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Bell Laboratories RECORD

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Thirty years ago, crossarms and glass insulators were representative of telephone communication. Today, PIC cable, concrete conduit and computers symbolize the changing pattern of exchange outside plant *(see page 422)*

THE CHANGING PATTERN O-

XCHANGE OUTSIDE PLANT

The hardware and philosophy of telephone outside plant have changed considerably in recent years. Cables are getting longer and larger; more buried plant is being installed; new engineering tools and new transmission techniques are being designed.

W. J. Lally

Probably the most fundamental change that has taken place in outside plant materials since World War II is the introduction of plastics—notably polyethylene—for cable sheath and for conductor insulation. Until 1945, most exchange cables had pulp conductor insulation and lead sheath. With the end of the war, the Laboratories and the Western Electric Company resumed work on improved types of cable sheath. The first outcome of this program was the development of alpeth sheath in 1947 (RECORD, *November*, 1948). Alpeth sheath consists of a thin corrugated aluminum tape folded longitudinally around the cable core, and an extruded outer covering of black polyethylene. Alpeth was followed by the development of stalpeth, introduced in 1951 (RECORD, *August*, 1951). Stalpeth has a steel tape with a soldered longitudinal seam between the aluminum and the polyethylene. This tape serves as a barrier against moisture which may diffuse through the polyethylene jacket and lower the electrical performance of pulp-insulated conductors.

All but about two per cent of the exchange cable now manufactured for the Bell System has either alpeth or stalpeth sheath. This type of sheath has several advantages over lead sheath. It is cheaper; manufacturing savings amount to

W. S. Apgar installs ready-access terminal at Bell Laboratories location in Chester, N. J. These terminals facilitate rearrangement of pair connections and are economical to install and maintain.

several million dollars a year. It is lighter in weight, which is an important factor in installation. It does not crack when subjected to vibration and repeated stresses. Finally, it led to the development of mechanical splice closures, including a closure that has a built-in distribution terminal. These mechanical closures are much easier to install and remove than lead sleeve closures; and they do not require the use of molten solder, which is an important advantage from a safety viewpoint.

Polyethylene, first used as a sheathing material, began to replace pulp as a conductor insulation in 1950. Large-scale production began in 1952. Today, about 85 per cent of the sheath mileage (about 40 per cent of the conductor mileage) of all exchange cable produced for the Bell System is polyethylene-insulated conductor (PIC) cable.

PIC cable is economically attractive, even though it is higher priced than pulp-insulated cable except in small sizes. It is higher priced because polyethylene costs much more than pulp; also it has to be applied in a heavier wall thickness because its dielectric constant is higher, and therefore greater space per pair is required to provide the same mutual capacitance as pulp. The over-all economic advantage of PIC cable derives from the fact that its higher price is more than offset by savings resulting from polyethylene's high dielectric strength and its non-hygroscopic property.

Because PIC cable is unaffected by moisture, the cable system does not have to be hermetically sealed. This permits the use of low-cost ready-access distribution terminals that can be easily opened and closed without using special tools (RECORD, *November*, 1958). The installed cost of these terminals is much less than that of sealed terminals. In addition to lower installed cost, the ready-access feature makes it easier, and therefore less costly, to rearrange pair connections and to terminate additional pairs throughout the service life of the installation.

With the introduction of polyethylene insulation, three separate but related factors combined to bring about a new concept of cable design, called even count (RECORD, *June*, 1959). First, the use of polyethylene insulation made it economically feasible to manufacture cable in which all pairs are usable. In pulp-insulated cable, extra pairs of wires were included to provide spares for those which failed during manufacture and installation. This led to an odd-count numbering system in telephone plant. With PIC cable, and better manufacturing methods, those extra pairs were omitted and even-count cable became the standard.

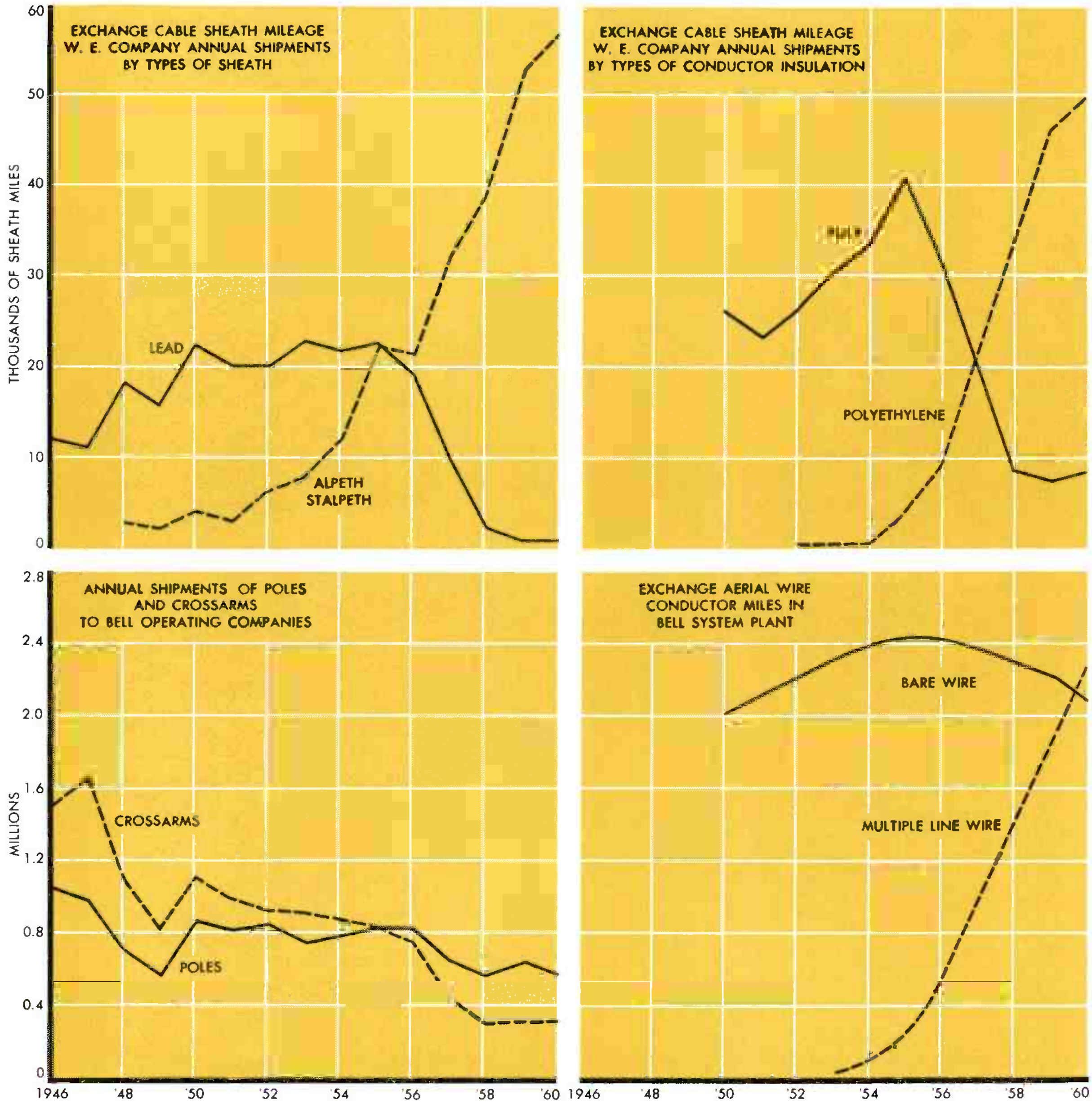
The second factor leading to the new design concept was that it became possible to provide polyethylene in a variety of readily distinguishable colors (RECORD, *August*, 1959), and this resulted in the development of an easily memorized color code. Thirdly, Western Electric developed a machine for stranding twisted pairs into units and cabling the units to form the complete core of the cable in one operation. To minimize crosstalk (an interaction between pairs that causes conversation on one circuit to be heard on another), 25 different twist lengths are used, and the stranding arrangement is such that pairs having twists of the same length do not lie close together in a unit. Even-count cable offers many advantages in the telephone plant. It simplifies the work operation of all telephone personnel concerned with cable counts and results in savings of several million dollars a year.

Boom in Buried Plant

From the earliest days of the telephone industry, the conventional way to build a transmission line where only a few circuits were required was to string bare wire from pole to pole, supporting it on glass insulators mounted on cross-arms. These open-wide lines have become a familiar sight along country roads. The use of open wire in Bell System exchange plant reached a peak of more than 2,400,000 wire miles in 1956, and then the downtrend started. Today, the demand for cross-arms has dropped from a high of 1,600,000 a year in the early postwar years to about 300,000 a year.

Two factors are responsible for the decline in exchange open wire: (1) the development of multiple line wire (RECORD, *October*, 1956) and (2) the trend toward buried plant (RECORD, *March*, 1959), which was stimulated by the development of PIC cable. Multiple-line wire consists of individually insulated and color-coded copper conductors twisted into pairs and then stranded around an insulated steel support wire. It provides a very economical type of plant—lower in capital cost and in maintenance expense than equivalent open-wire plant. Since its introduction in 1953, the conductor mileage of this wire in service has increased so rapidly that it already exceeds the amount of open wire.

When lead was the only type of cable sheathing available, corrosion protection (usually coatings of asphalt and servings of fungus-resistant jute) had to be applied if the cable was to be buried in the soil. At splice locations, the protective coverings had to be removed and the



Changing concepts of outside plant in recent years are reflected in equipment trends indicated above.

sheath thoroughly cleaned; then the splice had to have a corrosion-protective covering. If a crack or opening of any kind developed in the sheath of a buried cable, moisture might enter and dampen the paper-insulated conductors. When this occurred, the circuits became noisy and perhaps unserviceable. Another big drawback to the use of buried plant was that the construction equipment (plows and trenchers) then available was inefficient, with the exception of the large plow trains used for placing inter-city toll cables. The result was that only limited use was made of buried construction in exchange areas.

The advent of PIC cable brought about a boom in buried exchange plant in rural areas and also in urban and suburban housing developments (RECORD, *March*, 1959). The advantages of PIC for buried cable sparked the development of associated materials, apparatus, and methods. Today, buried distribution plant is competitive in cost with aerial plant in many situations. In addition, it is not vulnerable to storm damage, and, from an appearance viewpoint, it is a big improvement over aerial plant—particularly when both telephone and power lines are buried. Now, the Bell System and the power companies are actively exploring the feasibility of joint-trench installations of telephone and power cables. From a small beginning in 1956 with the installation of buried telephone plant for 4000 urban homes, this type of construction has almost doubled each year. New construction in 1960 provided buried telephone service for nearly 60,000 homes in urban areas and 44,000 in rural areas.

Keeping pace with advances in cable and wire design are developments in construction equipment. Although developments in this area are largely the work of commercial manufacturers, new equipment often incorporates design features recommended by Bell Laboratories. This is particularly so in the case of cable-and-wire-laying plows. Here the Laboratories have done a considerable amount of fundamental development to determine desirable design features. Laboratories engineers also have studied the amount of energy (draw-bar pull) required to move a plowshare through various types of soil and the capabilities of wheel- and trailer-type tractors in terms of draw-bar pull. This information is helpful in selecting the best equipment for a given job.

New Jersey Bell Telephone workman at Neptune, N. J., uses aerial lift to place multiple line wire.

In addition to new equipment for buried plant, mechanized equipment such as truck-mounted derricks and augers, powered from the truck engine, is being used for digging pole holes and erecting poles. Truck-mounted and powered aerial lifts are today's way of constructing aerial wire and cable plant. Even cable reel trailers are loaded and unloaded mechanically.

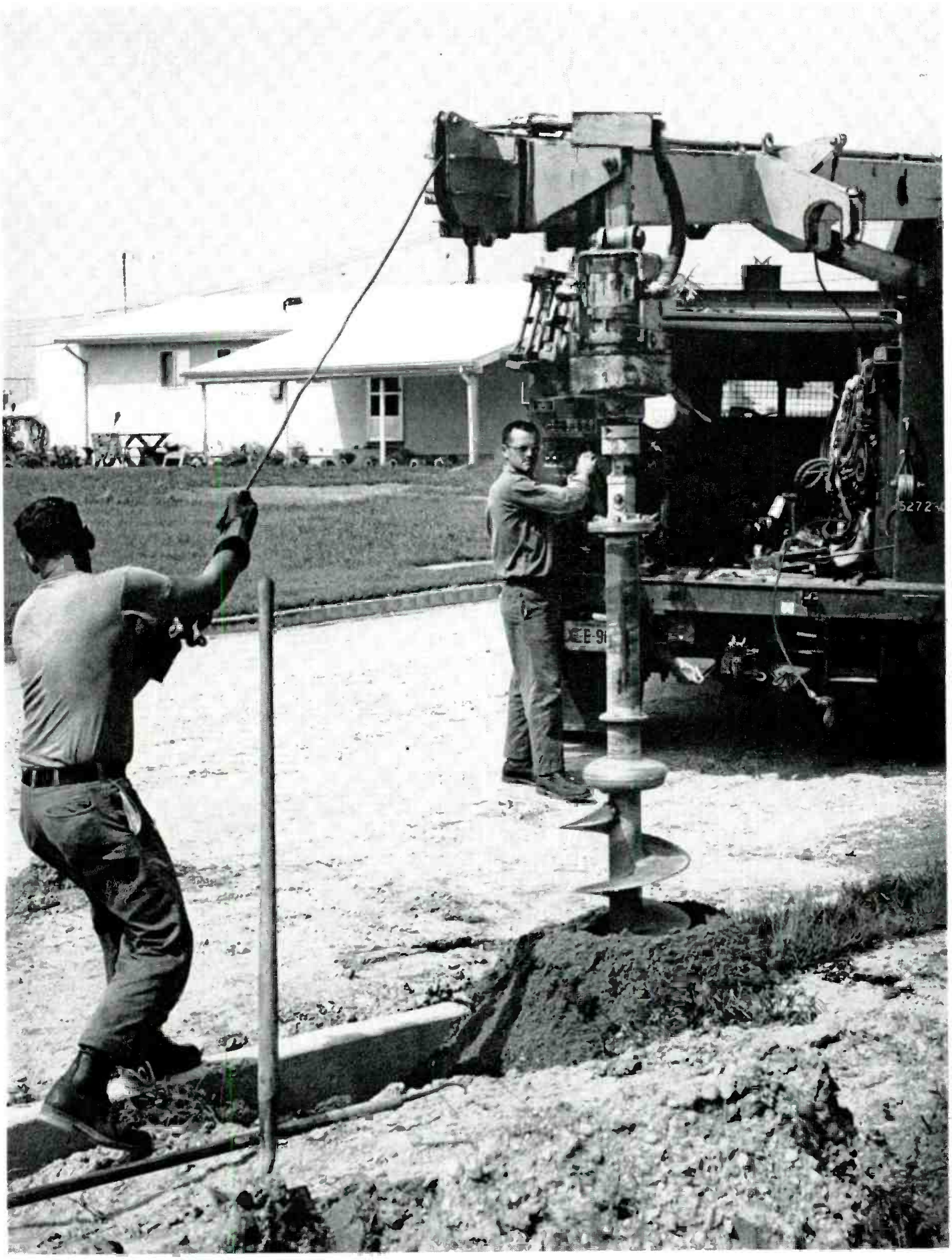
Construction and Maintenance Methods

Mechanized construction equipment is high-priced, but it "proves in" with improved efficiency. This is reflected in the changed pattern of work crews. A decade ago, the traditional line crew consisted of five men including the foreman. Cable splicing was always done by two-man teams. In the early 1950's a trend began toward small line crews and one-man (solo) splicing. Nowadays, about three-fourths of the line and cable placing force operates in small (typically, two-man) crews, and about three-fourths of the cable splicing is done on a solo basis. Each construction foreman supervises several small crews. This arrangement permits matching the labor force to the work load in all classifications of outside plant construction, and maintenance and in this way provides for more efficient use of manpower.

