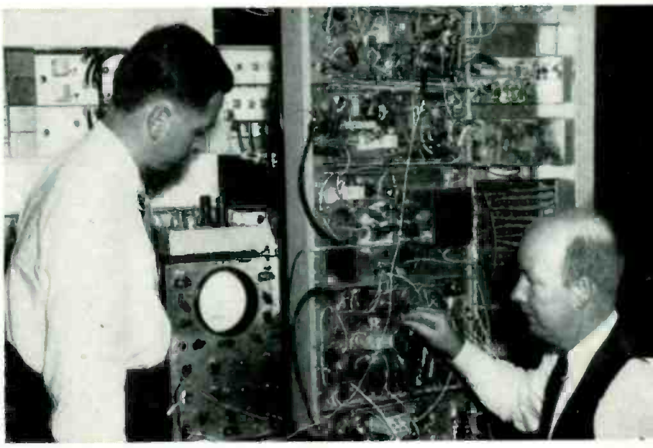
The new technique overcomes one of the difficulties of long-distance radio systems, namely, the building up of noise with the many amplifications needed for a long-distance radio hook-up. With PCM, an entirely new approach to the problem is provided by the use of special repeaters in which the signal code is reconstructed during each amplification. Thus, no matter how many repeaters are used, the PCM signal is received with its original quality.

Pulse modulation, or sampling, transmission in general is expected to be used on broadband communications systems on which many conversations can be carried simultaneously. Such transmission is so named because the amplitude of the continuous speech wave is sampled very briefly and rapidly and only information regarding these samples is transmitted. For a standard telephone circuit 3,000 to 4,000 cycles in width, samples taken at the rate of 8,000 per second are adequate. Just

.. E. Johanson and C. B. Feldman check the oise level at Murray Hill. On the right, J. M. Manley djusts an attenuator



L. R. Wrathall adjusts the circuits at Murray Hill for the transmission of music and, with R. L. Carbrey, observes the effect on the oscilloscope trace



these brief samples are sufficient to reconstruct the original wave with high fidelity.

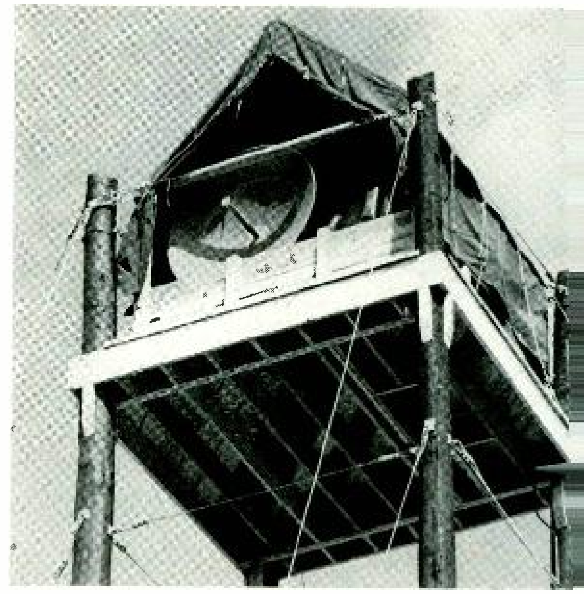
Since information regarding the sample can be sent very quickly—in roughly a millionth of a second—the system can carry not just one but many different telephone conversations each of which is sampled in turn and then reassembled at the receiving end. Thus, a transmission system of this type actually carries a sample from one conversation, then from another and so forth, repeating the sampling cycle through as many conversations as are being transmitted.

Microwave Systems Meet Television Emergency

By J. B. Maggio

At breakfast-time on Saturday, September 6, I had a telephone call that started a hard but interesting 30-hour grind. The call was not unexpected; in fact, Guy Atkins and I had already done some preliminary work on the project. Briefly, it was to assist Chesapeake and Potomac engineers in the final line-up of a three-link microwave channel 39 miles long, to carry a television program the very next day from the Baltimore Stadium to the telephone building in Washington, where wire lines were available to carry it to WNBW, the local television transmitter for NBC.

While television transmission goes through Baltimore to Washington on the coaxial cable, there was no television transmitting terminal at Baltimore, and the terminal equipment at Washington could not be taken out of service. So when an inquiry came from NBC as to television facilities for a series of football games beginning on Sunday, September 7, the only possibility was to use the new TE microwave radio system. From topographical maps, a line-of-sight route had been selected by the telephone company, with a transmitter at the Stadium, a repeater at Jessup, Md., 15 miles away; another repeater at Cheverly, Md., some 17 miles farther, and a receiver at Washington toll office, six miles from Cheverly.



Microwave relay tower at Cheverly, Maryland, use in the three-link television system from Baltimo to Washington on September 7

One of the three TE systems needed was already in Washington, one was at Western Electric's shop at Winston-Salem, and a third was a development model in use in the Laboratories. Through the initiative of W. C. Warman, C & P transmission engineer at Washington, the latter two systems had been shipped there; and all had been given a bench test.

During the Months of June, July and August the United States Patent Office Issued Patents on Applications Filed by the Following Members of the Laboratories

A. E. Anderson
W. O. Baker
R. Black, Jr.
G. M. Bouton
H. B. Brown
E. Bruce
N. W. Bryant
H. T. Budenbom
C. P. Carlson
R. W. Chesnut
C. C. Cutler
J. R. Davey
O. E. De Lange
C. Depew
W. A. Depp
W. H. Doherty
P. G. Edwards
G. B. Engelhardt
L. Espenschied
C. E. Fay
C. B. H. Feldman
E. B. Ferrell
A. G. Fox
C. J. Frosch
C. S. Fuller
D. K. Gannett
W. W. Halbrook
R. B. Hearn
G. Hecht
W. H. C. Higgins
S. C. Hight
K. S. Johnson
A. D. Knowlton
W. Y. Lang
F. B. Llewellyn
A. N. Luce
T. A. Marshall
W. P. Mason (4)
J. W. McRae
L. A. Meacham (4)
O. R. Miller
G. E. Mueller
N. A. Newell
R. C. Newhouse
H. Nyquist
G. L. Pearson
E. Peterson
K. W. Pfleger
J. A. Potter
R. K. Potter
J. B. Retallack
D. H. Ring
R. O. Rippere
D. D. Robertson
F. F. Romanow
J. C. Schelleng
E. E. Schumacher
O. A. Shann
C. B. Sutliff
G. K. Teal (2)
W. A. Tyrrell
C. A. Warren
J. W. West

After troubles had been cleared and missing parts replaced—some by air shipment from Winston-Salem Saturday evening—all systems were ready for service.

