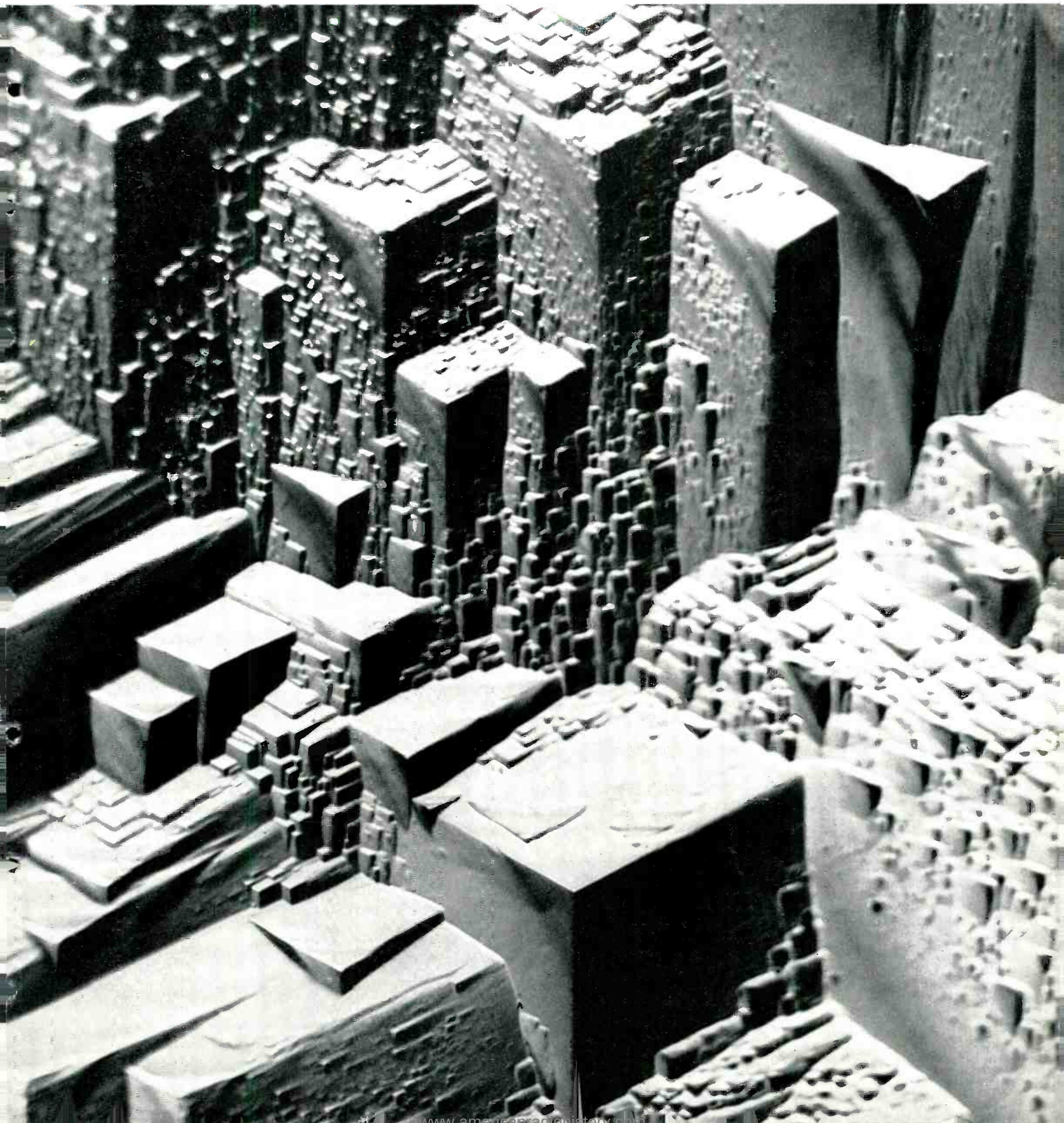
August 1958

Bell Laboratories

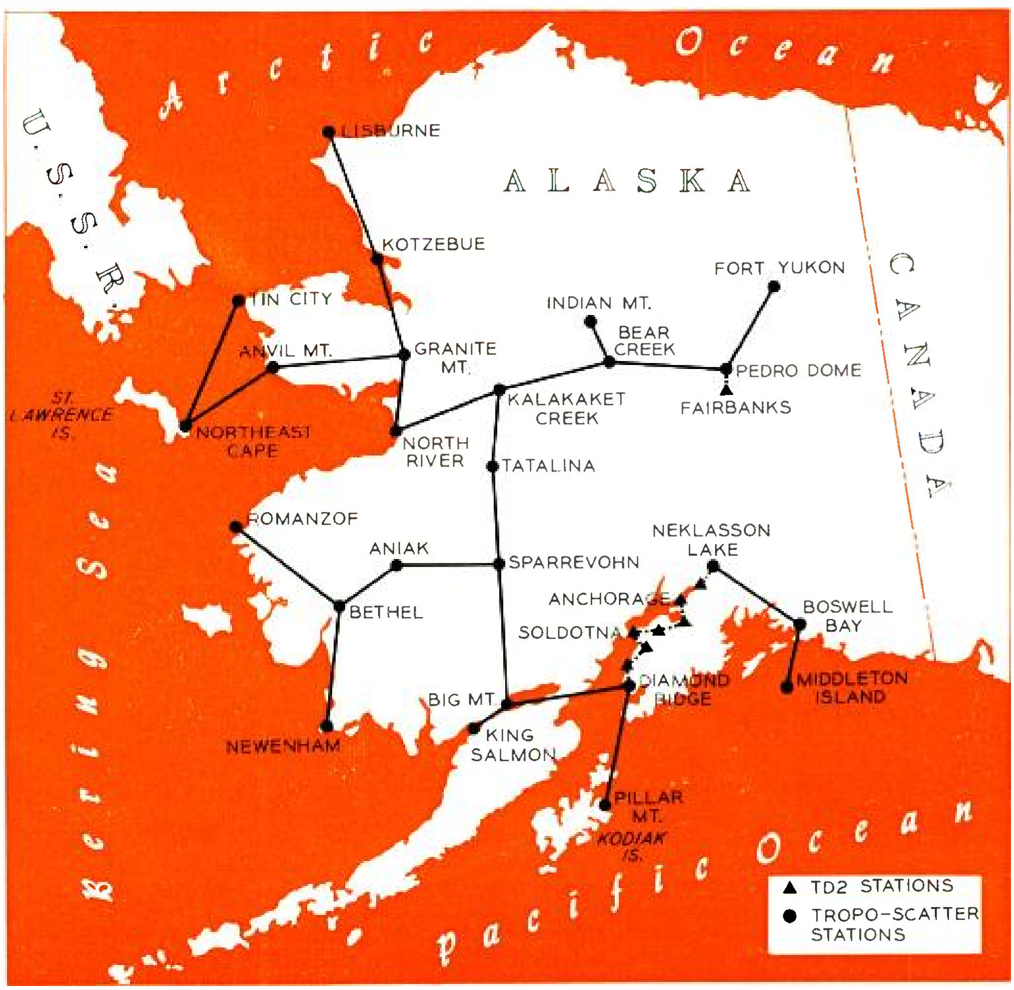
RECORD



White Alice, a new beyond-horizon radio communication system in Alaska, makes it possible for lonely far north outposts to telephone New York or Washington. America's last frontier is now spanned by a network of radio trunk routes designed to help solve pressing northern communications problems, both military and civilian.

WHITE

A New Radio Voic



V. H. Tidd

ALICE

for Alaskan Outposts

In March 1958 modern telephone communication spanned the entire territory of Alaska for the first time. It is now possible, with the system called "White Alice," to pick up a telephone in Fairbanks or Anchorage, or, almost as easily, one in New York or Washington, and talk to a salmon fisherman in King Salmon, an Eskimo missionary in Unalakleet, a jade mine operator in Kotzebue or a U. S. Air Force aircraft control and warning officer in the lonely DEW Line outpost at Cape Lisburne. You can be connected to our outposts of civilization on Cape Prince of Wales where on a good day it is possible to see Siberia, only 56 miles away.

White Alice's most important job is bringing early aircraft warning information back from the DEW Line and Alaskan warning stations to the Alaskan Air Command headquarters and the North American Air Defense (NORAD) installations in Canada and the United States. In addition new and interesting uses for White Alice circuits are constantly being devised.

White Alice is the largest communication system to rely on the comparatively new beyond-horizon mode of radio propagation, comprising 3000 route miles of telephone and telegraph circuits. Incidentally, the name has no particular meaning. It is an arbitrary code name dreamed up by the Air Force at the start of the project.

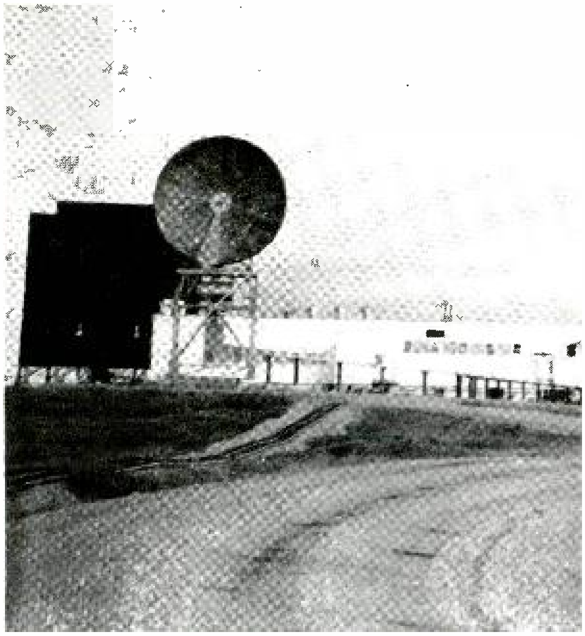
White Alice began in 1954 when the Department of Defense, realizing that a reliable communication system was needed to connect all the new military installations in Alaska, asked the Long Lines Department of the A.T.&T. Co. to study the problem. At that time, communications by means of HF and VHF radio and a few wire systems were rudimentary. The new network, therefore, was to be an integrated system to serve the needs of all agencies operating in Alaska. These included the military installations, air-traffic and weather networks operated by the Civil Aeronautics Administration, and civilian services furnished by Alaska Communication Service (Signal Corps).

It was estimated that current needs and future growth would require an extensive network with cross sections of several hundred voice channels for the backbone routes tapering off to a group of 12 channels at the extremities. Some of these channels should be further multiplexed with carrier telegraph to provide "teletypewriter" service. Many of the voice channels would be for full-talk military service, aircraft dispatching, and weather information; the remainder could be switched to provide long-distance telegraph service.