One of the major innovations in outside plant maintenance in the last 10 years has been the continuous pressurization of cables with dry air (RECORD, *January*, 1961). The primary purpose of cable pressurization is to prevent moisture from entering the cable through breaks that may occur in the sheath, especially in old lead-covered pulp-insulated cables. Pressurization is also important in locating sheath leaks.

The concept of maintaining cables in serviceable condition by raising their internal pressure above atmospheric is not new. In the late 1920's some toll cables were pressurized from tanks of nitrogen spotted along the cable route. What is new is the continuous feeding of dry air into cables (especially local cables) from a central source of supply. The first Bell Laboratories field trial of such a system in 1946 made use of a compressor dehydrator. Recently, Bell Laboratories developed a relatively inexpensive air dryer which compresses air and cools it (RECORD, *February*, 1961). This releases most of the moisture as water, which is drained off. Expansion to usable pressures provides dry air for use in the cable systems.

About 50 per cent of all paper-insulated cables in the Bell System are now under continuous pressure. Because pressurized cables cost less to



Two-man crew using construction truck with corner derrick and earth auger to dig telephone pole hole.

maintain and provide excellent service, the remaining 50 per cent will be put under pressure as rapidly as money and manpower permit. Air-drying apparatus is also being used to supply dry air under pressure to the waveguides and antennas of the Bell System microwave network as a guard against accumulation of moisture within these critical components (RECORD, *July*, 1961).

Changing Growth Patterns

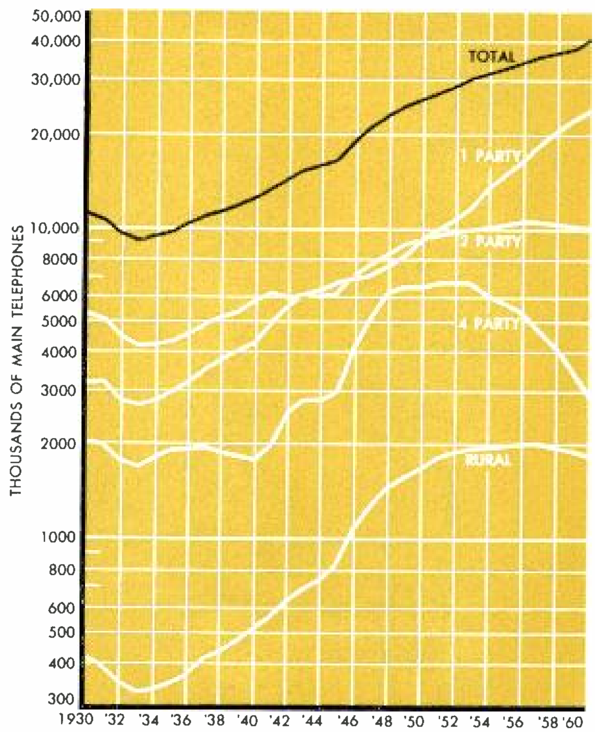
The changes discussed thus far have been technological changes resulting from development effort. But other important changes are taking place that are of interest and of concern from an engineering viewpoint. Customer cables are becoming longer and larger. A factor in this change is the trend in population movement to outlying areas. Where a decade ago there was farm land just beyond the outskirts of our cities and towns and therefore very little telephone development, today we are likely to find large housing developments and shopping centers with a big demand for telephone service. As a result of this new growth pattern, the amount of exchange cable has been increasing at a rate of 2 per cent a year. Almost all of this increase has been in "loop plant," that is, in the portion of the cable plant extending from the central office to the terminal nearest the customer's premises. Thus, subscriber cables are getting longer. Also, they are becoming larger partly because more pairs are needed to serve the increased number of customers.

Upgrading is another important factor in the trend toward larger cables. During World War II, telephone plant growth was curtailed because of restrictions against nonmilitary usage of copper and other strategic materials. This resulted in the accumulation of a large backlog demand for telephone service. When the war ended, the telephone industry began a major construction program to meet this demand but, even so, it was necessary to make large-scale use of mulitparty lines.

From 1946 to 1950, the Bell System had more two-party than one-party customers. When this backlog was taken care of, the System undertook an upgrading program with the objective of furnishing the class of service its customers desired. Because of this program, the percentage of total main telephones that have one-party service has been increasing since the early 1950's, and the amount of four-party service has been decreasing rapidly. Of 13.5 million lines added to Bell System plant in the past 10 years, more than 40 per cent were the result of the upgrading program. Because upgrading increases the ratio of lines to telephones, more cable pairs are required to serve a given number of customers. The over-all result of the trend in population movement and the upgrading program is that the average size exchange cable used for new plant construction has increased from 150-pair to 220-pair in the last decade.

This trend toward larger and longer cables is responsible for well over half the increase in Bell System exchange cable investment in the past decade. These changes in growth pattern are resulting in a costly outside plant. This has intensified the search for ways to construct outside plant at less cost, to utilize this plant more efficiently, and to provide the best administrative tools for holding capital expenditures for outside plant and those for central offices in good balance.

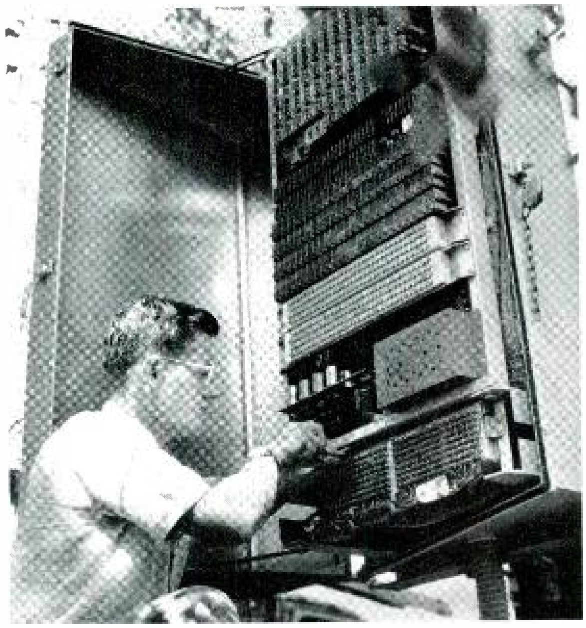
One of the recently developed means for utilizing cable plant more efficiently is the line concentrator (RECORD, *February*, 1958). This is a switching device that can be mounted on a telephone pole away from the central office. The line concentrator permits a number of customers to be connected to a central office over



Growth pattern of main telephones by class of service. Trend in last decade is toward 1-party.

considerably fewer cable pairs than would be required on the usual basis of one pair per line. For example, 50 telephones in a particular area require 50 cable pairs to the central office, assuming one-party service. With a line concentrator, however, these lines can be switched or concentrated, onto say, 10 pairs of wires which will carry calls back to the central office.

Such concentration of lines onto high usage trunks has been standard procedure *within* central offices. Thus, the concept of remote line concentrators is essentially an extension of central-office switching to a location near the customer's premises to save copper. The economic advantage of line concentrators depends on the cost of the additional facilities made available by the concentrator as compared to the cost of providing these same facilities by additional cable. Now the Laboratories is developing computer techniques that will enable Operating Companies' engineers to determine quickly whether the installation of a concentrator or additional cable would be the more economical course in any given growth situation.



R. Miller of New Jersey Bell Telephone Co. installing a 1A line concentrator at Martinsville, N. J.

Carrier transmission is another means for making efficient use of pairs of conductors by multiplying their circuit capacity. Carrier has been in use in toll plant for more than 40 years. In 1956, with the introduction of the P1 Carrier System, carrier was adapted to open wire for rural customers. P1 carrier is an amplitude-modulated system that employs frequencies up to 100,000 cycles. It provides up to four individual channels on one pair of wires. A modified P1 system is available for use on trunk cables.

Another new carrier system, T1, is scheduled for 1962. This system uses the newest of the carrier techniques, pulse code modulation (PCM). Instead of sending a continuous voice signal, PCM takes samples of the speaker's voice at a rate of about 8000 times a second. These samples are encoded into a series of pulses, and the pulses are transmitted over the line. The system transmits pulses at the rate of 1,500,000 a second. This fast transmission rate permits the codes of many different voices to be interlaced on the same wires. It provides 24 channels on two pairs of wires.

The T1 system is designed for use on short-haul trunks with a maximum length of about 25 miles on 22-gauge cable. The system will provide lower per-channel costs than the existing N carrier trunk system, which provides 12 channels on two pairs and generally is assigned to 19-gauge cable.

The many developments in exchange plant during the last decade have tended to hold unit costs at close to the 1950 level. But we are using more units—longer and larger cables. Exchange cable investment per line in service has been increasing at a rate of four per cent a year. This is a noticeably greater rate of increase than for dial central offices, a fact that raises a question whether exchange cable plant may be getting over-extended and investments in cable plant and central offices getting out of balance. Such a potential imbalance has led to studies at Bell Laboratories aimed at developing computer-processing techniques for quickly solving plant engineering problems. These new techniques will help keep capital investments for central offices and outside plant in optimum ratio.

The mathematics used to develop an optimum investment ratio is simple but very time-consuming when done manually. Generally, costs per line for central offices and for trunk plant vary inversely with the number of lines. The cost per line for subscriber outside plant, on the other hand, is apt to vary directly with the number of lines because usually as office size increases, the geographic area it serves increases. This results in longer loops, coarser gauges and, in outlying areas, smaller cables that have relatively high cost per pair mile.

The optimum size office for any given set of conditions is the size that will provide minimum total costs per line for central-office land, building, equipment, and outside plant. These costs are computed on the basis of the present worth of annual charges over a suitable study period, to account for plant installed at different times to accommodate growth. Computer techniques for studying this type of problem are already of value now; they will become increasingly important as new instrumentalities enter the outside plant picture.

The Years Ahead

So much for the past and the present. But what lies ahead? What will the outside plant of 1970 look like? While it always is hazardous to prophesy, the hazard is partly offset in the present case by knowledge of development and systems engineering projects that are under way or being planned and seem to have a good chance of success. Also, it is reasonable to expect that recent developments such as the electronic central office, pulse code modulation, and line concentrators will come into full flower. The trend toward buried plant, too, is expected to continue, so that by 1970 a much larger proportion of outside plant will be underground.

Another possibility in the future picture is the use of small switching units distributed throughout the outside plant in a pattern that might permit use of fine-gauge cable exclusively. This, in turn, might indicate improved station sets of the low-current type and gain devices either in the station sets or the central office or both.

As the upgrading trend continues and we approach one-party service on all lines, there are a number of advantages in designing subscriber cable plant on the basis of a single line per customer, and leaving all lines permanently connected. Under these conditions, service connects and disconnects can be made at the central office. The goal here would be large savings in customer assignment costs and in plant rearrangements.

None of these changes present any insurmountable problems. We shall probably be able to take care of them just as in the past ten years we have assimilated PIC cable and ready-access terminals. An important impact of the future will be in the engineering phases of outside plant which will become more complex. Computers will play an increasingly important role in providing economical solutions to diverse plant engineering problems. The demands of industry and commerce, the surge of population, and the increasing necessity for people to communicate quickly and conveniently challenge the skill and ingenuity of the outside plant engineers as we press on into the 1960's.

New Way to Measur

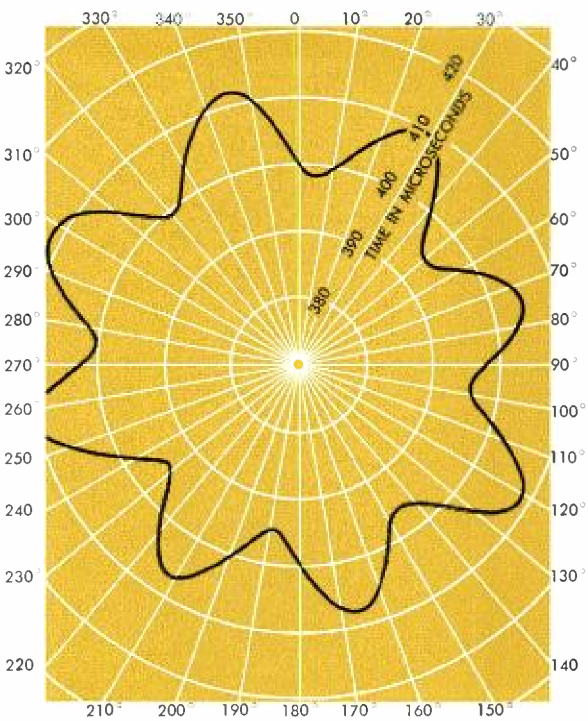
There are many methods of measuring variations in rotational speed. Most of them, however, are adaptations of methods designed for measuring long-time average speed, and their accuracy decreases seriously as the time of measurement is shortened. This is especially true for tachometers, ranging from a simple manually operated revolution counter with stopwatch to highly complex electrical instruments, and also for techniques based on the stroboscope, an instrument that compares an unknown with a known frequency. High-speed movie cameras permit speed measurements over very short periods, and flutter meters (RECORD, *April*, 1960), which are essentially FM demodulators, come close to measuring instantaneous deviations. Both are complex instruments and require rather tedious data reduction. This article describes a relatively simple method for measuring the actual rotational velocity over a small fraction of a revolution.