Late Friday night, September 5, the word was given to go ahead. Fortunately the telephone people had gotten work started on the tower at Cheverly; the one at Jessup was begun early Saturday. Each required four seventy-foot poles, supplied by the power company, who were also helpful in building power lines to the hilltop sites. Poles at Cheverly were set by the telephone company, while local contractors set the poles at Jessup with a high-lift road crane, and proceeded to build platforms about 50 feet above ground at both sites.

At midday on Saturday I was met in Baltimore by Sidney Miller, transmission engineer of C & P. At the Stadium we saw a platform being built for the transmitter; then we drove to Jessup for a look at the tower. Back in Baltimore, the transmitter was in place and we gave it a quick check, then went to a late supper with Mr. Atkins and several C & P and A T & T engineers. During the night we drove to Washington and as soon as the Cheverly transmitter was ready, we lined it up with the Washington receiver.

Now it was Sunday morning and "air time" was two o'clock that afternoon. At ten, Mr. Atkins, with the C & P people, began to line up the Jessup-Cheverly link. This path had not been checked optically, because one of the towers was not ready until Sunday morning, so we were all considerably relieved when the radio signal came through from Jessup. At 12:30 we had a test signal going through the entire system. At one o'clock the line-up was completed and the circuit was turned over to NBC.

During the game the circuit was monitored by engineers of the C & P and A T & T, with Mr. Atkins at Jessup and myself at Washington. At the Washington end the receiver was connected to a bridging circuit, from which it was fed to WNBW, local outlet of NBC, over an existing video wire circuit and to New York over the coaxial cable. The customer reported the picture to be excellent, an opinion confirmed by those who watched the monitor at the Washington and New York coaxial terminals.

Half past four brought the end of the game and a deep breath of relief to all; in particular to the inhabitants of the Jessup tower. In their haste, they had placed the transmitter over the trapdoor in the platform, so they were effectively marooned until the circuit was released.

One hundred and ten chemists, in New York for the fall meeting of the American Chemical Society, visited the Murray Hill laboratories on Friday afternoon, September 19. J. H. Scaff (extreme right) explains the process of preparing silicon and germanium for rectifier purposes

Due to the short time available, and the general tightness of telephone facilities, some expedients had to be used in setting up conference facilities. At the Baltimore end, a telephone extension was provided; at Jessup a station was connected to a rural line; and at Cheverly an urban mobile equipment was used. These facilities were tied together by conference-bridging circuits.

Although multiple link operation of four TE systems had been set up in the Laboratories, this was the first field set-up that involved as many as three links. This installation was a fine example of what can be done by Bell System teamwork.

Video Transmission Training Course

The Laboratories recently completed the first video transmission training course for associate company engineers. The instructors were the men who designed and put into operation the A2 video system for sending television pictures over ordinary telephone lines and the TE radio system for sending similar pictures between two points by means of microwaves. The course, held from September 2 to 19, was attended by twenty-four associate company engineers and, in addition to these, six part-time members from the A T & T and Western.

The program was divided into three weekly periods—the first devoted to basic principles; the second covered video transmission on existing telephone lines and lines specially designed for video circuits using the new A2 amplifier; and the third covered the use of the TE radio system for transmitting video signals.

The A2 system has been in use since before the war, but the amplifiers were recently redesigned and put into production at the Kearny plant of the Western Electric Company. The first eighteen amplifiers delivered were used at the school for solving laboratory problems. The excellent job done by the Western Electric Company on the initial production permitted the Laboratories to set up the equipment within three days prior to operating them at the school. The TE systems used in the school were the first production units built by Western Electric at the Winston-Salem plant.

Practically all members of the television group of Transmission Development assisted in both the preparation for and instruction at this school. A similar course of instruction will be given to other associate company engineers starting January 19, 1948.

R. M. Burns Honored by Tau Beta Pi

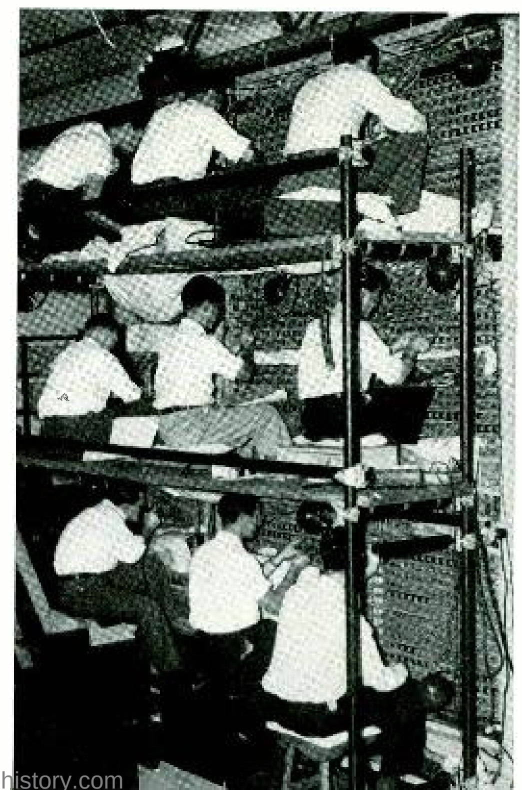
Five Bell System officials are among eleven prominent men in the field of engineering who were recently elected to membership in the Tau Beta Pi Association, honorary engineering fraternity. They are: Dr. Robert M. Burns, chemical director of Bell Telephone Laboratories; Stanley Bracken, president of the Western Electric Company; Keith S. McHugh, vice-president, and Harold S. Osborne, chief engineer, of the American Telephone and Telegraph Company; and Carl Whitmore, president of the New York company. Initiation took place at the Association's forty-second national convention in New York October 9.