At the time the White Alice plan began to take shape, a new mode of radio propagation (as shown in the drawing on page 281) was being explored. By this method, often called tropospheric scatter, radio frequencies in the VHF, UHF, and SHF can be transmitted with high reliability to distances well beyond the horizon (RECORD, *February* 1956; *June* 1952). It is particularly suited for communication systems where it is desired to cover distances of 100 to 200 miles without intermediate repeaters.

Bell Telephone Laboratories had been studying this mode of radio propagation since the late 1940's and other groups, notably Lincoln Laboratory at Massachusetts Institute of Technology and the National Bureau of Standards, had recently entered the field. As a result of the Laboratories' work on this subject, recommendations were made to the Department of Defense concerning the potentialities of beyond-horizon radio propagation. It was felt that its capabilities would be particularly valuable in providing reliable long-distance communications to military establishments in sparsely populated regions where terrain and climate are severe.

At this time the U. S. Air Force needed a reliable communication system for its widespread stations on the northeastern edge of the North American continent; in 1953 it contracted for two studies of beyond-horizon radio propagation. Western Electric Company was the contractor for both. One was to be carried out along the northern coast of Alaska and Canada in connection with the trial stations of the DEW Line. The second propagation study was subcontracted by Bell Telephone Laboratories to the Bell Telephone Company of Canada in connection with a proposed communications system along the eastern coast of Newfoundland. The object of both studies was the same: to determine the effects of weather, terrain, and radio



A typical White Alice station at Kotzebue, 30 miles above the Arctic Circle. At left are a 60-ft. and a 30-ft. antenna. Not shown are the two antennas for reception from the opposite direction.

For the beyond-horizon radio links, new designs were required for almost all of the components — including radio equipment, antennas, and hardware for transmission lines, dummy loads, and radio-frequency filters.

The channelizing equipment used with both the microwave and beyond-horizon systems was a combination of type L1 and type K carrier frequency telephone terminals. Some technical modifications and repackaging were required to adapt this equipment for White Alice.

The White Alice circuits were engineered by the Laboratories on the same basis as Bell System long-haul trunk circuits when these are furnished by radio. The over-all objective for noise on a trunk is 38 dba* at zero-db transmission level or 29 dba at -9-db transmission level. This represents the noise from all sources, observed at the terminal of a long circuit, which may be exceeded 50 per cent of the time during the month when propagation is poorest. Another consideration is that the radio system must be engineered so that noise peaks produced by fading should break the circuits only a small percentage of the time.