The problem of measuring variations in rotational speed can be attacked from two points of view. One is to measure the actual speed; the other is to measure the difference between the actual speed and the long-time average speed. Since the speed may be changing at all times, the ideal measurement would be that of instantaneous speed, or the instantaneous deviation from

A simple adaptation of known techniques provides a method of making a precise measurement of rotational speed over very short time intervals. The result approaches the measurement of instantaneous speed.

R. R. Anderson

ariations in Rotational Speed



Plot from an optical tachometer, showing variations in rotational speed for 900-rpm motor.

the average speed. Because these cannot be measured, we must content ourselves with making measurements over as short a time interval as possible.

One of the recurring problems in designing magnetic tape transports is the reduction of flutter. In one piece of equipment, pronounced flutter was caused by the drive motor. A simple optical tachometer showed that the time per revolution remained constant. This meant that variations in rotational speed occurred during certain portions of the revolution. To measure these variations in rotational speed, the author developed a slit-type optical tachometer.

This instrument consists of a slitted disk, a phototransistor, and an electronic counter. The disk, which is fastened to the motor shaft, is made of aluminum. It is cut with 180 radial slits, two degrees apart as shown on page 432. The light source is a lamp with a built-in lens plus a stationary slit for collimating the beam. This provides adequate light to activate the phototransistor. The light source is mounted so that, as the disk rotates, the light beam strikes the phototransistor 180 times per revolution. Thus, the counter records one pulse per slit, or 180 pulses per revolution.

When all but two adjacent slits are blocked, two pulses from the phototransistor are separated by exactly the time required for the shaft to rotate two degrees. These pulses start and stop an electronic counter. By measuring the time interval between different pairs of adjacent slits, we can find the motor speed through each two degrees of a complete revolution. A polar plot of the measured time interval graphed against the angle at which the interval was measured is shown on page 431. This plot indicates, for example, that at 30 degrees from an arbitrary reference, the motor takes 410 microseconds to move over the two-degree interval, 29 to 31 degrees. Similarly, at 50 degrees the time is 394.5 microseconds. The rotational velocity differs, at these two points, by 15.5 microseconds or 3.9 per cent. Rather than uncover different pairs of slits in this test setup, the motor stator was rotated in five-degree steps between measurements.

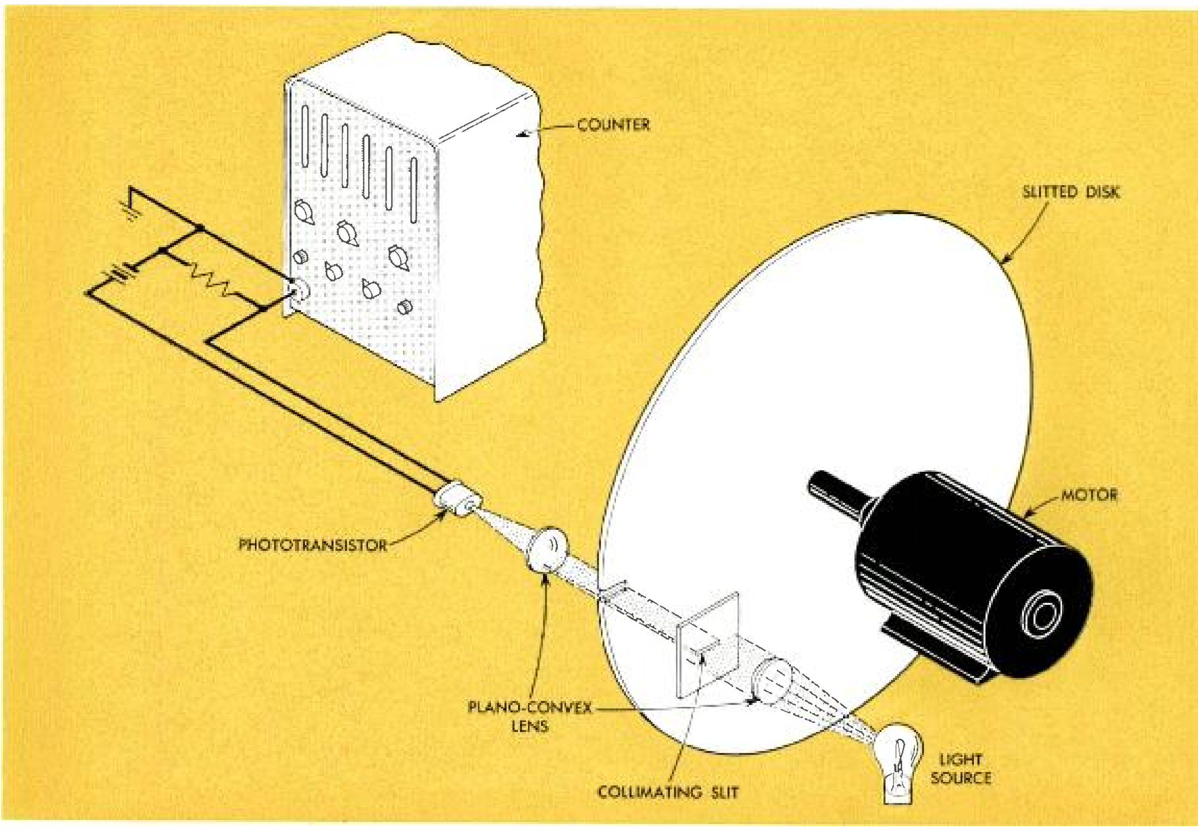
Speed variations, not measurable on other known tachometers, can be measured with this instrument to within one per cent, considering both displacement and time errors. Displacement errors can be eliminated using the same pair of slits as discussed above. The minimum measurable time interval is limited by the speed of response of the phototransistor, which together with mechanical considerations, determines the minimum slit spacing. Otherwise, the width of the slit and of the light beam has no effect.

For example, note that a 900-rpm synchronous motor will rotate through two degrees in 370 μsec. The measured apparent speed was about 10 per cent lower. This could be caused by incorrect slit spacing or by the transient characteristic of the phototransistor. In either case it is not important in measuring the speed variation.

The relatively crude implementation described here adequately measured the speed variations, and no attempt was made to refine the technique. Steps which might be considered to increase the accuracy of the device include: a larger disk to allow closer slit spacing, more careful machining, surface finish to reduce reflections, a second collimating slit before the phototransistor, and more care with the source of light. On the other hand, these measures would reduce the advantage of extreme simplicity of the setup.

The slit-type optical tachometer offers many advantages over the more conventional measuring techniques. The device can be easily built at a nominal cost. It is highly sensitive and comes closer to measuring instantaneous speed than any standard laboratory instrument.

Slit-type optical tachometer developed by the author to measure the variations of magnetic tape velocity.



The neutralizing transformer is one of many devices that protect communications circuits from abnormal voltages. This device may act as a transformer for only a few seconds in its lifetime; yet, during that time, its performance must be faultless.

L. H. Sessler

Neutralizing Transformers

Protective devices that safeguard telephone circuits from damaging voltage surges have played a major part in making the Bell System transmission network the world's most reliable communications system. One of these devices is the neutralizing transformer. It solves a unique protection problem for telephone circuits that serve power generating stations and substations.

The problem originates when one of the high voltage lines from the power station develops a fault to ground. Fault current returning through the station ground system causes the station ground to rise in potential with respect to remote ground. The magnitude of the potential rise is the product of the current and the ground resistance. When a telephone circuit is brought into the power station it is at remote potential because of its connection to the distant central office ground. For the sake of the telephone user it is necessary to keep within safe limits any difference of potential between the telephone line and local ground. Ordinarily this is done by connecting carbon protector blocks between the line and the local ground. This arrangement affords satisfactory protection as long as there is no objection to a momentary interruption of telephone service, because while the fault current is flowing the protector blocks, in effect, short circuit the telephone line. The interruption may be for only a fraction of a second; but many circuits serving power stations are used for relaying, control, metering and supervision, and their performance may be vital in that very instant. Neutralizing transformers act to prevent such interruptions.

These devices have three identical closely coupled windings. The primary is connected between the power station ground and a remote ground; each of the two secondaries is connected in series with one side of the telephone circuit. When a rise in ground potential is impressed across the primary winding, an almost equal voltage is induced through the secondaries into each conductor of the telephone circuit. The polarity of the induced voltage is such that the voltage on the telephone lines on the station side of the transformer is raised to nearly the same value as that of the local power station ground. As a result the voltage difference at the power station is "neutralized."

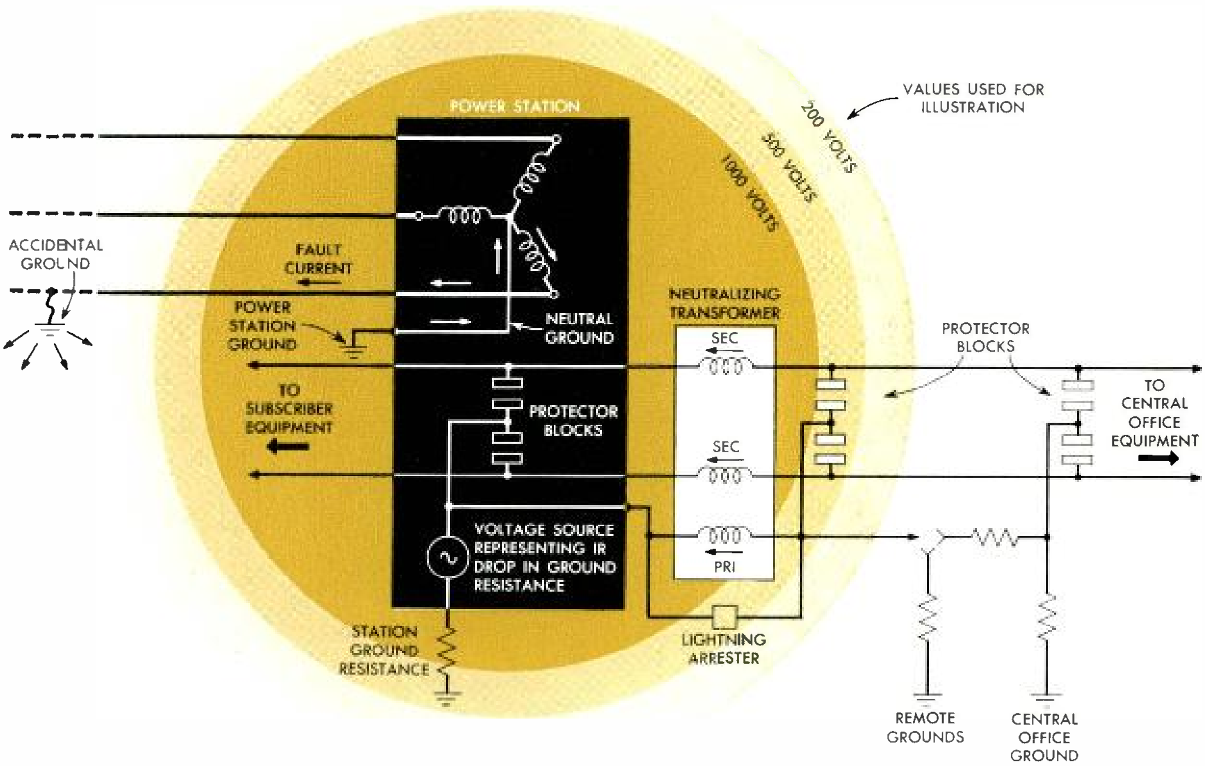
A small unneutralized, or remnant, voltage does appear across the protector blocks, however; its magnitude is essentially the product of the exciting current and the resistance of the primary circuit of the transformer. The voltage will not disturb the telephone circuit if it is less than the minimum operating potential of the protectors. There are two possibilities available to the engineer for reducing this voltage, namely, to specify a low exciting current for the transformer and a low resistance external primary circuit.

At most stations the telephone cable sheath is a sufficiently low resistance circuit to remote ground. In open wire areas, a separate wire must be run to a ground, usually constructed of driven ground rods. In this case, it is often not practical to construct a ground of the desired low resistance. However, materials for modern transformer cores usually allow an exciting current low enough so that there is no need to construct a very low resistance ground.

Within its design limits, a transformer will also neutralize rises in ground potential caused by lightning surges. Often, however, these potentials are too large for the transformer to handle. Therefore, a commercial valve-type lightning arrester is connected across the primary winding to protect the transformer.

Telephone currents, which may be voice, signaling or battery currents, must, of course, also flow through the two secondary windings. However, for these currents the secondary windings are in series opposition as shown in diagram on this page. Thus, these currents do not cause excitation in the transformer core, which would result in large transmission losses. Small transmission losses caused by the transformer are due primarily to the loop resistance of the secondary windings and the mutual capacitance between the windings.

For many years the Western Electric Company has manufactured three-winding, dry-type transformers (*see the table on the opposite page*) at



Arrangement of protector blocks and neutralizing transformer on the lines serving a power station. Rings in color illustrate how fault current causes a rise in potential with respect to remote ground.

two ratings, namely, two and four kilovolts. However, the expected maximum rise in ground potential at many installations exceeds four kilovolts. Until recently, two 4-kilovolts transformers connected in series were required to neutralize this rise. But Bell Laboratories solved the problem in a more satisfactory manner with the KS-16076 transformer.

This device, manufactured by the Kuhlman Electric Company, is an oil-filled, 8 kilovolt neutralizing transformer. In addition to the increased voltage rating, it has several improvements over the older designs. First, in this transformer a high impulse strength of at least 75 kilovolts has been achieved, a level that assures a greater margin between the spark-over value of the arrester and the withstand level of the transformer. Second, the exciting current is very much lower. This permits a low remnant voltage without restricting the resistance of the remote ground circuit. A final advantage of the KS-16076 transformer is that all protective devices are mounted on the transformer itself which allows much easier installation and wiring.