Robert G. Brown, Inventor of "French" Phone, Dies

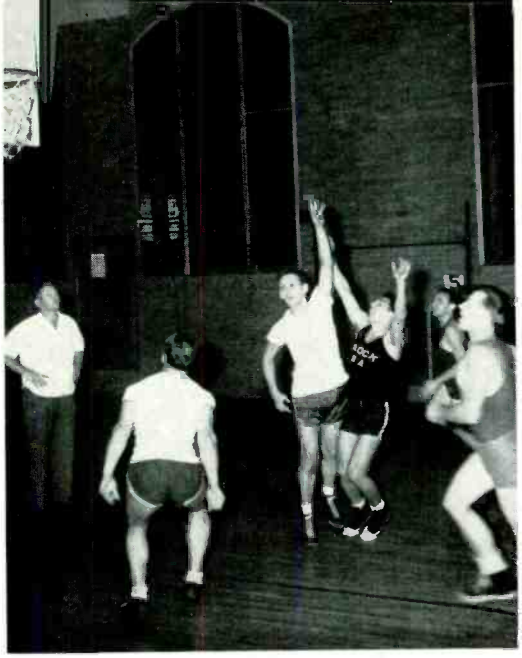
Word has been received here of the death of Robert G. Brown on October 7 at St. Petersburg, Florida. While never a member of the Bell System, Mr. Brown was active in the telephone business during its earliest years and was known to many pioneers.

Born in England 93 years ago, Mr. Brown graduated from Polytechnic Institute of Brooklyn and in 1878 was in charge of the Gold & Stock Telegraph Company's telephone office at 198 Broadway. This company was a competitor of the Bell Company. Operators in those days used separate transmitters and receivers held in their hands. Mr. Brown connected the two instruments by a curved iron bar, which was also the permanent magnet of the receiver. When the following year he became chief engineer of the French telephone system, he put the handset into service there. Thus, an American was the inventor of the so-called "French" telephone set.

Mr. Brown's handset was pictured in an article by H. A. Frederick on early handsets in the Record for July, 1934. Later the inventor and the author met, as pictured in the Record for November, 1934.



Three tiers of scaffold being used in the 4I assembly and wiring shop to speed up the completion of frames for the No. 5 crossbar trial installation at Media. Top, left to right, William Gonzales, Donald Lynne and John Nicholas; center, Warren Mailly, Masaji Ito and Arthur Boratto; and bottom, Juilo Calesso, Edward Jurek and Fred Newhall



Basketball has again become a Club activity at the Laboratories. Left to right, D. O'Sullivan, referee, who assisted in organizing the game with A. Kuczma (not shown); C. W. Thulin, G. A. Carlson, F. R. Monforte, A. Brandt and V. G. Chirba

Football Broadcasts 25 Years Old

Twenty-five years ago on October 28 was the beginning of long-distance football broadcasting. On that date in 1924, Princeton's close victory over Chicago on the latter's home field was brought to New York by Long Lines and broadcast from WEAF, then located on the eleventh floor at West Street. A further part in this occasion was played by the Laboratories in furnishing a public address system, mounted on a truck, to distribute the play-by-play story to a crowd in Park Row.

Out-of-Hour Courses

With a registration of about 175, the fall term of Out-of-Hour Courses began during the week of October 20. The following courses, arranged by the Personnel Department under the supervision of H. P. Smith, are being given:

Telephone Switching, given by the Staff of the Systems Department's Switching School, covers the fundamental concepts underlying the design of switching systems. (At New York.)

Applications of Electronic Devices to Telephone Switching, by W. H. T. Holden, presents a review of the present status, current thinking, and future trends. (At New York.)

Exchange Area Transmission, by C. W. Carter and other members of Transmission Engineering, covers the fundamental technical principles and economic considerations that are involved. (At New York.)

Mathematics of Wave Phenomena, by S. A. Schelkunoff and R. W. Hamming, presents some of the advanced mathematical methods appropriate to the analysis of wave phenomena. (At New York.)

Electronics, by W. A. Depp, C. E. Fay, R. J. Kircher, R. M. Ryder and R. W. Sears, covers the basic features of the operation of electron tubes as circuit elements and the electronic phenomena that determine tube characteristics. (At New York.)

Atomic Structure, by J. P. Molnar, covers the experimental and theoretical basis for the concept of the nuclear atom with its surrounding electronic charge. (At Murray Hill.)

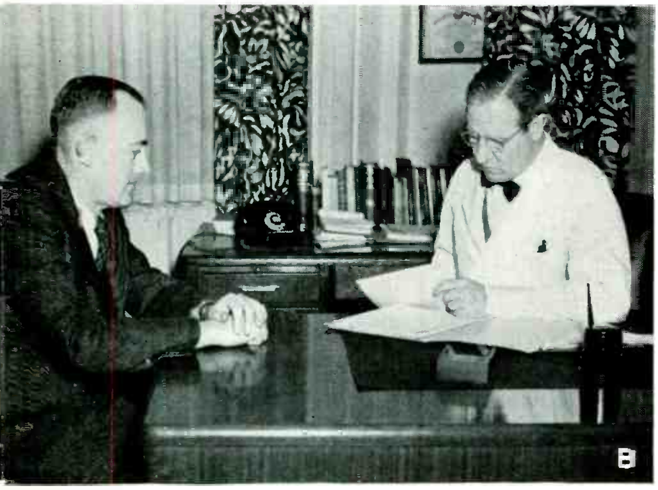
Piezoelectric Crystals and Their Applications to Ultrasonics, by W. P. Mason, covers the principles and theory of these crystals and their applications. (At Murray Hill.)