The message-channel noise objective, shown as a probability curve, indicates that the noise may exceed 38 dba at reference transmission level about 50 per cent of the time, while it can be expected to exceed this value substantially for only a small percentage of the time. Noise as high as 49 dba should be observed no more than one per cent of the time during the worst month. This is illustrated in the graph below.

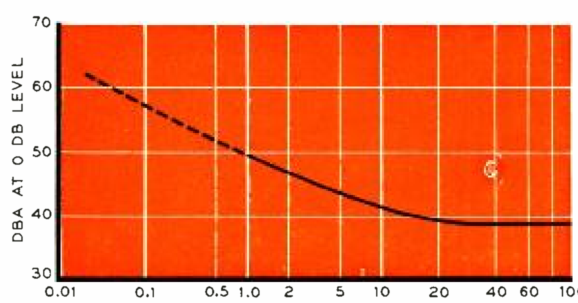
* The dba is an electrical noise unit referred to a 1000-cycle sine-wave power 85 db below one mw.

The 38 dba median noise objective is for a multilink system of several thousand miles. Thus, each path must be much better insofar as noise is concerned so that, when all are connected, the over-all objective will be met.

The first step in engineering White Alice communications links was to establish path losses that would be compatible with the transmission objectives. For microwave systems, the methods for doing this were well established, but much less was known about beyond-horizon radio transmission. However, the variations in transmission were fairly well understood, for hourly medians in db have a normal distribution in time; rapid fading, characteristic of tropospheric beyond-horizon propagation, in general, has an envelope or "Rayleigh" distribution. With these facts it was determined that a median path loss of 204 db annually would satisfy the transmission objective with 10-kilowatt transmitters and 60-foot parabolic antennas. These choices of equipment appeared to be feasible at that time in the 750-950-mc RF band chosen.

Another method of radio transmission between two stations beyond line-of-sight ranges was found especially useful in White Alice; this is known as "knife-edge" diffraction. It turns out that the diffraction over an obstacle between the two stations, visible from both, produces a signal which is appreciably better than that produced by reflections from the atmosphere alone. The high mountain peaks that abound in Alaska offered many such paths, and about one half of the White Alice links are of this type.

From existing maps engineering estimates were made of all the paths, and suitable sites



The message-channel noise objective used in engineering the White Alice system during worst month. The noise may exceed 38 dba at reference transmission level about 50 per cent of the time.

were tentatively selected. The inaccuracies of maps, however, and some of the empirical methods used in estimating the path losses, made it desirable to test the paths of all the routes. Frequently, several sites were tried until a favorable one was located. It was especially difficult to find sites where transmission in 3 or 4 directions was required. In several cases, the station was finally located on top of a mountain to meet such requirements.

"Dual space diversity reception" was decided upon to minimize the effects of rapid fading. The propagation tests had indicated that fades on two antennas spaced 200 feet apart would in general be uncorrelated. To make use of this fact, receivers are connected to the two antennas, and their outputs, after detection, are combined so that the one having the least noise is predominant. A typical White Alice station at Kotzebue, 30 miles above the Arctic Circle, is pictured on page 282. Two 60-foot antennas for use in one direction and two 30-foot antennas for the opposite direction are used; radio and terminal equipment are housed in the white building.

The most reliable equipment was necessary to be consistent with the high standards of transmission reliability engineered into the system. Where possible commercially available equipment was used. Perhaps 25 per cent was of the Standard Bell System type such as TD2 microwave; types K and L carrier terminal equipment and type 43A1 carrier telegraph equipment were also included. The remaining 75 per cent, consisting of such items as diesel engine generators, beyond-horizon radio equipment, antennas and transmission lines, was obtained from more than eight hundred suppliers. In some cases, such as beyond-horizon radio and antennas, new designs were required to meet requirements.

The interior of Alaska is still very much a frontier. Anchorage and Fairbanks can be reached by road, but most of the area depends on air transportation for almost everything; truly the airplane has been the covered wagon of the north. A modern reliable communication system will be of great value to the airmen of Alaska as well as to all its other users. White Alice should be a significant influence in the development of this last frontier; by spanning the 3000 route miles of Arctic wilderness it will bring people together and be a major factor in the fulfillment of the destiny of our newest state.

H. A. Wenk (left) and F. E. Willson survey the field intensity before 60-foot parabolic beyond-horizon antennas at the Neklasson Lake Station of the White Alice system near Wasilla, Alaska.

Various engineering and economic advantages could result from All-Numeral Dialing (AND), but is AND acceptable to the telephone user? At Bell Laboratories, preliminary experiments in 1954 suggested that, contrary to general expectation, telephone customers might actually prefer an AND system, and might dial faster and more accurately.

J. E. Karlin

ALL-NUMERAL DIALING—WOULD USERS LIKE IT?

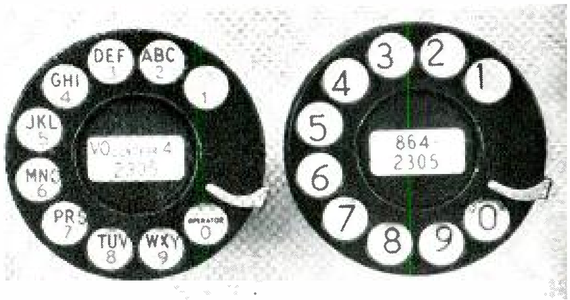
When a new item of telephone equipment is designed at Bell Laboratories, its technical aspects are put to an exhaustive series of tests before it is placed in the hands of the customer or of a Telephone Company employee. Characteristically, a new item is thoroughly tested in the laboratory and later is used in a field trial before it is recommended for general use. In this way, the Bell System guards against unforeseen circumstances which could lead to costly failures.

It has long been recognized, of course, that other factors besides those of a purely technical nature help to determine the success or failure of a new design. Specifically, since all equipment is at one point or another used, installed, or maintained by human beings, the Bell System has always considered the preferences and performance of users as one of the crucial groups of facts to be determined in any extensive trial of telephone equipment.