ELECTRICAL CHARACTERISTICS—NEUTRALIZING TRANSFORMERS

		TRANSFORMER			
		362C	355A	356A	KS-16076
Rated voltage, 60~, volts RMS		2000	4000	4000	8000
Insulation		Dry	Dry	Dry	Oil
Mounting		Indoor	Outdoor	Indoor	Outdoor
Average DC resistance of each winding in ohms		61	60	65	62.5
Approximate mutual capacitance between secondary windings in microfarads		0.05	0.06	0.06	0.088
Average trans. loss as measured between 600 ohms in db:	200~	0.8	0.8	0.8	1.1
	1000~	1.0	1.0	1.0	1.0
	3000~	1.6	1.6	1.6	1.5

The neutralizing transformer is one of the many devices that Bell Laboratories engineers have developed to protect customers and telephone equipment against the effects of lightning surges and accidental power fault currents. The neutralizing transformer may be called upon to act as a transformer for only a few seconds in its entire life, but Bell System standards require reliable performance in that brief period.

Nike-Zeus Scores Successes In Four Test Firings

The U.S. Army successfully fired its NIKE-ZEUS anti-missile missile four times last month —twice at White Sands Missile Range, New Mexico and twice in over-water tests at Pt. Mugu, California. Bell Laboratories project engineers said important test objectives were met in all firings. The Laboratories is responsible for the design and development of NIKE-ZEUS under a Western Electric Company prime contract from the Army Ordnance Missile Command. The Army Rocket and Guided Missile Agency, a division of AOMC, is the Army's supervisory agency for NIKE-ZEUS development.

In the first test at White Sands, NIKE-ZEUS radar tracked a special test target and the ground electronics of the missile defense system successfully controlled a NIKE-ZEUS missile in flight.

The second firing was a combination test of the NIKE-ZEUS missile in the launch method planned for operational use, and of the ground electronics that controlled it in flight. The missile was fired from an underground launch cell, then maneuvered in flight in response to control commands from its ground guidance center.

Sunk vertically into the ground, the launch cell was a prototype of that planned for operational use. It had been successfully tested in previous firings. The missile launched in the first test was fired from an above-the-ground rail used in development testing.

In both Pt. Mugu firings, performance was similar—the missile flashed from a seaside launcher boosted by its 450,000-pound-thrust first stage motor. Shortly after launch, while the missile was still climbing vertically, the booster motor completed its burning and dropped into the sea. After the second stage motor had fired as planned, the missile curved in a controlled trajectory and had disappeared in an arcing curve over the Pacific within seconds.

ZEUS missile test firings will continue at Pt. Mugu where firing over the Pacific will permit sending the 3-stage ZEUS over its full range at very high altitudes. Range limitations of the 100-mile long White Sands Missile Range prevent such tests at that location. Firing tests of the missile at lesser ranges will continue to be held at the White Sands Range.

During all tests the NIKE-ZEUS was controlled in flight using elements of the Command Guidance System developed by the Laboratories and manufactured by Western Electric.

C. Throckmorton checks operation of the converter circuit for step-by-step with a manual test box. Maintenance testing is accomplished in this manner.

When Touch-Tone Calling goes into effect, switching systems will have to understand the language of the pushbutton signal and the dial pulse. This is why Laboratories engineers have designed modifications that can make central offices "bilingual."

N. Lazo and A. S. Martins

Central-Office Modifications For Touch-Tone Calling

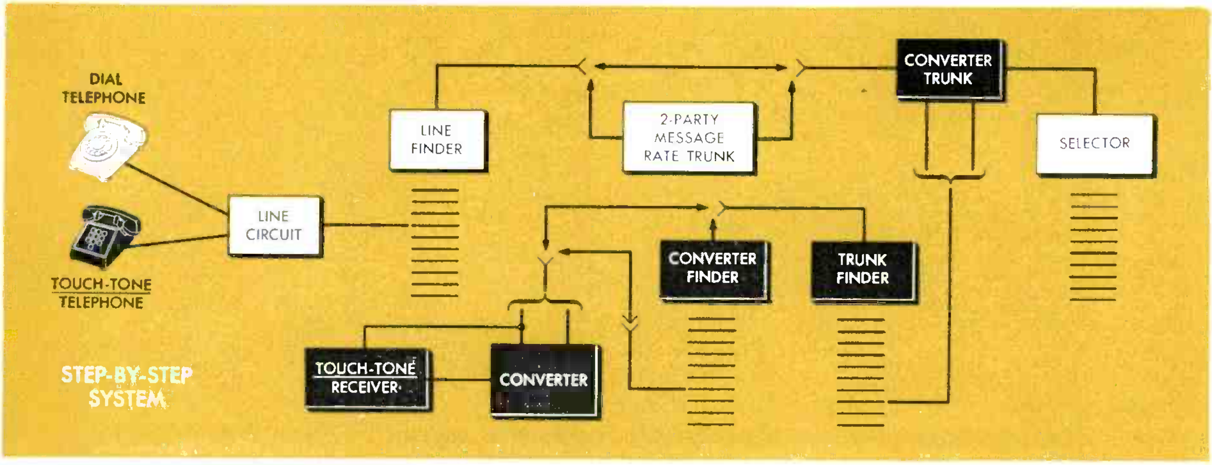
The progress of the communication industry is linked tightly to the area of research. From the principles of telephony discovered in a Boston laboratory nearly 90 years ago to the investigation of modern telephonic systems at Bell Laboratories, scientific exploration ultimately leads to the improvement of communication. It was this kind of research that opened up a new dimension in telephone dialing.

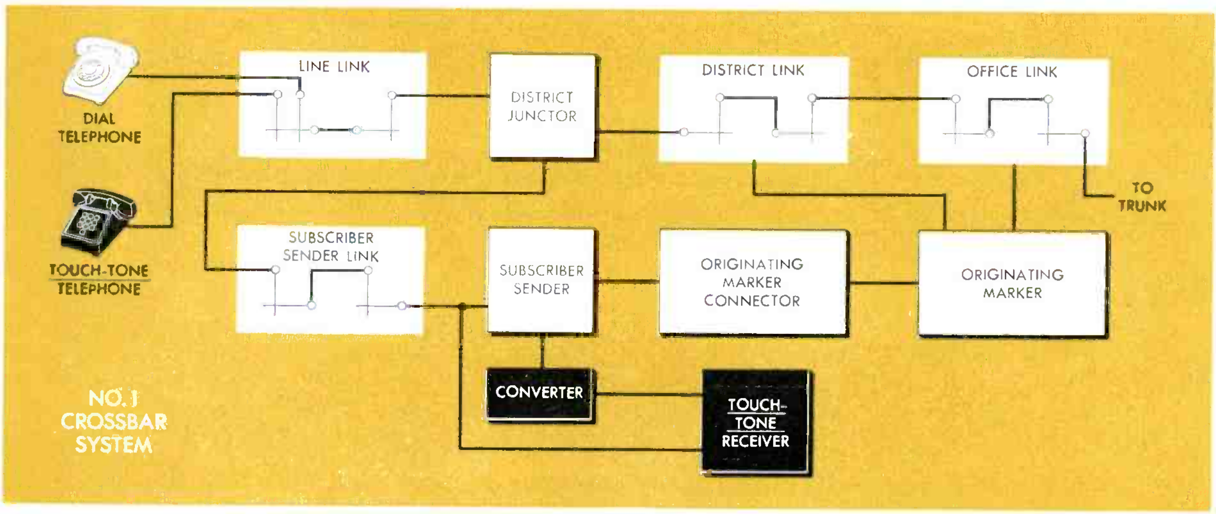
For 65 years, the rotary dial has been synonymous with automatic switching. Now we have progressed to the point where we can take advantage of preceding discoveries—such as the transistor—and develop an extremely rapid and efficient method of customer pushbutton signaling —TOUCH-TONE Calling. With TOUCH-TONE Calling, you can place a call in less than half the time it takes with a conventional dial. This increase in dialing speed anticipates the increasing demand of business, industry, and government for the faster transfer of information. At the most basic level, TOUCH-TONE Calling means a more convenient medium for the interchange of ideas.

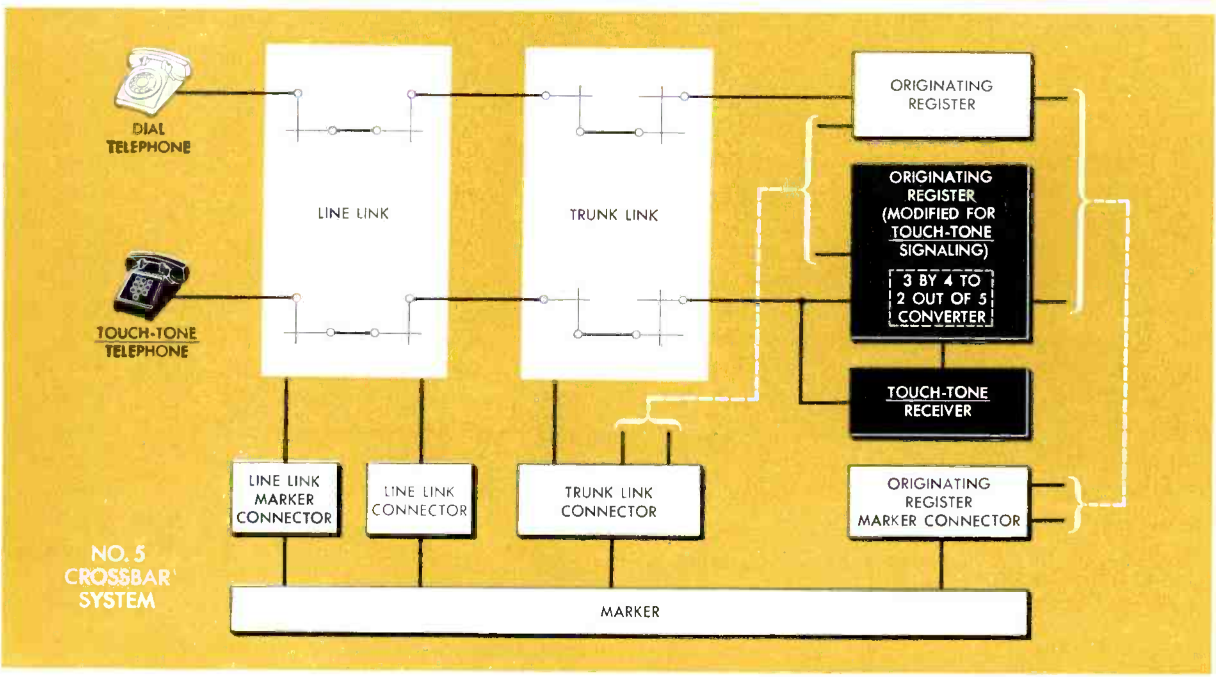
In 1940, the Bell System introduced a 10-button keyset with ac signaling, known as "two-out-of-five multifrequency signaling." This keyset was used by toll operators. Later, two-out-of-five multifrequency signaling was used to communicate between switching systems. In two-out-of-five systems, there are five frequencies in the voice range. Each digit—zero to nine—is assigned a combination of two of these frequencies. For special signals, a sixth frequency combines with one of the five digit frequencies.

Customer multifrequency signaling was not introduced at that time because it was impractical to provide an oscillator to generate the required tones from the telephone. Oscillators in 1940 were unsuitable because of cost and space factors and also because oscillators using vacuum tubes required a relatively long warm-up time.

The invention of the transistor at Bell Laboratories in 1948 was the breakthrough that made TOUCH-TONE Calling possible. Once the feasibility of the system was established, engineers began an investigation to determine the most suitable multifrequency system that could be used with a TOUCH-TONE telephone. The first


DIAL TELEPHONE
TOUCH-TONE TELEPHONE
LINE CIRCUIT
LINE FINDER
2-PARTY MESSAGE RATE TRUNK
CONVERTER TRUNK
SELECTOR
CONVERTER FINDER
TRUNK FINDER
TOUCH-TONE RECEIVER
CONVERTER
STEP-BY-STEP SYSTEM


DIAL TELEPHONE
TOUCH-TONE TELEPHONE
LINE LINK
DISTRICT JUNCTOR
DISTRICT LINK
OFFICE LINK
TO TRUNK
SUBSCRIBER SENDER LINK
SUBSCRIBER SENDER
ORIGINATING MARKER CONNECTOR
ORIGINATING MARKER
CONVERTER
TOUCH-TONE RECEIVER
NO. 1 CROSSBAR SYSTEM


DIAL TELEPHONE
TOUCH-TONE TELEPHONE
LINE LINK
TRUNK LINK
ORIGINATING REGISTER
ORIGINATING REGISTER (MODIFIED FOR TOUCH-TONE SIGNALING)
3 BY 4 TO 2 OUT OF 5 CONVERTER
TOUCH-TONE RECEIVER
LINE LINK MARKER CONNECTOR
LINE LINK CONNECTOR
TRUNK LINK CONNECTOR
ORIGINATING REGISTER MARKER CONNECTOR
MARKER
NO. 5 CROSSBAR SYSTEM

experimental TOUCH-TONE system used the two-out-of-five multifrequency signaling. Laboratories engineers, however, found that a three-by-four multifrequency system would be even better than the two-out-of-five.

The three-by-four system uses seven frequencies in the audio range: three in the high-frequency group (1209, 1336, 1477 cps) and four in the low-frequency group (697, 770, 852 and 941 cps). Each digit consists of a spurt of two superimposed frequencies: one from the high group and one from the low group. For example, the digit 8 consists of the frequencies 1336 and 852 cps (see tabulation on page 441).

Note that this plan includes two pairs of unassigned frequencies (1209-941 cps and 1477-941 cps). These "spare" frequency combinations permit pushbuttons to be added if special services are desired. The ten pushbuttons and the associated oscillator are built into the telephone in the space currently occupied by the dial.

A change in customer signaling necessitates a change in the customer's telephone and also a modification in the central-office equipment. To facilitate such a cutover, the central-office circuits must be modified to serve calls originating at either a dial or a TOUCH-TONE telephone. This will permit the change from dial to TOUCH-TONE Calling to be made for individual customers on a random basis.