Design Principles of Electroacoustic Devices, by F. F. Romanow, presents the various means available for effecting conversions of energy from the electric to the acoustic form and vice versa. (At Murray Hill.)

When the cameraman called on Louise Ellin, of Central Files, she was answering a call for one of the 170,000 different photographs which are her responsibility to index, classify and maintain. She also maintains a file of A T & T Circular Letters, Bell System Practices and BTL Development Letters

A

TEAMWORK FOR BETTER HEALTH



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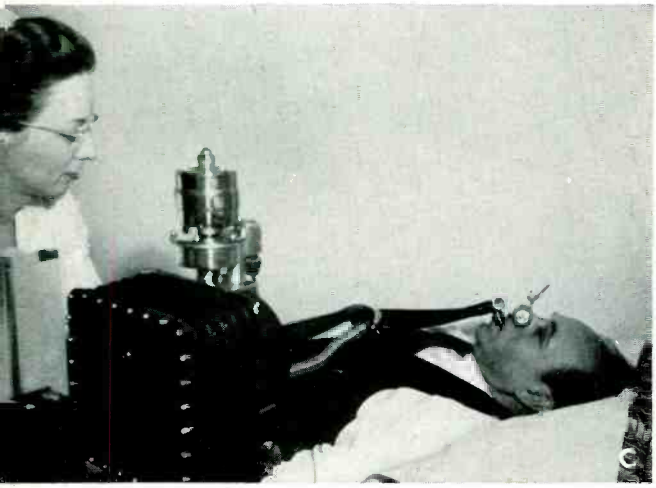
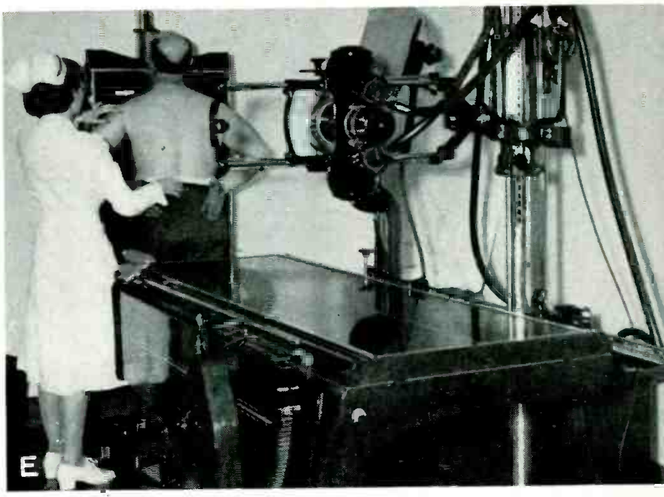


C

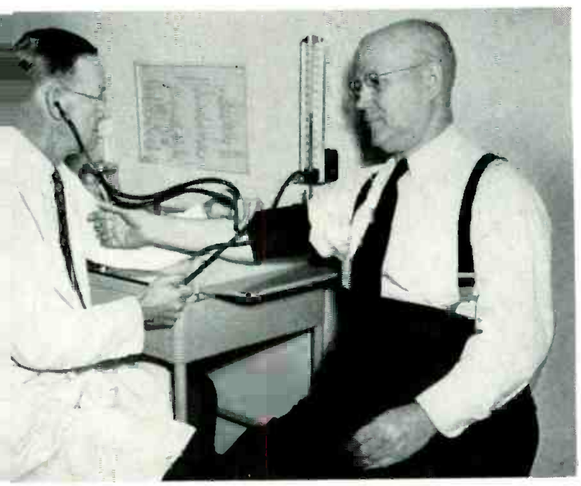
High on the list of well-equipped units in "Ma Bell's House of Magic" are the Medical Department's facilities at Murray Hill, West Street and Whippany, under the supervision of Charles E. Martin, M.D. His staff is comprised of fourteen associates through whose teamwork members of the Laboratories are assured better health and happiness.

Last year 41,000 visits were made to the Medical Department in three locations and more than 53,000 services were rendered by them. In some cases the visits were for diagnostic advice and aid in medical and surgical cases; in others, for conferences with Dr. Martin for general advice or health education (B). Some were for medical aid for "usual" ailments; others for first-aid care of accidents received on or off duty, such as Nurses Ella Good (H) and Gertrude Thomas (I) are giving.

Approximately a thousand members of the Laboratories avail themselves annually of complete periodic health examinations. A few of them are shown above in (A) awaiting their appointments, while another patient is shown in (F) having his blood pressure taken by Dr. C. A. O'Malley, and in (E) having a chest X-ray by Nurse Technician Florine Manderbach. Electrocardiograph, basal metabolism (C) and various other tests are given as required. A part-time technician (G) assists the staff in performing blood-counts, blood sugars, blood count differentials, throat cultures and other such examinations as may be indicated. Assisting on the clerical staff at the time the picture (D) was taken were Katherine Poellman (front), Nora Larkin (center), and Anne Roeder (rear).