As outlined in a previous article (RECORD, *May*, 1954), Bell Laboratories makes an organized effort to study user characteristics, and this raises the question as to how effectively human factors important in the telephone situation can be measured under laboratory conditions with Laboratories employees as test subjects. Clearly, both the "users" and the conditions may, in any given instance, vary widely from their counterparts in a real residence or business telephone situation. The value of human-factors testing, however, is seen by drawing an analogy with engineering testing. Large-scale field trials of equipment are expensive and are never undertaken unless technical facts determinable in the laboratory are known. A field trial could also be an inconvenience to customers if a major technical fault were found, and this is another reason that laboratory testing, even if it cannot uncover *all* the facts, ensures that the more inclusive trials under actual field conditions are worth their expense and effort. The same is true of human-factors testing. Much information can be accumulated in the laboratory, and this information is of great value in the subsequent steps in the process by which a laboratory idea becomes a reality of the telephone industry.

These observations about users and the extent to which their preferences and performance can be determined in the laboratory are illustrated by some recent studies of all-numeral dialing. All-numeral dialing, or AND, involves the use of numerals in place of the office-name letters of the present letter-numeral dialing or LND system. For instance, the office letters UN of the telephone number UNiversity 4-5271 would be replaced by their numeral equivalents on the telephone dial to result in the AND number 864-5271. The telephone dial would thus contain only the digits 1-9 and zero, and the telephone directory would list all numbers by numerals alone.

AND offers certain advantages, some of them



Telephone numbers can be found with less effort because of uncluttered face of all-numeral dial.

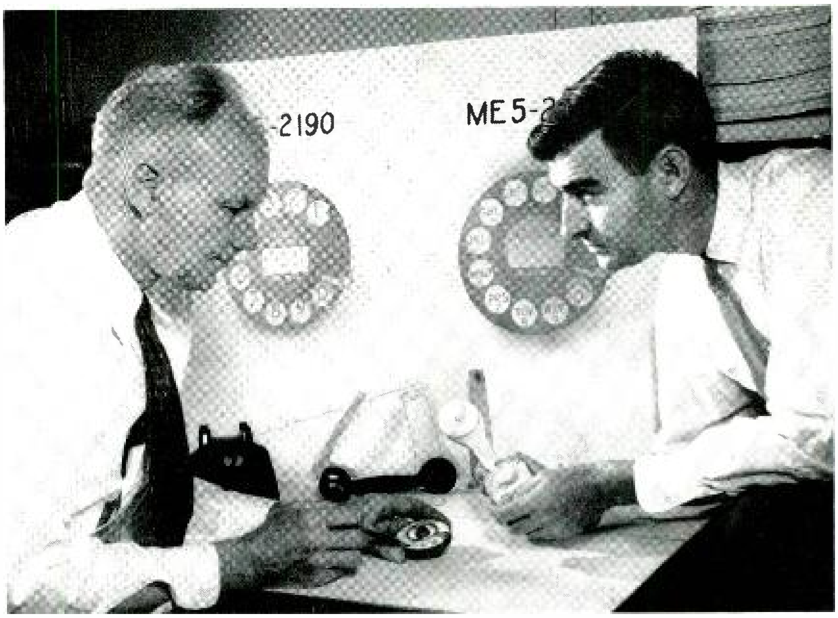
rather obvious and some perhaps less so. AND eliminates the confusion between "oh" (letter O) and "oh" (number zero), and also between "l" and "1"—features that are especially important for direct-distance dialing of long-distance calls, in which the second digit is always a "zero" or a "one". In addition, the space saved by deleting letter designations would be advantageous in looking ahead to possible designs of pushbutton telephone sets: one number on a small button would be read more easily than three letters and one number. Similarly, elimination of letters would be helpful in any future reduction in size of the present telephone and dial, for example in the "dial-in-handset" where the dial is placed around the transmitter.

One other advantage of AND has to do with international dialing. In anticipation of the time when we may see dialing of calls to other countries, AND would simplify international dialing codes, since foreign telephones frequently have the letters in different finger-holes. As desirable as these advantages might be, however, they are secondary to the fundamental question of the acceptability of AND to customers, and it was to this question that the Laboratories experiments were directed.

In a matter such as this, we would all tend to have our own opinions as to whether AND would be good, bad, or indifferent. In fact, the most common reaction is that AND would not work, and the principal objections expressed are that AND numbers would be hard to dial and to remember. Specifically, four issues are involved. With AND, would telephone users dial numbers faster, slower, or at the same speed? Would dialing be more or less accurate? Are AND numbers actually harder to remember? And, beyond other considerations, would customers *like* the AND system?

All-numeral dialing has from time to time been considered by people at the Laboratories and by many others in the Bell System, and a number of limited but valuable investigations have been carried out. The present investigation, carried out in 1954 and 1955 by the Human Factors Engineering Group at the Laboratories, was intended to be more comprehensive and to carry the laboratory type of study as far as it could go. Four separate experiments were conducted, and it will be seen that they proceeded in a progressive order, each growing out of the previous results and attempting to answer a new phase of the problem.

The first experiment was designed to simulate the dialing aspects of a cutover from LND to AND and to determine users' reactions to it.

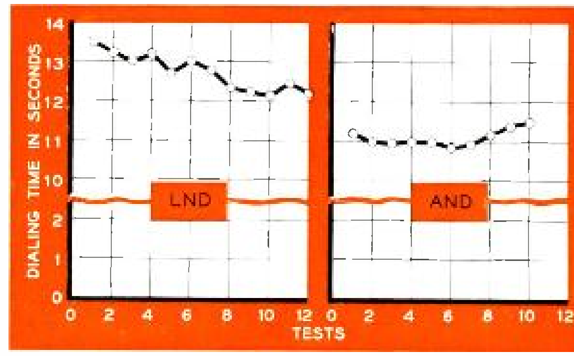


C. F. Mattke (left) and the author discussing aspects of dials as they relate to use with all-numeral dialing.

Nine employees of Bell Laboratories were selected for the experiment, and care was taken that insofar as possible, these employees were more nearly representative of the range of telephone users than other employees who might have specialized interests in techniques of using the telephone instrument. Each person was asked to go to a special test room once a day for 22 days, and while in the test room place a list of calls. The list consisted of names of people and places to call, rather than numbers. For the first 10 of these 22 days, each person used the regular Manhattan Telephone Directory to look up LND numbers and place the calls. For the other 12 days the Manhattan Directory was so modified that the number found appeared on the page in its AND form, and the person placing the calls had to use a telephone with an all-numeral dial. In such Laboratory experiments, it has been found that dialing speeds and errors are quite close to the values observed in the field.

The calls actually terminated in a nearby room and were answered by the experimenter. "Busy's" and "Don't Answer's" were introduced with appropriate frequencies; these calls were repeated until successful. Mechanical aspects of dialing that could be observed from the receiving end — such as dialing speed and dialing accuracy — were measured and tabulated. To reduce the "guinea pig" effect to a minimum, there was no contact between the user and experimenter until the entire experiment was finished, at which time each user was interviewed.