In any type of central office modified to accept TOUCH-TONE signaling, one essential change is the addition of a TOUCH-TONE receiver (RECORD, *June,* 1961). This unit receives and identifies each digit—transmitted as tones—by a customer. Each pair of frequencies representing a valid digit signal causes the central-office receiver to connect a dc signal to one of the four low-group leads and to one of the three high-group leads. We refer to this type of connection as a three-by-four output. Each receiver operates in conjunction with a converter which converts the three-by-four output of the receiver signals to electrical pulses. These pulses actuate the register for the system.

In a No. 5 Crossbar office, the originating registers are divided into two groups; one group for TOUCH-TONE dial-pulse calls and the other for dial calls. Dial stations assigned to either group of registers will have access to only the registers in the assigned group. TOUCH-TONE stations, on the other hand, must be assigned to the modified group of registers and will have access only to the registers in that group. Each register in the modified group has a TOUCH-TONE receiver and a converter. These registers can serve customers who have either a dial or a TOUCH-TONE telephone.

When a customer with a dial telephone originates a call, he is connected through a line link and a trunk link to an originating register in the assigned group as shown on page 438. The register line relay responds to dial pulses as they are received. Counters in the register record the pulses of each digit and register the dialed digits on successive two-out-of-five code memory relays.

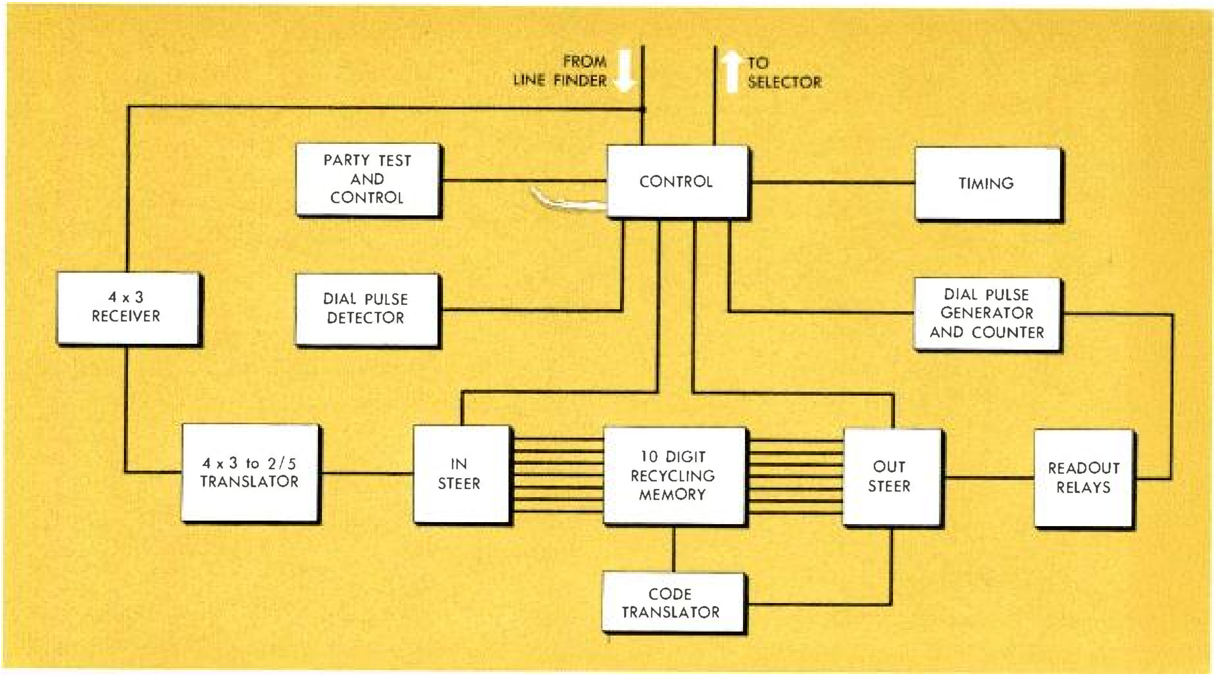
These diagrams show the modifications required for TOUCH-TONE *Calling at three types of central offices. The modified equipment is shown in black.*

Touch-Tone Operation

When a customer with a TOUCH-TONE set originates a call, he is connected through a line link and a trunk link to an originating register in the modified group of registers. A TOUCH-TONE receiver associated with the register translates the incoming digit frequencies to a three-by-four dc code and transmits this information to the converter. The converter then transforms the three-by-four signals to a two-out-of-five code and registers the keyed digits on the same memory relays used for originating dial calls. The originating register then transmits the digit information to the marker which sets up the call to a trunk which terminates in the called office.

In a No. 1 Crossbar office, a local call is registered on a crossbar switch in the subscriber sender. To simplify matters, we will consider only the switching of local calls; the same general arrangement, however, holds true for long distance calls. Since it is not feasible to divide the subscriber senders into two groups (as with No. 5 Crossbar offices), all senders of a No. 1 Crossbar office must be modified when the office is arranged for TOUCH-TONE Calling. When a customer originates a call through a No. 1 Crossbar office, he is connected through a line link and a sender link to a subscriber sender as shown on page 438. The subscriber sender has (1) a line relay connected to the ring conductor of the line, (2) a TOUCH-TONE receiver connected to the tip and ring conductors of the line, and (3) a converter connected between the receiver and the sender.

A call originated by a customer with a dial telephone causes the sender line relay to release and reoperate in synchronism with the number dialed. Counting relays in the sender count the pulses for each digit and register the successive digits on the crosspoints of a crossbar switch. A call originated by a customer with a TOUCH-TONE set causes the TOUCH-TONE receiving circuit



The converter for step-by-step translates information from multifrequency to dial pulse form.

to translate the incoming signal frequencies to a three-by-four dc code. The receiver transmits this information to the converter. The converter temporarily registers the keyed digits on two-out-of-five memory relays, converts the signals received from the TOUCH-TONE receiving circuit to corresponding dial pulses, and pulses the keyed digits into the subscriber sender. The subscriber-sender counting relays then count the dial pulses as they are received from the converter and register the keyed digits on the crossbar switch.

Calls from both dial pulse and TOUCH-TONE telephones use the same sender counting relays and crossbar switch. The tone signals must be converted to dial pulses because of the dial-pulsing requirements of the auxiliary sender.

When a customer places a call through a panel office, he is connected through line finder and district selector and a sender link to a subscriber sender. The method for registering the keyed digits in the sender is similar to the arrangement used in the No. 1 Crossbar system in that the digits are temporarily stored in the converter and then pulsed into the sender. In this case, however, the converter has a line relay which controls the line relay in the sender. With a dial-pulse call, the line relay in the converter follows the dial pulses from a customer dial and controls the line relay in the sender. The sender, in turn, repeats these pulses to the counting and register circuit.

With a TOUCH-TONE call, the line relay in the converter remains operated throughout the dialing period, and the dial pulses from the converter cause the line relay in the sender to follow these pulses. In the panel system, the digits are registered on register relays or on rotary switches, depending on the type of sender involved.

In step-by-step offices, customer lines in groups of 200 are served by a common group of 20 or less line finders. Only those line groups with one or more TOUCH-TONE Calling customers need be modified for operation with TOUCH-TONE signaling. Thus, by assigning the TOUCH-TONE customers to selected line groups, the central-office modification may be made in easy stages.

A simple converter trunk circuit is inserted between each line finder and first selector in a modified group. This trunk recognizes the beginning of a new call and proceeds to connect a TOUCH-TONE receiver and converter to the originating customer's line for use during the signaling interval as shown on page 438. The converter trunks appear on the bank terminals of trunk finders which, in the smaller offices, are connected directly to a receiver and converter circuit. The trunk finder hunts for and connects to the converter trunk associated with the calling customer. In the larger offices, each trunk finder is connected to a converter finder which hunts for and connects to an idle receiver and converter circuit. For greater efficiency, this arrangement provides a large number of converter trunks with access to a common pool of converters.

When a customer in a modified line group originates a call, the line finder starts a trunk finder hunting for the associated converter trunk. While the line connection to the converter is being established, a closed loop is maintained from the telephone to the first selector. After the connection to the converter is established, the line connection is split so that the telephone set is connected to a supervisory relay in the converter, and the selector is held operated under control of the converter. If a customer places a call from a dial telephone, the pulses of the first digit are transmitted by the supervisory relay to the selector, and the converter releases during the interval between the first and second digits. The remainder of the digits are handled as a dial call is handled in unmodified line groups.

When a TOUCH-TONE Calling customer originates a call, the receiver translates the multifrequency signals to dc signals and transmits them to the converter. The converter translates the three-by-four code of the station signaling system to a two-out-of-five code for storage on memory relays. The converter then pulses the digits to the central-office equipment, and, when the last digit is outpulsed, the converter releases.

As mentioned previously, in crossbar and panel offices the TOUCH-TONE receiver and converter are connected to a register or sender. These common-control circuits supervise the progress of the call by recognizing various telephone conditions such as connect, disconnect, and dialing. In the case of a "permanent signal," where the customer fails to dial, or a "partial dial," where the customer fails to dial a complete number, these circuits time-out and route the call for corrective action. They also measure the time required to complete various work functions, such as outpulsing, and bring in suitable audible or visual alarms if the time is too great. Step-by-step offices do not have these common-control circuits, and therefore the converter must be provided with some additional features as shown on page 440.

By examining the first few digits stored on the memory relays, the converter provides a modest amount of code translation to determine how many additional digits to expect on a call so that the converter may be released as quickly as possible. This minimizes converter holding-time and results in an over-all saving in equipment.

Timing of work functions, partially dialed calls, and permanent signals reduces converter holding-time and gets the converters back into service with a minimum of delay. If a converter fails to complete a work function within the allotted time, the customer receives a busy-tone signal and the converter is released. There are also arrangements for automatically holding this circuit out of service for maintenance, if desired. If the converter fails to receive the correct number of digits for a call, it times out and releases. For a permanent signal condition, the converter pulses a predetermined code before releasing so that the line may be connected to a permanent signal-holding trunk for tracing. In offices arranged for automatic number identification (ANI), the converter makes a party test of the calling line to determine which customer on a two-party line originated the call, and it transmits this information to the ANI equipment for charging purposes.

The introduction of TOUCH-TONE receivers and converters in central offices necessitates the addition of facilities for testing the capabilities and proper operation of these units. The originating register test circuits in the No. 5 Crossbar and the automatic sender test circuits in the No. 1 Crossbar and panel offices are modified to include these testing facilities. A new test circuit, consisting of a frame-mounted unit and a portable test set, is available for step-by-step offices. The test set may be connected directly to the equipment or connected through a "belt line" of jacks located near the receivers and converters. Central-office maintenance of receivers will be limited to determining whether a receiver is faulty. If so, central-office personnel replace it with one known to be in good condition. For this reason, the receivers are "plug-in" units.

Field trials to check both customer and equipment performance. of TOUCH-TONE signaling were made at a No. 5 Crossbar office at Hagerstown, Md. and at a step-by-step office at Roanoke, Va. At these trials, TOUCH-TONE calls were checked against dialed calls for customer speed, accuracy, and equipment performance. The trial results were satisfactory, and the customer reaction was favorable to TOUCH-TONE Calling.

DIGIT FREQUENCY ASSIGNMENTS

Low-Group Frequencies (cps)	High-Group Frequencies (cps)		
	1209	1336	1477
	DIGITS		
697	1	2	3
770	4	5	6
852	7	8	9
941		0	

Handling small parts during assembly is a tedious operation. Now, a simple method for assembling tiny needles for B Cable Clips promises to save both time and money.

C. F. Kodey

Automated Handling of Pins For B Cable Clips

Telephone field forces frequently encounter situations where two sides of a cable pair must be temporarily connected, as in maintaining service continuity during cable splicing operations. The B Cable Clip, consisting simply of two clip assemblies and an interconnecting cord, was designed to fill these requirements.

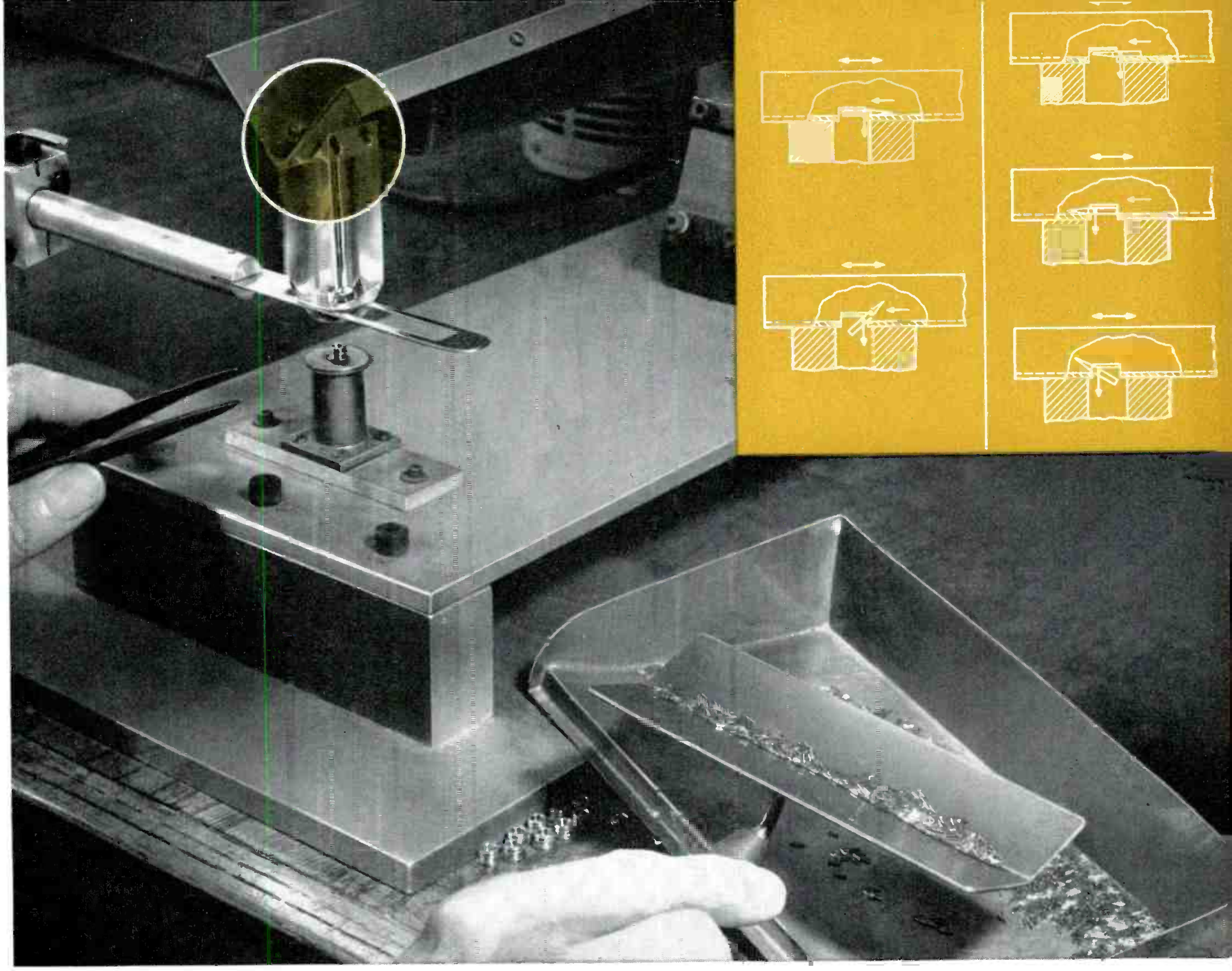
The clip assemblies are furnished with two removable cuplike inserts in which 19 needle-pointed pins are soldered. When the clip is used, these pins pierce the paper insulation and make electrical contact with the conductor.