TEAMWORK FOR BETTER HEALTH



The Rifle Club opened its season on September 13 with a qualification meet at the Ramapo range

Rifle Club Qualification Meet

The 1947-48 Rifle Club season opened with a 30-caliber qualification meet held at the Ramapo Rifle Range of the Ridgewood Rifle Club on September 13. Of the 28 members participating in this meet, nine qualified as expert, eleven as sharpshooter and six as marksman. The Army "C" course was fired. This course consists of firing 39 shots over a range of 200 yards. Twelve of these are fired "slow fire" at the regular Army A target having a 10-inch round "bull's-eye," while 27 shots are fired "rapid fire" at the silhouette or Army D target. Of the several rifles fired at this meet, four were semi-automatic M1 service rifles, popularly known as the "Garand," used by the Armed Forces during the war. There were recently issued to the club by the Director of Civilian Marksmanship.

The Kearny indoor rifle range will be open to club members for small bore shooting Tuesday evenings and the Summit range in the Masonic building Wednesday and Thursday evenings throughout the season.

Front to rear, J. E. Shafer, Arthur Wright (vice-chairman of the Club), V. L. Holdaway and R. E. Strebel

New Convertible Debentures Authorized by A T & T

Stockholders of the American Telephone and Telegraph Company, at a special meeting held on October 15, voted to authorize a new issue of convertible debentures in an amount expected to be approximately $360,000,000. The debentures will be offered to stockholders of record on October 31, 1947, for subscription in the ratio of $100 principal amount of debentures for each six shares of stock held on that date. Assignable warrants for subscription will be sent to stockholders on or about November 10, 1947, and subscriptions will be accepted by the company to and including December 15, 1947.

R. E. Strebel, chairman of Laboratories Rifle Club in record firing-sitting position

The new convertible debentures are to bear interest at the rate of 2¾ per cent per annum, will be dated December 15, 1947, and will mature December 15, 1957. They will be convertible to the capital stock of the company on and after March 1, 1948, but not later than December 14, 1955. The conversion price will be $140 per share payable by surrender of $100 principal amount of convertible debentures and payment to the company of $40 in cash for each share of capital stock to be issued upon conversion. The debentures may be redeemed as a whole or in part on or after December 15, 1949, on 30 days' notice, the initial redemption price being 107 per cent.

Three-Team Archery Meet

Archery groups from Murray Hill, West Street, and Whippany held a meet on October 4 just outside the Murray Hill grounds. Shown below are, left to right, H. J. Wehe, Alice Jastrom, whose score 515 was highest for women; O. Engelhart; Dorothy Storm; Helen Cruger, third among women with a score 326; W. E. Whidden; Herma Procopiadi, second highest among women, 331; Joan Burke; C. A. Bengtsen; and Ruth Young. Highest scores for men were made by W. D. Goodale, Jr., 608; H. A. Bredehoft, 556; and K. D. Smith, 537.

News Notes

DR. E. K. RIDEAL, Director of the Royal Institution, London, visited Murray Hill on September 22, where he spoke to a local group in the Arnold Auditorium on the general subject of catalysis.

O. E. BUCKLEY attended the Bell System Presidents' Conference from September 30 to October 2 at the Waldorf-Astoria.

R. L. JONES spoke on *Organization of Research Laboratories* at a conference on the administration of research held at Pennsylvania State College on October 6 and 7. The conference was sponsored by the School of Engineering of Pennsylvania State College.

D. A. QUARLES attended a meeting in Washington of the Committee on Electronics, Joint Research and Development Board.

R. K. HONAMAN attended a meeting of the Publication Committee of the A.I.E.E. on September 25 at Dayton.

G. C. DANIELSON, W. H. HEWITT, W. A. YAGER, E. J. MURPHY, S. O. MORGAN, D. A. MCLEAN, H. A. SAUER, K. G. COUTLEE and G. K. TEAL attended the meeting of the Conference on Electrical Insulation at M.I.T. Mr. Danielson and W. L. BOND presented a paper at the conference on *Domains in Barium Titanate*. Mr. Morgan was elected chairman of the conference for the coming year.

W. SHOCKLEY attended a meeting in Washington of the National Academy of Science Committee on *Properties of the Solid State*. He also spoke, at the Deal-Holmdel October Colloquium at Holmdel, on several subjects related to new studies in physics.

New Coaxial Cable in Service Between New York and Philadelphia

Crowded long-distance telephone circuits on the New York-Philadelphia route were eased by a new coaxial cable placed in service on September 25. There is one other cable now in operation between New York and Philadelphia. Completed in 1936, this cable now forms a segment of the coaxial network which has been used for the past year and a half by television broadcasters on an experimental basis to carry programs between New York and Washington.

During the recent World Series between the Yankees and Dodgers, fans in Philadelphia and Washington were brought within television range of the baseball classic by the coaxial facilities now in service. At Philadelphia, a new terminal was set up for the series under the direction of L. W. Morrison. Working with Long Lines engineers to install the terminal also were J. R. Brady, A. R. Kolding, R. S. Hawkins and C. I. Cronburg.

C. H. TOWNES visited Harvard and M.I.T. on microwave spectroscopy.

P. B. ONCLEY gave a lecture-demonstration on *Synthesis of Sound in Acoustical Research* before the combined convention of the Hudson Division of the American Relay League and

ELIZABETH ARMSTRONG WOOD has written on *X-ray Wave-Length Standards* in the *Physical Review*, September 1 issue, Letters to the Editor section.

R. K. POTTER's book, *Visible Speech*, was reviewed in the September 19 issue of *Science*.

November Service Anniversaries of Members of the Laboratories

35 years
F. B. Livingston

30 years
C. H. Amadon
L. D. Habermehl
E. C. Hagemann
Howard Hall
G. J. Maggi
W. F. Malone
W. R. Stuart

25 years
Martha Briegs
E. C. Caulk
James Collins
T. G. Kinsley
George McDermott
L. P. Rannow
M. L. Weber

20 years
W. M. Baldwin
W. C. Ball
N. A. Hall
R. L. Kaylor
W. R. Lundry
J. G. Oseroff
Richard Rafferty
Paul Smarsly
James Sullivan
E. D. Sunde

15 years
A. H. Wagner

10 years
T. J. Boland
Emma Kennedy
L. J. LaBrie
John Nichol
R. B. Ramsey

the Monmouth Sub-section of the Institute of Radio Engineers. A. R. SOFFEL, S. BALASHEK and J. H. KRONMEYER assisted Mr. Oncley.