What were the results of this experiment? It was found that AND was about 10 per cent faster *(see the graph on this page)* and also was slightly more accurate than LND. Five of the nine users preferred AND and four thought both systems equally acceptable. All nine, however, strongly preferred AND once a number was fixed in mind, for the reason that it was easier to place the call using the large, uncluttered symbols of the AND dial. All nine felt that it was just as easy to memorize AND numbers long enough to dial.



When nine Laboratories users were "cut over" to AND, their dialing performance improved.

Modification of the telephone directory for Bell Laboratories experiments in all-numeral dialing.

It turned out, however, that this experiment fell short of realistic dialing in one respect: with a telephone directory always at hand, users had little incentive to memorize the AND numbers, even though certain of these numbers were dialed every day. In fact it was known that users in this first experiment almost never dialed from memory, because the times between successive calls from the lists clearly indicated that users consistently consulted the directory.

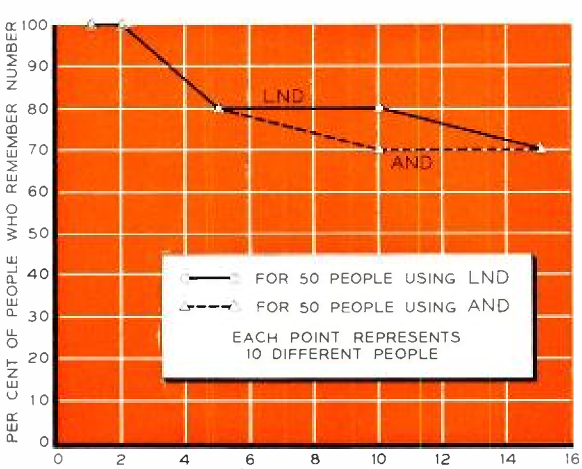
The second experiment was therefore conducted in a different manner. A second group of nine employees was selected. Each was a resident of Manhattan who, in his or her normal LND telephoning, had already memorized several frequently-called numbers. Instead of dialing from a test room, each user placed calls from his own desk. He was given a specially prepared directory page containing both his memorized numbers and many unfamiliar ones. Each day the experimenter called the user at his desk and asked him to place a certain series of calls. For three days all numbers were in LND form and for 16 or more days were in AND form.

As before, all calls terminated in the same Laboratories building, and dialing performance was measured. In this case, the user had an incentive (but was not instructed) to rememorize familiar numbers in their new AND form. Whether he rememorized them at all, and if so, how rapidly and how completely, was observed by the experimenter.

Of the nine users in the second experiment, eight found AND as acceptable as LND, but one expressed a general dislike of AND. Dialing speed and accuracy were again superior, and within the month following cutover to AND, six of the nine had rememorized all the numbers they had previously dialed from memory with LND, and two felt that they could memorize all their numbers given more time.

In both of these two experiments, it was difficult to isolate memory difficulties from dialing errors; when a wrong number was dialed, it was not always possible to tell whether the subject had memorized incorrectly or had merely made a mistake in dialing. The third experiment was therefore designed as a straight "memory test," with no actual dialing of calls. One hundred employees were involved in this experiment, fifty being tested for ability to memorize unfamiliar LND numbers and fifty for their ability to memorize the equivalent AND numbers. The experimenter called each person at his desk and gave him a number. If the person were in the LND group, for example, he might be told that "The Sears Roebuck number is Foxcroft 9-2675." Similarly, another person in the AND group would be told that "The Sears Roebuck number is 369-2675." (All numbers were made up specially for the experiment and were therefore equally unfamiliar to all participants.) The experimenter then called back daily to ask what the number was. If the person had forgotten it, he was given it again on consecutive days until he succeeded in memorizing it. When he had memorized it he was given a second number, and when he had memorized *both* numbers he was given a third. This test of long-term memory ended when all three numbers were memorized.

In addition to these daily calls, the experimenter tested *short-term memory* by sometimes calling back soon after a number was given, to determine whether the person remembered it. The situation was such that he was not expecting to be called back. This short-term memory is the type used in going from a directory to a dial; it was tested in this fashion over a range up to fifteen minutes.



After using a new telephone number, people at the Laboratories remembered all-numeral numbers about as well as letter-numeral numbers.

As indicated in the graph on this page, the experiment showed that it was just as easy to remember AND numbers for short periods of time as it is for LND numbers. This experiment also demonstrated, however, that it takes a little longer to memorize AND numbers for greater periods of time. In quantitative terms, if a person dials an LND number once each day and succeeds in memorizing it on the third day, he would on the average require about one extra day to memorize the equivalent AND number. The importance of this aspect of AND dialing of course depends partially upon how much memory is involved in real telephone situations, and it should therefore be noted that the average telephone user "permanently" memorizes only about four or five numbers.

The three studies yielded rather definite results, but there could always remain some doubt about their value because of the possibility that user dialing in real homes would be different from employee dialing under laboratory conditions. The final experiment was therefore conducted in the homes of telephone users. Seventy-three Laboratories employees and relatives of employees participated in the test. About half were in New York City and half in various small towns in New Jersey. In each home, telephone numbers in the ready-reference directory were changed to the equivalent AND forms, an all-numeral dial was put on the telephone, and a "card translator" for converting LND to AND numbers was supplied (ABC = 2, DEF = 3, *etc.*). The participants then used AND for ten weeks, and their reactions to it were determined at various times during the trial.

The results of this home experiment were not as objectively measurable as in the previous three in the laboratory, but they nevertheless were of great value because this experiment approached most nearly to an actual AND cutover. Of the 73 users, 31 preferred AND, 17 found AND and LND equally acceptable, and 24 preferred LND. Of the 24 who preferred LND, only 8 felt strongly about retaining it. The reasons given were chiefly the reluctance to change from the LND habits acquired over many years, and the difficulty of discussing telephone information when everybody around them was still using LND. Of the 73 users, 58 stated that they found no difference between memorizing AND and LND numbers, and no one felt that remembering numbers would be a serious handicap. There was little difference in reaction between users in small towns and those users who live in New York City.