Each pin is 0.028 inch in diameter and 0.150 inch long. In the early stages of development of the clip, it became evident that the assembly of such short pins in the cup by the usual hand methods would be overly expensive. Therefore, a method has been developed to permit assembly of the insert without manual handling of the pins or other individual treatment.

The problem was solved in three parts: (1) separation of the 19 pins required from a bulk supply, (2) orientation of the pins so that their points are up, and (3) delivery of the pins, in a group, to the cup. During assembly operations, a batch of more than 19 pins is scooped up from a supply bin. The scoop is then agitated gently, and a pin drops into each of 19 cavities formed in the bottom of the scoop. The excess pins roll from the ends or the front of the scoop as it is being agitated. The 19 pins are then dumped into a chute where they are to be oriented point up.

The orientation method depends on the difference between the center of gravity of the pin and the midpoint of its length. This difference results because the pin has a conical point; thus, its center of gravity is displaced by 0.0175 inch toward the butt end. The orientation device uses this property as shown in the drawing on page 443. The pins slide along a v-shaped chute, until they come to a rectangular slot cut in it, with a tube attached directly under the slot. A vibrator attached to the chute moves the pins in the chute toward the slot.

Any given pin in the chute must be facing either point or butt first as it approaches the slot. The left column of views in the diagram shows a pin reaching the slot butt first. The center of gravity of the pin passes the right edge of the slot before the pin completely spans



Equipment for assembling cup inserts for B Cable Clips. Inset shows method of orientation, which takes advantage of variation in center of gravity from center of symmetry to position pins point up.

the slot, and the pin falls butt first into the tube. The right column of views shows a pin reaching the slot with its point first. Here, the pin spans the slot before its center of gravity passes the right edge of the slot. This pin therefore continues its motion to the left until the butt end loses support. Again, the force of gravity causes the pin to fall in the tube butt first.

The diameter of the tube and of the cup into which the nineteen pins fit is smaller than the length of a pin. Therefore, they cannot reverse themselves end for end once they are properly oriented in the tube. It was found however, that the pins could not be delivered directly into the cup, because invariably, one or two of the first few that dropped into the cup would lean against the wall, preventing the rest of the pins from properly settling in place. To correct this, the pins are intercepted in the tube by a thin, slotted diaphragm immediately above the cup. This diaphragm is slowly oscillated, so that its slotted section is in line with the tube. When a pin in the tube tends to lean, part of the butt end of the pin engages one of the slots and the motion of the diaphragm erects the pin. The butt of any pin that is upright does not engage the slots. When the last pin of the group has fallen into the tube and all 19 pins are arranged vertically in a group, the diaphragm is shifted so that a hole in the diaphragm lines up with the tube. The group of pins then drops into the cup as a unit on top of a preformed solder disk. Cup, pins, and solder disk are then removed for soldering. The complete machine for assembling B Cable Clip inserts is shown above.

With this orientation method, the time required to complete a needle-cup assembly has been reduced to about one-fifth that required by hand methods, with commensurate savings in manufacturing costs.

A Laboratories scientist recently announced he's been listening to speech and music in auditoriums that don't exist. He has not been hearing imaginary sounds, however; he has been using a computer to simulate what happens to sound waves as they bounce around imaginary rooms.

Computer Simulates Auditorium Acoustics

A method for simulating the acoustics of concert halls and auditoriums in an electronic digital computer has been devised at the Laboratories by M. R. Schroeder of the Visual and Acoustics Research Laboratory. With this new technique, the acoustics of a proposed auditorium can be listened to and evaluated before the hall is actually built. The architectural design can be modified, if necessary, and a final plan drawn up which will ensure that the completed auditorium will be acoustically satisfactory.

News of Acoustics Research

The method of simulating in a computer the transmission of sound waves in rooms was explained by Mr. Schroeder at a meeting of the Acoustical Society of America last month. Starting with an architectural plan drawing of a proposed concert hall, Mr. Schroeder selects a point on the stage and then draws major paths that sound waves would take between this source and a typical seat in the audience. He draws one-bounce and multi-bounce reflections from the walls and ceilings as well as a direct path. He then calculates the time it takes a sound impulse to travel over these various paths from source to listener and computes, by the usual methods known to acousticians, the reverberation time of the hall.

This information is stored in the computer, along with a program which instructs the computer to treat any sound which is put into the computer the same way the auditorium would treat the sound on its way between the source (on the stage) and the listener's ears. Then a sample of speech or music is recorded on digital magnetic tape which is fed to the computer. The computer acts on these sounds (actually, patterns of tiny magnetized spots on the tape) just as the floor, walls, and ceiling, of the auditorium would and produces an output tape, also in digital form. The output tape is fed to another machine which converts the digital information into an analog multi-track sound tape suitable for playing on a multi-channel tape recorder playback. This tape is played over several loudspeakers in Bell Laboratories anechoic chamber—a free-space room which doesn't add echoes and reverberations of its own. The sound has the necessary echo delays, amplitude variations and directionality to give a good stereophonic resemblance to an actual hall.

The listener decides, on the basis of what he hears, whether the simulated room has good or bad acoustics. By changing the computer program the acoustic characteristics of the simulated hall can be modified. Architects and acousticians who are not familiar with computer programming can make use of the technique by employing a special translator program which was devised at the Laboratories at an earlier date.

Mr. Schroeder explained that in addition to designing new concert halls, computer simulation can be used to improve the acoustics of existing halls. The computer can be programmed to simulate the effect of minor architectural changes on the acoustic characteristics of the hall. The tape from the computer is played over loudspeakers set up in the hall and the proposed changes evaluated before renovations are begun. In the hall itself, reverberations can be controlled by wall materials and covering that will absorb sound energy.

Where undesirable acoustics cannot be eliminated except by expensive construction changes, it is often possible to change the acoustics of halls by adding loudspeakers (as imaginary walls). For example, the Arnold auditorium at Bell Laboratories was designed for speech and has a very good reputation for that purpose. However, it is too "dry" for music—that is, the reverberation time is too short. Mr. Schroeder proposes to install an electrical sound system which will add artificial reverberation to the room.

He has simulated several different artificial reverberation schemes in a computer and the computer has generated tape recordings of music with artificial reverberation added. Listening to these recordings over loudspeakers in the auditorium will aid him in choosing an optimum design. Mr. Schroeder's current research in which he uses computers to simulate room acoustics stems from his previous research in artificial reverberation and room acoustics. Such research is very useful to the Bell System in developing new types of telephone equipment and in carrying radio and television programs around the nation.

M. R. Schroeder listens to music coming from loudspeakers suspended in Bell Laboratories anechoic chamber. In this way, he can evaluate the acoustics of proposed auditoriums before they are built.

A new method has been found to make quartz crystal resonators suitable for use in high temperature environments. These specially prepared crystals will resonate stably despite temperature changes in the environment.

High Temperature Resonators Made from Electrolyzed Quartz

A method of treating quartz which makes it suitable for use as a crystal resonator at temperatures higher than ever before possible has recently been devised at Bell Telephone Laboratories. J. C. King of the Solid-State Device Laboratory has found that major causes of energy absorption at high temperatures can be removed from a quartz crystal by subjecting it to electrolysis. He also has found that an electrolyzed quartz crystal can be made to resonate very stably in this higher temperature range if it is cut at a higher orientation angle than previously thought practical.

News of Solid-State Development

The frequency at which a quartz crystal resonate depends primarily upon its dimensions and temperature. To obtain a very constant frequency from a crystal a very constant temperature must be maintained. This is often quite difficult to do, particularly at high temperatures. Fortunately, a quartz crystal can be cut in such a way that it will have an optimum operating temperature, at which slight temperature deviations will not result in very great frequency change. A plot of resonant frequency versus temperature for such a crystal would show that as temperature is increased, the crystal's resonant frequency changes rapidly, until a temperature is reached at which the direction of change suddenly reverses. Right at this "turn-over" point slight changes in temperature, either higher or lower, will not cause very large changes in frequency.

The temperature at which the turn-over point of a resonator occurs depends primarily upon the angle at which it is sliced from a single crystal of quartz. For example, a wafer cut at an angle 35 degrees 25 minutes to the optical axis of the crystal will maintain a resonant frequency within one cycle in 100 million if kept within one degree of 70 degrees C. In general, the higher the angle of cut, the higher the temperature at which the turn-over point occurs. It has been generally thought that turn-over points occur only in the temperature range under 250 degrees C. Ordinary quartz absorbs so much energy of vibration at higher temperatures that precise measurements cannot be made. Hence, up to now it has been exceedingly difficult to investigate the possibility of higher turn-over points.

Recently, Mr. King impressed an electric field of about 500 volts per centimeter across a quartz crystal for a period of about 24 hours at a temperature of 500 degrees C. This caused impurities such as sodium and lithium to be swept out of the crystal. He discovered that as a result of this electrolysis quartz retains its ability to vibrate with little energy dissipation, even when used at temperatures as high as 550 degrees C.

The availability of a high Q (low loss) crystal at high temperatures encouraged Mr. King to look for turn-over points at temperatures in this higher range. He studied various crystal wafers cut from blocks of electrolyzed quartz at angles of rotation (from the optical axis) greater than 38 degrees. He found that quartz did indeed exhibit turn-over points at various temperatures from

J. C. King places quartz crystal in furnace for electrolysis treatment. Wafers cut from quartz are used as frequency control resonators at temperatures higher than possible with ordinary quartz.

300 degrees C to 535 degrees C, depending upon the angle of cut.

The discovery of high temperature turn-over points (which permit stable frequency operation) and the effect of electrolysis of quartz (which increases the Q of quartz at high temperatures) make possible the fabrication of treated quartz resonators for use in high temperature environments. This suggests another application.

When ordinary quartz is exposed at room temperatures to ionizing radiation such as x-rays, its resonant frequency is altered. The crystal can be restored to its initial frequency by annealing it at 400 degrees C or more for a few minutes. On the other hand, electrolyzed quartz can be exposed to ionizing radiation without incurring frequency changes because of the high temperatures at which it can be operated. At these high temperatures, there is a continuous annealing-out of the ionization effects. Thus, it is feasible to operate these electrolyzed quartz resonators in the gamma ray environment of nuclear reactors or in satellites which must traverse the Van Allen belts.

Electrolyzed quartz also will be very useful in piezoelectric devices in high temperature environments, such as near heat engines, or perhaps in missiles where it is difficult or costly to maintain moderate temperatures.

Silicon Crystals in "Ribbon" Form

A new form of silicon crystals which may have important implications for semiconductor devices has been discovered at Bell Laboratories. E. S. Greiner, J. A. Gutowski and W. C. Ellis of the Metallurgical Research Laboratory have succeeded in growing from silicon vapor "ribbons" which are so thin they are semi-transparent. Typically about 1 micron thick, the silicon ribbons are near-perfect crystals. Their mechanical properties resemble those of the ultra-strong "whiskers" first reported by the Laboratories several years ago (RECORD, *November*, 1954).

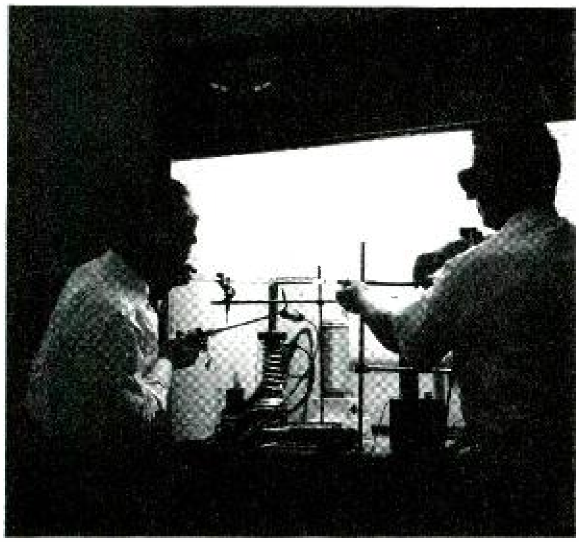
News of Metallurgical Research

The process for making silicon ribbons was described last month at a meeting of the Metallurgical Society of the American Institute of Electrical Engineers in Detroit. In the process, silicon is reacted with iodine and hydrogen, and with small amounts of arsenic and nickel, at high temperatures in a closed tube. The ribbons, plus silicon whiskers with a hexagonal cross-section, grow rapidly in the hot tube.

The ribbons vary from 0.1 to 15 microns in thickness, are about 0.1 millimeter wide, and are from one to three centimeters long. They contain few or no crystal defects except for a single twin plane (junction in mirror-image crystals) parallel to the ribbon surface. Because of their crystalline perfection, the ribbons are very strong mechanically. They are also quite flexible because they are extremely thin.

A single twin plane in all the ribbons observed is a central feature of a theory developed by R. S. Wagner and R. G. Treuting, also of the Metallurgical Research Laboratory, which explains some of the main mechanisms of ribbon growth. According to the theory, the twin plane, together with what appears to be a growth "poisoning" effect of certain impurities, causes the crystal ribbon to grow very rapidly in length but relatively slowly in width and thickness. The crystal ribbons are quite uniform and have a nearly perfect surface. These properties would make it possible to incorporate them directly into semiconductor devices with little or no mechanical preparation.