W. A. SHEWHART attended meetings in Washington of the International Statistical Congress, called by UNESCO, the International Statistical Institute, and the Inter-American Statistical Institute. He was a delegate of the United States to the first General Assembly of the Inter-American Statistical Institute.

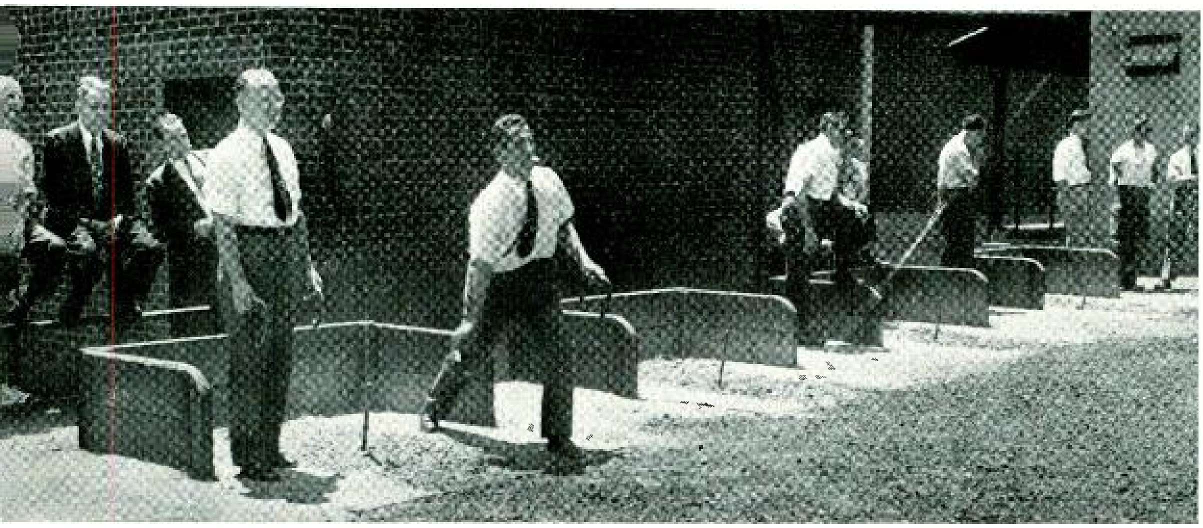
F. HARDY went to Washington for a meeting called by the Joint Army-Navy Aeronautical Board to discuss low-temperature lubricants. He also went to the Signal Corps Laboratory at Fort Monmouth on lubrication problems.

W. E. CAMPBELL spoke on *Lubrication of Communication Apparatus* at the local section meeting of the American Society of Lubricating Engineers in New York City. Mr. Campbell and C. L. LUKE visited the duPont Experimental Station at Wilmington to discuss the determination of moisture in insulating oils.

J. LEUTRITZ and R. H. COLLEY conferred with the members of the Forest Products Laboratory in Madison, Wisconsin, on coöperative tests.

W. J. KIERNAN attended a conference held at the American Society for Testing Materials headquarters in Philadelphia for the purpose of determining whether a committee on appearance standards should be established.

Noon hour at West Street in the area behind Building T, with the boys lined up to pitch or to kibitz in the sunshine



RETIREMENTS

John Hughes C. M. Darienzo Arthur Raynsford

Members of the Laboratories who retired recently include Arthur Raynsford, with 42 years of service on October 31; John Hughes, 39 years on October 31; and C. M. Darienzo, 27 years on October 27.

Arthur Raynsford

After Mr. Raynsford received his A.B. degree from the University of Rochester in 1905, he became a member of a special student course of the Western Electric Company at West Street. He then engaged in special work on capacity unbalance in the cable plant group until 1909, when he was sent to Hawthorne, where he worked for a year on engineering inspection and then transferred to equipment engineering. Since 1915, when he returned to West Street, Mr. Raynsford has been engaged in the development of the panel and crossbar systems. More recently he has been concerned with the development of equipment associated with the No. 5 crossbar system.

John Hughes

Mr. Hughes entered the employment of the Western Electric Company at West Street in 1907, and later, from 1913 to 1919, was assigned to the Murray Street Repair Shop. During his entire employment Mr. Hughes was part of the Building Service Department, in later years being assigned as Paymaster Guard and as a main entrance Usher and Guard.

Carmine M. Darienzo

Mr. Darienzo has been continuously associated with the Plant Department at West Street since he joined the Laboratories in 1920, having worked in the building service group, in the power plant, and since 1936 in the Building Shop as a pipefitter.

News Notes

B. S. Biggs is a member of the Summit Adult Education Council for the 1947-1948 season.

C. C. Hipkins visited the Pipe Line Service Company in Pittsburgh in connection with the application of a bituminous type of coating over copper tubing that is to be in service underground.

K. G. Compton, S. M. Arnold and A. Mendizza inspected central-office equipment being installed in Albany. Mr. Compton visited Wright Field and Hawthorne recently. He also delivered a paper on *The Selection of Protective Coatings* in Cleveland at the Symposium on *Modern Metal Protection.*

H. A. Stone, J. E. Ranges and C. C. Houtz visited Winston-Salem regarding the construction of pulsing networks.

W. J. King consulted with engineers at the Pittsfield plant of the General Electric Company on high-voltage connectors.

R. T. Staples was at Point Breeze in connection with cord development problems.

P. W. Rounds, at Los Angeles, participated in the field trial of single-sideband program channels on the type-K carrier telephone circuits.