It should be noted that in this experiment, and to a certain extent in experiments 1 and 2, certain factors tended to make the test AND cutovers more troublesome to the user than they would be in actual practice. Since it is impracticable in laboratory experiments to reprint entire telephone directories, users had to depend on modified directories, typed "directory" pages, or, in experiment 4, on card translators for determining AND numbers. Second, users were dialing AND numbers in an isolated environment. That is, unlike a real AND cutover where a whole community would be involved, test users were subjected to AND while everyone else was dialing LND. This meant that an AND user could not discuss telephone information with his neighbor; for example, he could not give anybody his home number without first mentally translating it back to LND. It was therefore felt that these disadvantages would tend to act as a conservative factor in the final results.

How helpful are the results of such laboratory experiments on human beings for predicting field results? On the basis of Laboratory results alone, no one can say definitely that telephone users would surely accept or reject AND. On the other hand, one can see that when more extensive field trials are conducted, the preliminary laboratory results will be of great value in deciding how to conduct the trials and what facts to determine.

The most one would want to say at this point is that with AND, dialing speed should increase and the error rate should be about the same or slightly lower. There should be little strong feeling against AND, and there is a good chance that it would be widely accepted. With field trials,* it will be possible to compare the results with those obtained in the laboratory. A study of any discrepancies should be helpful in improving laboratory testing methods.

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* The foregoing analysis was prepared prior to a field trial of AND which was begun in Wichita Falls, Texas, in January of this year. On the basis of the first three months of this trial, indications are that AND performance compares quite favorably with LND. This seems to verify some of the conclusions reached as a result of laboratory studies. It should be emphasized, however, that the Wichita Falls numbering change is a trial only, and that the Bell System has reached no conclusion that a change in present numbering is desirable. Wichita Falls results are still under study, and substantial advantages must be demonstrated to justify a change in numbering for millions of our customers. If such advantages seem indicated when Wichita Falls studies are complete, other more stringent trials of the all-numeral type of numbering plan would have to be undertaken in larger cities before any firm conclusions could be drawn. Many factors outside the scope of this article are involved in numbering plans and dialing procedures. If AND comes at all, its adoption is obviously a long way off.

F. J. Biondi

Cleaning Electro

The technology of designing and building electronic devices such as electron tubes and transistors has developed rapidly during the past decade or two. With this development, considerable technological emphasis has shifted from studies of the intrinsic properties of the materials used, to studies of the environments in which they must operate. The life and reliability of many electronic devices now appear to be more dependent on the contaminating influences of the impurities associated with the materials of construction than on the inherent behavior of the materials themselves.

For some time now, the Bell Telephone Laboratories Electronic Materials and Process Development Department has been evolving new techniques to determine the presence and influence of electronic device contaminants together with processes to reduce their level. Many members of this Department have contributed new processes and testing procedures, and members of the Electronic Device Development Departments have cooperated in their evaluation. It is the aim of this article to present the coordinated story of this teamwork in a broad but abbreviated manner. Under these circumstances credits to individual contributors cannot be given, but those interested in more detailed descriptions of the tests and processes are referred to the technical literature where the detailed presentation will shortly be available.

Undesirable contaminants have been divided into the following five groups: (1) physical contaminants such as dust, lint, and minute metal fragments; (2) ionic contaminants, which are generally water-soluble acid or plating residues; (3) contaminants which are soluble in solvents other than water, principally mineral greases and oils; (4) chemically combined contaminants such as polar organic materials, oxides, sulfides, *In the past, useful performance of electronic devices depended on choice of materials and accurate location of individual parts. Research has reduced these limiting factors and revealed another: contamination associated with materials and methods of construction. New cleaning procedures are overcoming these factors and increasing the range of devices.*

...evice Parts

and (5) gaseous contaminants that may be adsorbed, absorbed or generated within the device.

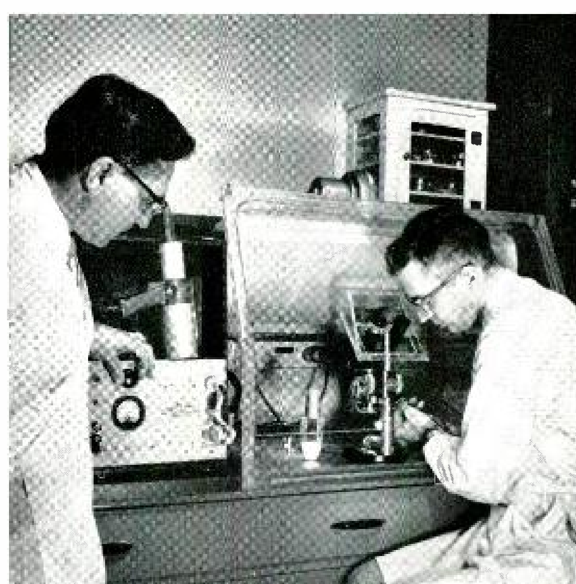
The cleaning problem was separated into two parts: first, the development of simple tests to measure the degree of contamination present, and second the development of suitable techniques to eliminate or materially reduce the level of contamination.

In the past, such phrases as, "wash thoroughly" or "maintain clean" were used, but for present purposes these have been found to be inadequate. Test procedures of known reliability have been developed which are, where possible, nonsubjective in nature. Our object has been to eliminate personal judgment and the need for special aptitudes and skills to carry out decontamination procedures.

In our study of physical contaminants, it was discovered that the presence of dust on the components of modern electronic devices has three principal effects. First, some particles are large enough to bridge the close spacings, and thus provide leakage paths between parts. Second, many particles decompose to yield gaseous or other end products whose presence is deleterious. Finally the finer particles have surface areas so large that they are best described in terms of acres per gram. Many unwanted gases and chemicals are adsorbed on these immense areas.

With dust and lint, our first problem was to determine how to measure the size and amount present, and then to make changes in air filtering and treating procedures to supply electronic device assembly areas with the cleanest air possible with available commercial equipment. The next problem was to determine the contribution made by people or their operations to the dust-lint level in an area, and to devise means for reducing these contributions. Finally, efforts were made to demonstrate that all this effort was worthwhile in terms of improved life and performance of electronic devices.

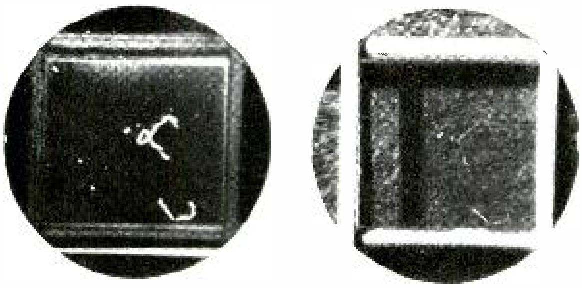
After evaluating many testing procedures, we found one developed many years ago for central office contact-erosion studies to be quite useful. This consists essentially of counting by microscopic means the size and quantity of dust and lint particles that fall on a clean glass dish exposed in the area of interest, generally for one working day. Another technique consisted of



P. R. Pondy (left) and G. E. Helmke adjust air flow in assembly hood. Assembly operations are carried on inside carefully designed and controlled transparent hoods in special clean rooms.

measuring the dust content by the light-scattering principle, and a third test employed a miniature electrostatic precipitator that first charges and then collects the dust particles on a weighed aluminum sleeve.