The Laboratories scientists emphasized that considerable development would be required before the ribbon process could be used in commercial devices. However, control of impurities at desired levels will permit a number of potential applications. For example, using the ribbons for piezoresistive strain gages appears promising because, being extremely thin and flexible, they can accurately follow elastic strains in materials to which they are bonded.



E. S. Greiner, left, and J. A. Gutowski seal the quartz tube in which silicon ribbons are grown.

At the right they remove tube from furnace to examine the growth of the ultra-thin ribbons.

news in brief

A. C. Peterson and E. I. Green Honored

A. C. Peterson, Head of the Radio System Engineering Department at the Laboratories, and E. I. Green, retired executive vice president, were given special awards by the Institute of Radio Engineers during the Seventh National Communications Symposium in Utica, New York last month.

Mr. Peterson was presented with the Professional Group on Communications Systems Special Award "for his leadership and guidance as national chairman of the Professional Group on Communications Systems 1955-1956." It was during Mr. Peterson's chairmanship that the Rome-Utica chapter sponsored its First National Communications Symposium.

At the same meeting, E. I. Green was given the Professional Group on Communications Systems Achievement Award in recognition of "outstanding contributions to the sciences and techniques of communications systems." The purpose of this award is to "honor a member of the Professional Group on Communications Systems who has made outstanding contributions to the field of interest of the group."

Former Labs Official Elected AT&T Vice President

Richard R. Hough has been elected a Vice President of American Telephone and Telegraph Company. He will be in charge of engineering for the company.

Mr. Hough has been Operating Vice President of Ohio Bell Telephone Company for the last two years. A native of Trenton, N. J., he joined Bell Laboratories in 1940 after receiving an electrical engineering degree at Princeton University.

R. R. Hough

During the next 17 years his work at the Laboratories centered on the development of military weapon systems. In 1957 he was elected Vice President of the Laboratories and later that year was transferred to A.T.&T. where he was named Assistant Chief Engineer.

New Program To Safeguard Country's Technological Supremacy

The Employer's Inventory of Critical Manpower, a new program endorsed and supported by the Director of Selective Service, which is directed to the effective utilization of engineering and scientific manpower in the event of a national emergency, was announced jointly by S. B. Ingram, Chairman of the Engineering Manpower Commission and Bell Laboratories Director Technical Employment, and Colonel Daniel O. Omer, Deputy Director of Selective Service.

Mr. Ingram said that "present safeguards are inadequate to prevent wholesale withdrawal of engineering and scientific manpower from industry in a national emergency. The increasing importance of technological manpower in the event of armed conflict demands maximum utilization of engineering and scientific personnel whether in industry or in the armed services.

"The Employer's Inventory of Critical Manpower, developed by the Engineering Manpower Commission of Engineers Joint Council and the Scientific Manpower Commission is an attempt to aid in the solution of this problem in the national interest," Mr. Ingram said.

Briefly, the Inventory program supplies condensed information on critical employees liability to the draft and shows what will happen to a given company during mobilization. It identifies the balance between critical and non-critical personnel subject to military service, and indicates a probable order of call to the armed services during an emergency. It also gives employers and Selective Service a complete analysis of critical personnel problems through the collection and tabulation of relevant Selective Service data.

Laboratories Honored By Physics Institute

Bell Telephone Laboratories was one of sixteen organizations in the United States that received silver anniversary certificates from the American Institute of Physics on September 29. The awards were made in recognition of the various organizations' support of the objectives and program of the Institute over the past quarter of a century.

Dean Ralph A. Sawyer of the University of Michigan, Chairman of the governing board of the Institute, made the presentations at the annual meeting of Corporate associates of the Institute of Arden House of Columbia University. Among the other organizations receiving the award were the Massachusetts Institute of Technology, E. I. duPont de Nemours Company, General Electric Company, and Eastman Kodak.

Goldey, J. M., *Integrated Semiconductor Circuits*, AIME Semiconductor Conf., Los Angeles, Calif.
Gossard, A. C., Jaccarino, V. and Wernick, J. H., *Nuclear Magnetic Resonance in Rare Earth Intermetallic Compounds*, International Conf. on Magnetism and Crystallography, Kyoto, Japan.
Grieco, M. J., see Miller, K. J.
Grunwald, E. and Meiboom, S., *Fast Proton Exchange Reactions in Buffered Solutions in Methyl Alcohol*, Am. Chem. Soc., Chicago, Ill.
Gummel, H. K., see Smits, F. M.
Hansen, R. H., *The Mechanism of Efficient Production of Fine Cells in the Extrusion of Expanded Polymeric Compositions*, Soc. of Plastics Engineers Symposium, Buffalo, N. Y.; Soc. of Plastics Engineers, Regional Tech. Conf. on Plastics Foams, Buffalo, N. Y.
Jaccarino, V., see Gossard, A. C.
Jaccarino, V., see Walker, L. R.
Javan, A., *A CW Optical Frequency Oscillator Using a Gaseous Discharge*, National Elec. Conf., Chicago, Ill.
Johnson, D. A., see Sheldon, H. E.
Johnson, G. R., see Turner, D. R.
Keller, J. D. R., see Sheldon, H. E.
Kossman, W. H., *Educational Programs at Bell Telephone Laboratories, Inc.*, Tech. Drawing Associates, Urbana, Ill.
Kostkos, H. J., *Progress in Satellite Communications*, Baltimore Section, Am. Soc. of Mech. Engineers, Baltimore, Md.; Baltimore Section, Am. Inst. of Elec. Engineers, Baltimore, Md.
LeCraw, R. C., *Relaxation of the Uniform Precession in Ferromagnetic Resonance*. Conf. on Magnetism and Crystallography, Kyoto, Japan.
Levinson, J., *Low-Pass and Inhibitory Mechanisms in Human Vision*, International Biophysics Cong., Stockholm, Sweden.
Light, T. B., *Imperfections in Germanium and Silicon Epitaxial Films*, AIME Conf. Los Angeles, Calif.
Linares, R. C., *The Growth of Yttrium Iron Garnet Crystals from Molton Barium Borate*, Basic Science Div., Am. Ceramic Soc., Schenectady, N. Y.
Long, T. R., *A Discussion of Electrodeposited, Cylindrical Film Memory Elements*, Am. Electrochem. Soc., Detroit, Mich.
Lundberg, J. L., *Diffusivities and Solubilities of Gases in Polymers*, Phys. Chem. Seminar, Polytechnic Inst. of Brooklyn, N. Y. C.
MacRae, A. U., *Low Energy Electron Diffraction Studies of Nickel Surfaces*, Phys. Colloq., Syracuse Univ., Syracuse, N. Y.
Maguire, D. A., see Sheldon, H. E.
Manz, R. and Miller, K. J., *Epitaxial Silicon Thin Films*, Electrochem. Soc. Meeting, Detroit, Mich., Oct. 3, 1961.
McAfee, K. B., Jr., see Edelson, D.
McLaughlin, J. W., see Courtney-Pratt, J. S.
Meiboom, S., *NMR Spin-Echo Techniques in the Measurements of Reaction Rates*, Conf. on Experimental Techniques for Studying Very Fast Reactions in Solutions, Madison, Wis.
Meiboom, S., *NMR Study of the Rates of Ring Inversion of Cyclic Paraffins*, Am. Chem. Soc., Chicago, Ill.
Meiboom, S., see Grunwald, E.
Meyers, S. T., *An FM Data Set for Serial Transmission up to 1600 Bits Per Second*, AIEE, Detroit, Mich.
Miller, K. J. and Grieco, M. J., *Epitaxial Silicon-Germanium Alloy Films on Silicon Substrates*, Electrochem. Soc. Meeting, Detroit, Mich., Oct. 3, 1961.
Miller, K. J., see Manz, R.
Moest, R. R. and Shupp, B. R., *Vapor Phase Growth of GaAs and GaP*, Electrochem. Soc., Detroit, Mich.
Morrison, J. A., see Edelson, D.
Olson, H. M. and Von Ohlsen, L. H., *The Coaxial Magnetron; A Superior Microwave Power Source*, WESCON, San Francisco, Calif.
Pascale, J. V., see Russell, C. A.
Rider, D. K., *Adhesives in Printed Circuit Applications*, Ordnance Corps, Symposium on Adhesives, Dover, N. J.
Robin, M. B., *The Color and Electronic Configurations of Prussian Blue*, Am. Chem. Soc., Chicago, Ill.
Rogers, C. E., *The Effect of Association of the Propagating Ion-Pair on Polyisoprene Microstructure*, Am. Chem. Soc., Chicago, Ill.
Ross, I. M., *Reliability of Components for Communication Satellites*, U.R.S.I. Symposium on Space Communication Research, Paris, France.
Russell, C. A. and Pascale, J. V., *The Early Stages of Isotactic Polypropylene Oxidation*, Am. Chem. Soc., Chicago, Ill.
Saari, V. R., *Feedback, Stability and Transients in Solid-State Low Frequency Amplifiers*, National Elec. Conf., Chicago, Ill.
Salovey, R., *Irradiation on Crystalline Polyethylene*, Am. Chem. Soc., Chicago, Ill.
Saltzberger, B. R., see Becker, F. K.
Schramm, E., see Courtney-Pratt, J. S.
Schreiber, H., Jr., *X-ray Emission Excitation*, Workshop on X-ray Emission Spectrochem., Stevens Inst. of Tech., Hoboken, N. J.
Schnettler, F. J., *Magnetic Ferrites and Garnets*, Am. Chem. Soc., Chicago, Ill.
Schramm, C. R., see Sheldon, H. E.
Schroeder, M. R., *Further Progress with "Colorless" Artificial Reverberation*, Audio Engg. Soc., N. Y. C.
Schroeder, M. R., *Improvement of Feedback Stability of Public Address Systems by Frequency Shifting*, Audio Engg. Soc., N. Y. C.
Sessler, G. M., *Condenser Earphones with Solid Dielectric*,

Audio Engg. Soc., N. Y. C.

Sheldon, H. E., Keller, J. D. R., Maguire, J., Johnson, D. A., and Schramm, C. R., *Introduction to Supervision*, Office Exec. Assoc. of N.Y., N. Y. C.

Shepard, R. N. and Chang, J., *Stimulus Generalization in the Learning of Classifications*, Eastern Psychological Assoc., Philadelphia, Pa.

Shepard, R. N., *Multidimensional Analysis of Rank Ordered Similarities*, Psychonomic Soc., N. Y. C.

Shupp, B. R., see Moest, R. R.

Shulman, R. G., see Sugano, S.

Slichter, W. P., *Nuclear Magnetic Resonance Studies of Polymers*, Dept. of Chem., Northwestern Univ., Evanston, Ill.

Smits, F. M., Gummel, H. K. and Froiland, A. G., *Terrestrial Determination of Solar Cell Short Circuit Current Under Outer Space Illumination*, WESCON, San Francisco, Calif.

Stillinger, F. H., see Frisch, H. L.

Sugano, S. and Shulman, R. G., *Studies of Covalency Effects in the $KNiF_3$ Crystal*, International Conf. on Magnetism and Crystallography, Kyoto, Japan.

Thomas, C. O., see Basseches, H.

Townsend, R. L., *Some Error Characteristics of a Data Communication System*, AIEE, Detroit, Mich.

Tukey, J. W., *Keeping Research in Contact with the Literature*, Am. Chem. Soc., Chicago, Ill.; IRE, Philadelphia, Pa.

Tung, S. K., see Basseches, H.

Turner, D. R. and Johnson, G. R., *The Effect of Some Addition Agents on the Kinetics of Copper Electrodeposition from a Sulfate Solution*, Electrochem. Soc., Detroit, Mich.

Von Ohlsen, L. H., see Olson, H. M.

Wagner, R. S., *Factors Influencing Dendritic Growth in Germanium*, Conf. on Elemental and Compound Semiconductor, Boston, Mass.

Walker, L. R., Wertheim, G. K., and Jaccarino, V., *The Isomer Shift in Fe^{57}*, International Conf. on Magnetism and Crystallography, Kyoto, Japan.

Weber, J. H., *Some Traffic Characteristics of Communications Networks with Automatic Alternate Routing*, Third International Teletraffic Congress, Paris, France.

Wernick, J. H., see Gossard, A. C.

Wertheim, G. K., see Walker, L. R.

Wertheim, G. K., *The Magnetic Properties of Divalent and Trivalent Iron in Cobalt Oxide*, Second International Conf. on The Mossbauer Effect, Saclay, France.

Wertheim, G. K., *Nuclear Resonant Gamma Ray Absorption in Ferrocene*, Second International Conf. on the Mossbauer Effect, Saclay, France.

West, J. E., see Sessler, G. M.

Wilkinson, R. I., *An Exploration of Some Methods for Administering Final Groups in Alternate Route Systems*, Third International Teletraffic Cong., Paris, France.

Williams, I. V., *Standards and Specifications—Guide to Mutual Understanding*, Magnesium Assoc., N. Y. C.

Wood, D. L., *Electronic Spectra of Ions in Garnets*, Symposium on Ligand Field Theory, Am. Chem. Soc., Chicago, Ill.

Wolfe, R., *Thermoelectric Semiconductors*, Metropolitan New York Section of the Am. Ceramic Soc., Pompton, N. J.

PATENTS

Following is a list of the inventors, titles and patent numbers of patents recently issued to members of the Laboratories.

Anderson, J. R.—*Ferroelectric Circuits*—3,005,976.

Anderson, O. L. and Christensen, H.—*Thermo-Compression Bonding of Metal to Semiconductors, and the Like*—3,006,067.

Anderson, O. L., Andreatch, P., Jr. and Christensen, H.—*Twist-Compression Bonding of Metallic and Metallized Surfaces*—3,006,068.

Andreatch, P., Jr., see Anderson, O. L.

Andrews, H. W. and Harkless, E. T.—*Traveling Field Sampler*—3,007,123.

Beurrier, H. R.—*Selecting Circuit*—3,003,143.

Brown, J. T. L.—*Electrically Controlled Switching Device*—3,005,072.

Broyer, A. P.—*Equipment for Automatically Producing Printed Inductor Photographic Masters*—3,004,469.