At Burlington, T. H. Crabtree, G. G. Lavery and J. M. Rogie discussed production and testing problems relating to hearing aids; and L. Vieth, H. A. Henning and R. E. Prescott, 9-type reproducer problems.

J. R. Power and R. O. L. Curry conferred on problems relating to audiometry at Northwestern University, Evanston, Illinois.

L. Vieth attended a meeting of an N.A.B. Committee on Standards for Recording and Reproducing, held at Atlantic City.

M. H. Cook went to Winston-Salem for F. R. Lack's staff conference. Mr. Cook participated in the annual meeting of the Army Ordnance Association in New York as well as the annual technical and scientific session at the Aberdeen Proving Ground. He and R. E. Poole also attended the Navy Industrial Association conference and banquet in New York and the National Association of Broadcasters convention in Atlantic City. Mr. Poole made a trip to Burlington to discuss the production of commercial broadcast equipment.

A. E. Currie conferred in Washington on a Government project with representatives of the General Electric and the Navy Department.

OBITUARIES

Edward C. Taylor
1878-1947

Leon J. Sivian
1894-1947

Fred. W. Hecht
1888-1947

Leon J. Sivian, September 23

Mr. Sivian of the Physical Research Department died in Philadelphia after a prolonged illness. Born in Latvia, he emigrated to this country as a youth. After receiving an A.B. degree in electrical engineering at Cornell University in 1916, he remained there for a year as an instructor before joining the Laboratories. His first assignment was in radio research in connection with World War I. In 1919 he left to become an instructor and to do graduate work at the University of Missouri, but returned the following year to the Elberon Receiving Station where he engaged in the development and operation of a three-channel receiving station for ship-to-shore telephony. Transferring to the Physical Research Department in 1921, he has since been engaged in the field of electroacoustics.

His early investigations of methods of measuring characteristics of telephone receivers and transmitters led to the development of an artificial ear and artificial voice for testing receivers and transmitters and to the development of the telephone transmission reference system. Mr. Sivian developed an electrostatic method of obtaining pressure calibrations of transmitters and microphones. He extended the use of the thermophone for the same purpose and the use of the Rayleigh disc for field calibrations. Associated problems on which he worked involved a comparison of the response of the ear to head receivers and to open sound fields; investigations of the binaural system; and measurement of amplitudes and spectra of speech and music. Some of his other work was concerned with acoustic time delay circuits, diffraction of sound, and sound waves of large amplitudes. He also pioneered in absolute sound measurements in liquids by means of tourmaline, involving both pyroelectric and piezoelectric effects. In the field of room acoustics, he supervised the investigation of sound absorption and sound transmission through partitions, with application to noise reduction; the design of soundproof rooms and telephone booths; and the use of absorptive material to obtain optimum reverberation times. Mr. Sivian was to a large extent responsible for the acoustical design of the Arnold Auditorium at Murray Hill.

A leave was granted him in June 1941 to become an assistant director for one year at the University of California division of NDRC, where he engaged in research on underwater sound at the Navy Radio and Sound Laboratory, San Diego. Returning to the Laboratories, he became special assistant to the Chief of Section 17.3, NDRC, on a number of war projects.

Mr. Sivian participated actively on technical committees of the American Standards Association, the Institute of Radio Engineers and the Acoustical Society of America. He was unmarried and bequeathed his estate to the Institute for Advanced Study and the Louis Bamberger-Mrs. Felix Fuld Foundation at Princeton to be used in furthering research in physics and bio-physics.

Edward C. Taylor, October 4

Mr. Taylor, a draftsman in the Apparatus Development Department at the time of his retirement in 1943, joined the Engineering Department of the Western Electric Company in 1914 during the time when the semi-mechanical dial system, installed at central offices in Newark, was being developed. For several years he was engaged in the drafting work involved in the apparatus phases of this development. He was also concerned with the design of spiral gears and friction-roll drives for panel systems. Later in Apparatus Development, Mr. Taylor was associated with the mechanical design of testing equipment and telephone apparatus. He also had worked on apparatus used in the special laboratory for precision linear measurements.

Fred. W. Hecht, September 25

Mr. Hecht, an instrument and toolmaker at the Whippany Development Shop, joined the Laboratories in 1917 as an instrument maker at West Street, where he worked on relays, machine switching, and sound equipment. In

1935 Mr. Hecht was transferred to the Special Products Development Department at the Graybar-Varick building, where he worked in close association with a group of engineers who were engaged in the development of airborne radio equipment.

In 1940, when the Laboratories expanded its operations at Whippany, Mr. Hecht transferred to the Development Shop at that location. Initially he was assigned to work on broadcast transmitters and receivers, but during the war years and since V-J Day he made experimental wave guides and other components of radar equipment.

John Conge, September 10

John Conge, who retired as a member of the Plant Department in 1930, was born on July 28, 1864. During his twenty-four years of Bell System service, he was in the building service group at West Street.

News Notes

W. H. Doherty, J. B. Bishop and J. F. Morrison participated in the Graybar-Western sales conference held on September 10 at Whippany. Mr. Doherty's topic was *Discussion of AM Transmitter Problems;* Mr. Bishop's, *FM Transmitter Developments;* and Mr. Morrison's, *FM Antennas* and *5A Monitor.*

R. D. Gibson spent a week at the Burlington and Winston-Salem shops in connection with the planning of commercial shipboard radio and radar.

W. C. Tinus attended meetings in New York of the Board of Institute Radio Engineers' Editors and of the Army Ordnance Association. With the Technical and Scientific Section of the Association, he visited the Aberdeen Proving Grounds.

At Winston-Salem, M. N. Yarborough and F. E. Ladd were concerned with radar equipment; B. O. Brown, the 3-kw FM transmitter; A. D. Liguori, A. C. Peyman and F. G. Swanson, the design of a new transmitter; and D. R. Frantz, the manufacture of FM transmitting equipment. W. A. Landy and E. T. Stammer spent two weeks there preparing a microfilm record of sonar projects. C. Flannagan spent four days discussing radio frequency shift telegraph equipment. J. B. D'Albora and J. H. Hershey assisted Western Electric in production problems of radar equipment.