Testing air filtering and conditioning required actual experience with several different arrangements of filters and conditioning equipment. These tests have been in progress for the past ten years. As a result, we are now able to supply



Highlighted fibers under polarized light (left) compared with illumination with ordinary light (right). This polarized light technique was developed for detecting and inspecting such fibers.

our critical assembly areas with air with a dust content considerably lower than we are able to maintain if people are working in the areas.

Studies of techniques to prevent undue recontamination of the air by people and objects in the assembly areas have also been going on for some time. Recognizing that people and clothing are a principal source of dust and lint, we are able to take reasonable precautions to maintain relatively clean air. First, we have adopted the general principle of successive compartmentizing. We keep our parts or assemblies in clean containers and carry on our assembly operations inside carefully designed and controlled transparent hoods that are located in an already clean and conditioned room as shown in the illustration on page 289. These hoods are pressurized with air drawn from the room through a local filter on top of the hood.

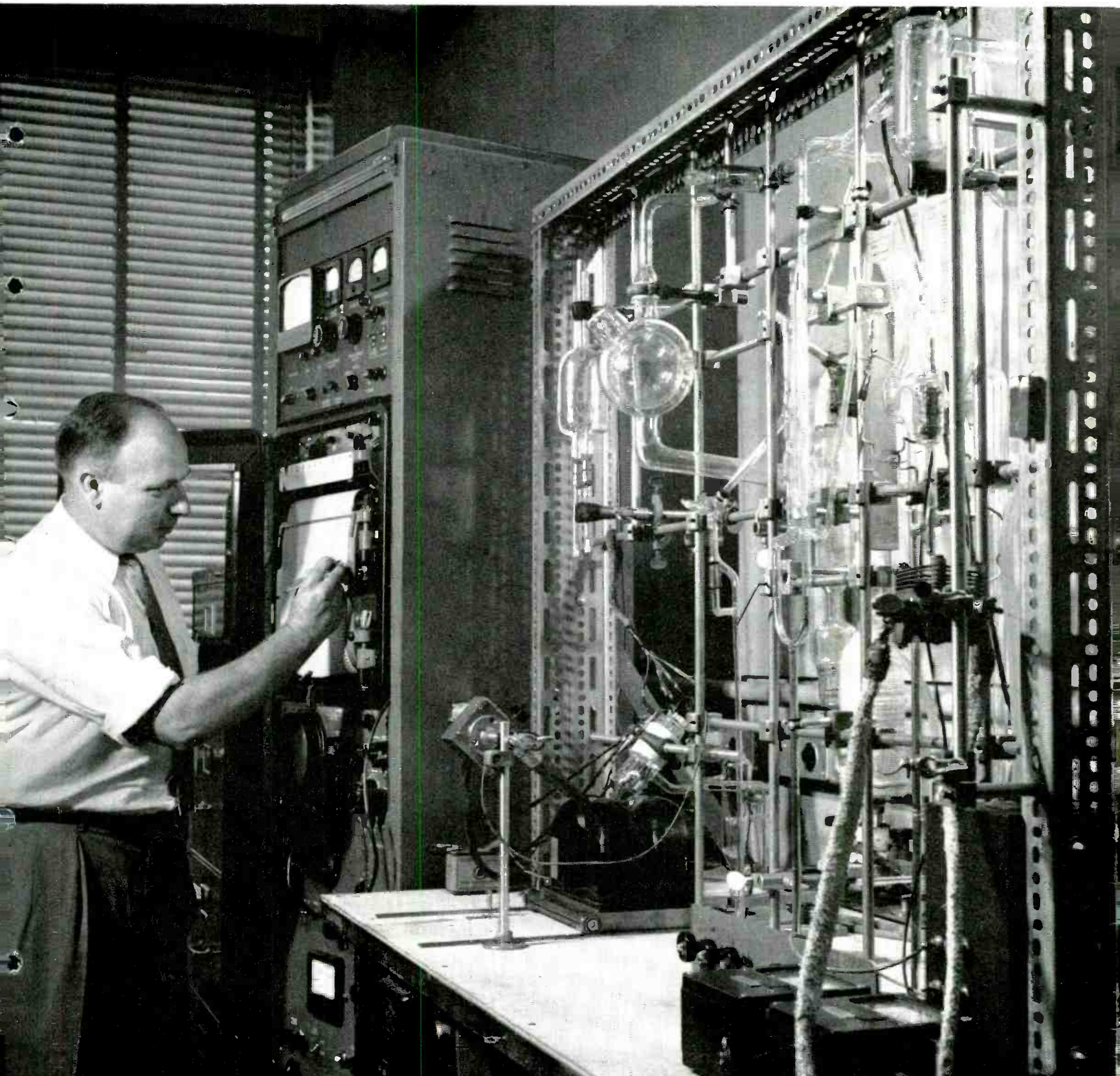
The air inside these transparent hoods represents the cleanest assembly ambient we are using at present. If one characterizes the dust level in the air supplied to our controlled environment assembly areas as one, activity of personnel, even in our best areas, will generally raise the dust level to about ten. Passage through the local filter on top the plastic hood will reduce the dust level to about three inside the hood. For comparison, the air in clean nonconditioned areas, which resemble large open-factory conditioned areas, may have a dust level as high as seventy on this same scale. We currently have underway experiments that are designed to produce working ambients in hoods essentially as clean as the supply air, but this has not yet been attained in practice.

Acetate gloves — adopted a number of years ago to reduce contamination of parts by fingerprints — proved to be one of the principal lint and dust contributing items of apparel. These were replaced by gloves woven from monofilament nylon threads similar to fine fishing line; they are nonlinty and sufficiently porous to make them comfortable to wear. The palm side of the glove is coated with a continuous thin film of plastic which is impervious to perspiration and the transfer of body oils and skin scales. In conjunction with this work, a polarized light technique was developed for inspecting parts for fibers, and it greatly improves our ability to detect them. The illustration at the left shows the highlighting of a lint fiber with polarized light as compared to the relatively dark image in ordinary light.