Coleman, S. B. and Williams, D. S.—*Squelch Circuit*—3,004,156.

Christensen, H., see Anderson, O. L.

Christensen, H., see Anderson, O. L.

Chynoweth, A. G.—*Irradiation of Monoclinic Glycine Sulphate*—3,005,096.

Cutler, C. C.—*Traveling-Wave Tubes*—3,005,126.

DeGrasse, R. W. and Schulz-DuBois, E. O.—*Traveling-Wave Solid-State Masers*—3,004,225.

Dickieson, A. C.—*Electron Discharge Device Switching System with Automatic Voltage Compensation*—3,004,223.

Dickieson, A. C.—*Control Circuit*—3,004,508.

Engelbrecht, R. S.—*Antenna with Electrical Lobing*—3,007,165.

Fox, W. M.—*Fabrication of Semiconductor Devices*—3,005,257.

Geller, S.—*Ferrimagnetic Garnet*—3,006,854.

Geller, S.—*Ferrimagnetic Garnets*—3,006,855.

Geyling, F. T.—*Self Realigning Waveguide Support System*—3,007,122.

Goodale, W. D., Jr., and Pferd, W.—*Transistor Oscillator Identifier for Communication Systems*—3,004,105.

Harkless, E. T., see Andrews, H. W.

Haring, H. E.—*Manufacture of Silver Chloride Electrodes*—3,006,821.
Herriott, W.—*Electro-Optical System*—3,006,234.
Jaeger, R. J., Jr.—*Line Switching and Control System*—3,005,874.
Joel, A. E., Jr.—*High-Speed Signaling System Using Magnetic Storage*—3,004,108.
Ketchledge, R. W.—*Electron Multiplier Tube Circuits*—3,003,065.
Ketchledge, R. W.—*Telephone Switching Circuit*—3,005,876.
King, D. H.—*Telephone Booth*—D-191,661.
Koenig, W., Jr.—*Telautograph System*—3,005,050.
Low, F. K.—*Pulse Transmitting and Receiving Circuit*—3,004,106.
MacNair, D.—*Hydrogen Breakdown of Cathodes*—3,004,816.
Mason, W. P. and Thurston, R. N.—*Electromechanical Transducers*—3,004,176.
Mattke, C. F.—*Tilting Dial Circuit Selector*—3,005,055.
Mendizza, A.—*Anodizing Method*—3,004,903.
Miller, S. E.—*Joining Assembly for Wave Guide Sections or the Like*—3,003,020.
Montgomery, H. C.—*Control Unit*—3,002,482.
Murphy, O. J.—*Synchronizing Circuit for Magnetic Drum*—3,007,145.
Pferd, W., see Goodale, W. D., Jr.
Powers, R. E.—*Party Line Identification Circuit*—3,005,052.
Schnettler, F. J.—*Production of Magnetic Ferrite Bodies*—3,004,918.
Schmidt, G. F.—*Telephone Signaling System*—3,005,053.
Schulz-DuBois, E. O., see DeGrasse, R. W.
Sellers, G. A., Jr.—*Telegraph Transmitter Control System*—3,005,041.
Sharpe, D. T.—*Sea-Water Battery*—3,005,864.
Smith, G. W., Jr.—*Pulse Generator Having Means for Independently Controlling, During Successive Output Periods, Amplitude or Slope and Duration*—3,003,111.
Smith, L. M.—*Transistor Pulse Generator*—3,007,058.
Steinberg, J. C.—*Depth Control Device*—3,002,483.
Theuerer, H. C.—*Preparation of Silicon Material*—3,002,320.
Thurston, R. N., see Mason, W. P.
Van Uitert, L. G.—*Polycrystalline Garnet Materials*—3,003,966.
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Werner, J. K.—*Powder Metallurgy Process*—3,004,332.
Wiebusch, C. F.—*Torpedo Control Circuit*—3,003,449.
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Blumberg, W. E., Eisinger, J., and Klein, M., *Isotope Effect in the Nuclear Magnetic Resonance in Rubidium*, Phys. Rev., 1, pp. 206, Oct. 1, 1961.
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Brugger, K., and Mason, W. P., *Relation Between Thermal Conductivity Defect in Sodium Chloride and Acoustic Relaxation Effects at Low Temperatures*. Phys. Rev. Letters, 7, pp. 270, Oct. 1, 1961.
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Compton, V. B., Corenzwit, E., Maita, J. P., Matthias, B. T., and Morin, F. J., *Superconductivity of Technetium Alloys and Compounds*, Phys. Rev., 123, pp. 1567-1568, Sept. 1, 1961.
Courtney-Pratt, J. S., *Some Uses of Optical Masers in Photography*, J. of Soc. Motion Pic. & Television Engg., 70, pp. 509-512, July, 1961.
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Courtney-Pratt, J. S., *Lenticular Plate Multiple Picture Shadowgraph Recording*, J. of Soc. Motion Pic. & Television Engg., 70, pp. 710-715, Sept., 1961.
Courtney-Pratt, J. S., *Modern Methods of High-Speed Photography*, Experimental Methods in Combustion Research, pp. 5-23 of Section 1.7, 1961.
Coenzwit, E., see Compton, V. B.
Dacey, G. C., *Light: A New Communication Medium*, Control Engg., 8, #9, pp. 147-149, Sept., 1961.
Deutsch, M., *The Interpretation of Praise and Criticism as a Function of their Social Context*, J. Abnormal and Social Psychology, 62, pp. 391-400, March, 1961.
Eisinger, J., see Blumberg, W. E.
Fox, A., see Gohn, G. R.
Frisch, H. L., and Lebowitz, J. L., *Electron Transport at High Temperatures in the Presence of Impurities*, 123, pp. 1542-1549, Phys. Rev., Sept., 1961.
Frisch, H. L., see Vyssotsky, V. A.
Garrett, C. G. B., see Kaiser, W.
Geller, S., *Parameter Interaction in Least Squares Structure Re-*

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THE AUTHORS

W. J. Lally

W. J. Lally, a resident of Madison, N. J., was educated at Yale University where he received degrees of Bachelor of Philosophy (magna cum laude) in 1919 and Master of Science in 1921. After a period with the Metropolitan Engineering Company, Brooklyn, N. Y., he joined Bell Telephone Laboratories in 1929. At the Laboratories his work has been entirely in outside plant. It has included wire and cable development, underground facilities development and long-range planning. At present he supervises a group engaged in systems evaluation in the Outside Plant Systems Engineering Center. Author of "The Changing Pattern of Exchange Outside Plant," Mr. Lally is a licensed Professional Engineer and a member of the Yale Engineering Association.

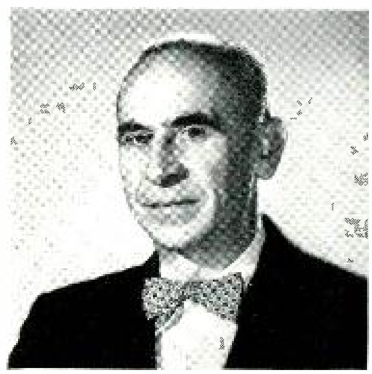
Richard R. Anderson was born and raised in Marshall, Minnesota. From 1944 to 1945, he served in the Army Air Corps. Mr. Anderson received a B.S.M.E. from Northwestern University in 1949 and an M.S.E.E. from Stevens Institute of Technology in 1960. He joined the Laboratories in 1949 and was graduated from the Laboratories second CDT class in 1952. As a member of the Switching Research Department, he conducted research on switching systems for telephone central offices. In 1956, he joined the Data Transmission Exploratory Development Department and made several prototype magnetic-tape transports for storing digital data. Recently, he has conducted theoretical studies of data transmission systems by computer simulation. A noted speleologist, Mr. Anderson has explored caves throughout the United States and is a member of the Board of Governors of the National Speleological Society and Chairman of the National Cave Files Committee. Author of "New Way to Measure Variations in Rotational Speed" in this issue. Mr. Anderson is a member of the ASME, Sigma Xi, Tau Beta Pi, and Pi Tau Sigma.

R. R. Anderson

L. H. Sessler, author of "Neutralizing Transformers" in this issue, was born in Youngstown, Ohio. He served as a navigator and radar observer in the Army Air Force from 1943 to 1945 and following that attended Purdue University where he received the B.S.E.E. in 1949. After graduation he joined an engineering construction firm where he was concerned with the electrical design of power generating stations. In 1952 he joined Bell Laboratories as a member of the Outside Plant Department. His work here has been primarily in the field of electrical protection. Mr. Sessler was recently transferred to the Operating and Engineering Department of the A.T.&T. Company in New York City.

L. H. Sessler

Nicholas Lazo was born in Athens, Greece, and received his E.E. degree from the Polytechnic Institute of Brooklyn in 1936. Mr. Lazo joined the New York Telephone Company in 1929 and transferred to the Laboratories in 1942. During World War II, he was engaged in the Sonar Project and later in circuit development of Panel and No. 1 Crossbar Systems and recently on Direct Distance Dialing and TOUCH-TONE signaling. Co-author of "Central-Office Modifications for TOUCH-TONE Calling in this issue, Mr. Lazo is currently engaged in developing an automatic telephone conference system for the North American Air Defense Command.



N. Lazo

A. S. Martins, a native of Queens, New York, and now a resident of New Hyde Park, Long Island, joined the Laboratories in 1928 and completed the Laboratories' student engineering course in 1932. In 1936, he joined the step-by-step systems laboratory testing group. During World War II, Mr. Martins took part in the development of electrical gun directors and in the construction

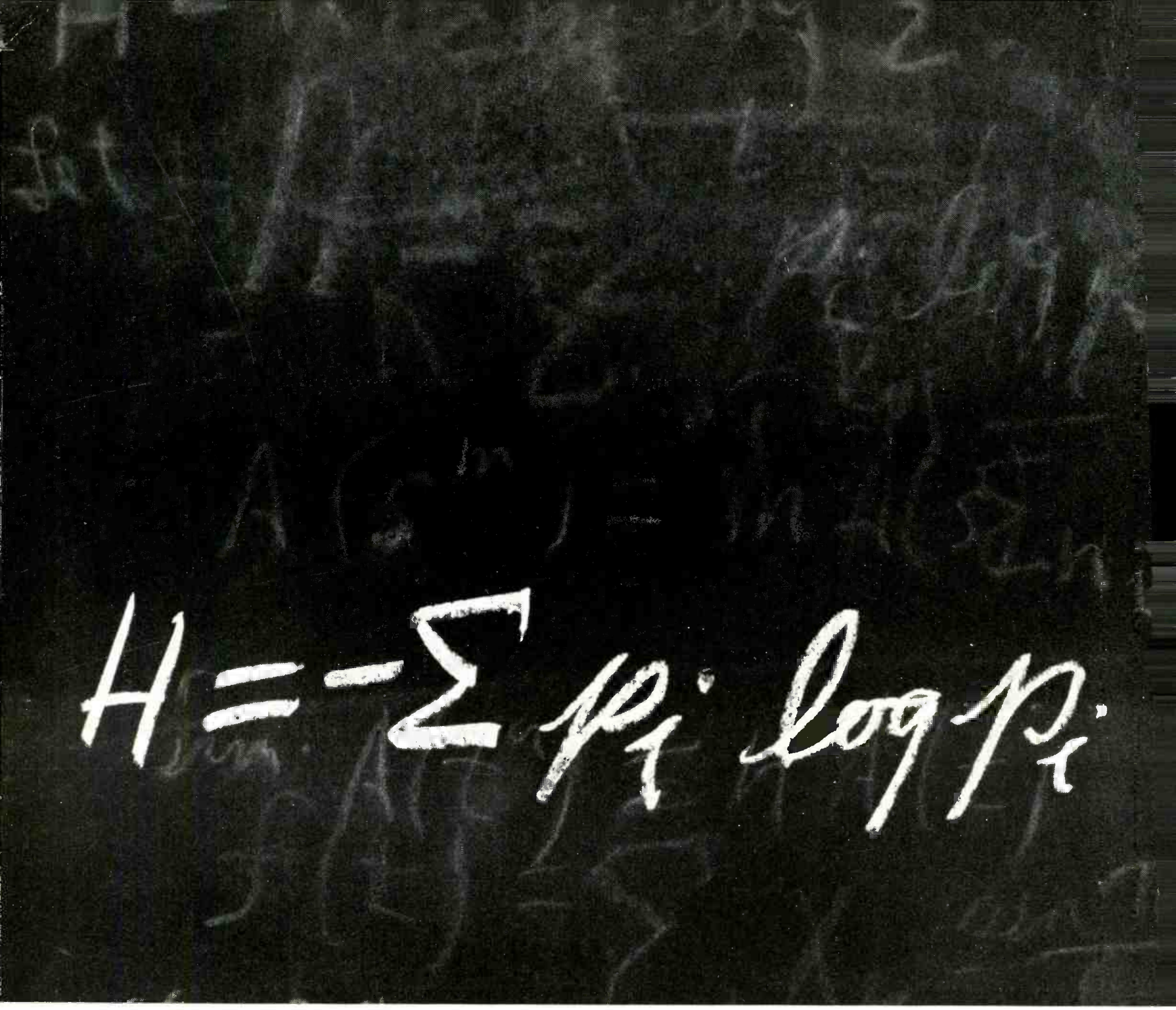
A. S. Martins

and testing of the early models of a submarine radar system. Since the war he has been concerned primarily with the design of switching circuits for step-by-step systems. He is now in charge of a group responsible for the design of step-by-step common-control circuits. Mr. Martins received the B.E.E. degree from Brooklyn Polytechnic Institute in 1943. He is co-author of "Central Office Modifications for Touch-Tone Calling" in this issue.

C. F. Kodey, Jr. was born in Endicott, New York. He enlisted in the Marine Corps in 1947 and was with the Marine Detachment aboard the U.S.S. Leyte for a 2-year tour of duty until early 1950. During the early phases of the Korean War he saw action with the First Marine Division. After being discharged in 1952 he attended the New York State Institute of Applied Arts and Sciences at Binghamton, New York and received his A.A. degree there in 1954. Mr. Kodey joined the Test Set Group of the Outside Plant Development Department in 1954 and has been concerned with test set development. He is attending

C. F. Kodey, Jr.

evening classes at Newark College of Engineering where he is studying Electrical Engineering. He is the author of "Automated Handling of Pins for B Cable Clips" in this issue.



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