J. G. Ferguson and O. J. Morzenti conferred at Hawthorne and Duluth on the development of crossbar equipment.

J. A. Becker presented a paper entitled *General Survey of Electrical Conductivity in Semiconductors* and C. B. Green, a paper, *Applications of Thermistor,* before the conference on Electrical Insulation of the National Research Council on September 24 at M.I.T.

H. J. Delchamps, Chairman of the West Morris County Chapter, American Red Cross, presided over the Board of Directors' October meeting. Mr. Delchamps outlined the heavy program facing the organization, particularly in regard to the care and rehabilitation of veterans, including the work of a Camp and Hospital Council for hospitalized veterans. B. O. Templeton, Chairman of the Mountain Lakes Branch, also participated in the meeting.

R. G. Koontz, together with W. A. Bischoff and A. A. Carrier of the Apparatus Department and W. J. Adams of Whippany, visited Hawthorne to discuss engineering and equipment drafting standards.

H. E. Marting and A. Mendizza visited various offices in the New York Telephone Company area at Albany in connection with protective finishes on central-office equipment.

P. W. Sheatsley and R. L. Lunsford discussed crossbar equipment at Hawthorne.

J. A. Potter observed power control and regulator techniques as applied to machine tools at the Dodge-Chicago plant.

F. F. Siebert discussed questions of machine design with the General Electric Company at Lynn, Massachusetts.

P. T. Haury visited the Nashville Office of the Long Lines in connection with K2 carrier. Mr. Haury, E. W. Anderson and F. B. Anderson studied carrier pilot wire regulators at the Leeds and Northrup plant in Philadelphia.

F. W. Koller and P. T. Sproul observed the installation of television terminals for the coaxial carrier at Philadelphia and Baltimore.

A. H. Lince visited the Dow Chemical Company at Midland, Michigan, concerning special materials for antenna and microwave radio.

W. Buhler and G. A. Hurst made a relay study in the No. 1 crossbar office at Baltimore.

O. H. Kopp's visit to Philadelphia concerned the modification of the panel tandem circuits to prepare for operation with the new No. 5 crossbar office being installed in Media.

L. J. Stacy conferred at Harrisburg with representatives of the Bell of Pennsylvania on the problems of ringing over rural lines exposed to power line interference.

F. J. SCUDDER has been made a Fellow of the American Institute of Electrical Engineers.

H. C. FRANKE, with the assistance of Pacific Telephone and Telegraph Company engineers, made transmission measurements on the TC microwave radio installation between Marysville and Redding, California.

D. K. MARTIN participated in discussions and demonstrations sponsored by the Radio Technical Commission for Aeronautics in connection with navigational facilities for airlines.

F. J. SKINNER visited Allentown, Scranton and Harrisburg in connection with the mobile radio telephone system program.

L. A. DORFF was in Chicago and St. Louis to discuss the coördination of the mobile highway radio system.

WALTER STRACK is in Washington in connection with the mobile radio telephone system.

G. W. GILMAN and M. B. MCDAVITT attended an FCC engineering conference in Washington.

H. C. FLEMING, at Atlanta, measured power modulation on K2 carrier telephone systems from Terre Haute to Atlanta.

B. A. FAIRWEATHER, I. M. KERNEY and D. B. PENICK have returned from Los Angeles, and H. H. FELDER from Denver, where field tests of 8,000-cycle single-sideband program channels on type-K carrier telephone circuits have been concluded. H. A. AFFEL and P. W. ROUNDS also participated in the final tests.

H. A. ETHERIDGE and H. B. BARLING spent a month in Dallas in connection with an automatic set for measuring delay, phase and gain characteristics of L1 coaxial systems.

Is this the bus to Graybar?

"The Telephone Hour"

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

November 10	*Fritz Kreisler*
November 17	*Set Svanholm*
November 24	*Lily Pons*
December 1	*Naumburg Foundation Winners*
December 8	*Ezio Pinza, Claudia Pinza and Glenn Burris*

H. B. BARLING of Transmission Development has completed his work at N.Y.U. for a Bachelor's Degree in Electrical Engineering.

E. C. ERICKSON was in Chicago in connection with American Standards Association meetings regarding the standardization of nomenclature and definitions of engineering standards. While there, he visited Hawthorne on matters relating to standardization of screw threads.

L. W. KELSAY, G. E. HADLEY and R. M. C. GREENIDGE discussed cable terminal and station protector questions at St. Paul.

P. G. CLARK's visit to Point Breeze was in connection with cable terminal matters.

C. C. LAWSON was at the North Tonawanda plant of Western Electric discussing problems relative to textile insulated cables.

T. A. DURKIN, with representatives of the New Jersey Bell Company, inspected trial installations of drop wire in the Atlantic City area.

W. K. OSER took part in inspections of buried wire plant in the Maryland area of The Chesapeake and Potomac Telephone Company.

J. M. HARDESTY, S. M. SUTTON, C. R. BREARTY and W. L. FRENCH participated in a quality survey conference on clay conduit at plants in Brazil, Indiana, and Haydenville, Ohio.

THE LABORATORIES were represented in interference proceedings at the Patent Office by F. MOHR before the Primary Examiner.

J. E. CASSIDY and E. B. CAVE appeared before the Board of Appeals at the Patent Office relative to applications for a patent.

F. D. LEAMER attended the American Management Association Personnel Conference in New York City, on October 2 and 3, and was Chairman of the session on *Current Salary Administration Problems.*

THE ENGINEER pictured in this month's advertisement is W. C. BUCKLAND of Telephone Instruments.