Despite all these precautions, many dust particles remain on the surfaces of the parts, dust that must be removed before the parts are processed further. A convenient technique to remove dust and lint from electronic device parts was developed. *(See illustration on page 292.)* With this technique, the work is immersed into the first section of a tank which is fed with tap water with a high surface velocity. In this stage, loosely held physical contaminants are washed from the surfaces and swept away. Tap water is used in this operation since the physical contaminants must not be wet thoroughly because they would sink and not be carried out of the system. Water is circulated clockwise from one tank section to the next, while the work is moved counterclockwise. The part is next immersed in the third section of the apparatus which contains hot tap water, a wetting agent and ultrasonic transducers. These agents combine to beat off the more firmly bonded dust and suspend it to be carried out of the system. Finally, the part is immersed in the second section of the apparatus which contains hot tap water to remove the wetting agent. Although this procedure is very effective in removing physical contaminants, it cannot remove contaminants that are embedded in metal parts. These must be removed by etching procedures.

After electronic device parts have been cleaned by the methods described, they will still contain intolerably large amounts of ionic, chemically combined and gaseous contaminants. The parts are also coated with thin films of organic materials which are so tightly bonded to the surfaces that they act as though they were chemically bonded.

For several decades, distilled water has been used to remove water-soluble contaminants from electronic device components. It has always been difficult, however, to supply sufficiently pure water in the quantities required. Therefore, a new source of ultra-pure water was needed. One important criterion of purified water is its electrical conductivity. It was found that the conductivity



E. J. Becker uses mass spectrometer to measure gases released while pumping out an electron tube.

W. H. Craft uses water washing system to remove dust and lint from the tube components.

of normal distilled water ranges from 2.5 to 5.0 μmhos per cm. For comparison, tap water at the Murray Hill Laboratory ranges between 350 and 450 μmhos per cm.

About ten years ago, the ion-exchange industry developed a new technique called mixed-bed resin de-ionizing, which was adapted to supply the need for inexpensive, ultra-pure water. In this system, for example, any calcium ions which may be present are exchanged for hydrogen ions, and sulfate ions are replaced by hydroxyl ions. The hydrogen and hydroxyl ions immediately combine to form water. A typical deionizer, as used at the Laboratories, is shown in the photograph on the next page. The apparatus constantly produces water with conductivity less than 0.1 μmho per cm at a lower cost than distilled water. It would require 27 successive distillations in quartz to produce water of equivalently low conductivity.

Using this ultra-pure water poses an entirely new set of problems, since it is a solvent for many materials normally regarded as insoluble in less pure water; that is, it must be generated close to the site of use to avoid recontamination by dissolving constituents of the pipe lines.

To remove ionic materials that may be residues of tap water or residues from acid or alkaline etches or plating baths, the parts are immersed in a countercurrent extractor. Water surrounding the parts dissolves and removes the ionic contaminants. This technique can be made very efficient by recirculating the discharge water, which may have a conductivity of only a few μmhos per cm through a deionizer. A few gallons of ultra-pure water can therefore be used repeatedly for many months of washing.

The air around us, even in the best air-conditioned laboratories, has organic materials suspended in it. These materials exist as vapors or are carried as films on extremely fine airborne dust. Within a few minutes to a few hours, any part exposed to such air is covered by a thin film of water-insoluble organic material. Further, some of these organic materials associate themselves so intimately with the surfaces that they act as though they were chemically combined and are, therefore, extremely difficult to remove.

The problem in this instance was to develop methods to detect and measure the thickness of such films, to devise simple methods for their removal, and finally to develop procedures for preventing the recontamination of the parts once cleaned. Consider, for example, that a greasy dish when dipped into water, even warm water, will not show a uniformly wet surface; water gathers in some spots and avoids others. This is called the water-break test and has been employed by electro-platers for many years to test the cleanliness of metals prior to their plating. If, instead of dipping into water, one sprays fine droplets of water onto a test sample, the same test exists in principle, but much thinner oily films can be detected. The atomizer spray test is performed by observing the tendency of the fine droplets to coalesce and form a thin uniform film.

It has been established that the parts which pass the water-break test may have organic films on them of the order of one and one half molecular layers in thickness. On the other hand, parts that pass the atomizer spray test will generally have organic films of less than a tenth of a molecular layer. We also needed, however, a readily available clean surface to calibrate our testing system. This need was met by employing high quality mica sheets that can be easily split to provide a fresh surface not contaminated with organic material. This freshly cleaved surface is sprayed, and if the fine droplets immediately coalesce, the test system is clean and we can proceed to test the sample parts.

Armed with this simple test and calibration specimen, we proceeded to evolve techniques for removing the tightly bonded organic films. The classical processes employed by the electronics industry — such as trichlorethylene degreasing, vacuum firing, hydrogen firing and acid etching — do not remove these films. The only effective way found to remove tightly bonded organic films was substantially to alter or split the organic molecules. A convenient technique was to expose the films to oxidizing conditions such as heating the parts in air at 400°C, boiling them in a 3 per cent solution of hydrogen-peroxide, or exposing them to the action of oxidizing acids. If the part in question cannot tolerate the resultant lightly oxidized film, it can be removed chemically or by reduction in an atmosphere of hydrogen.

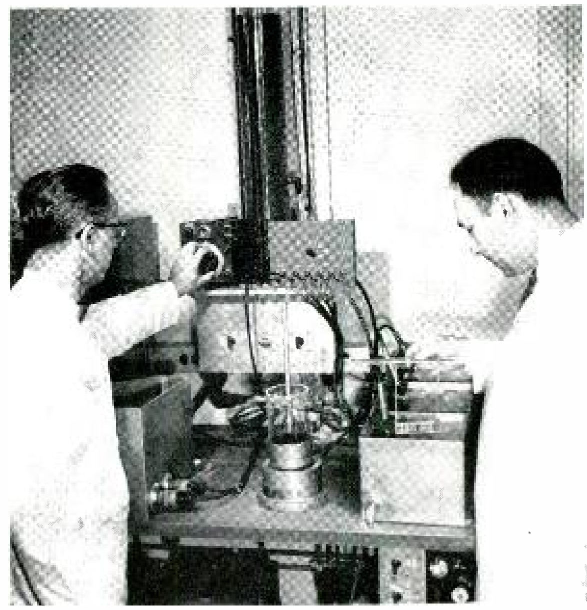
In addition to the contaminants discussed above, we have also carefully controlled the compositional chemistry of our materials. For example, in metals used in electron tubes, we limit to a very low level any high vapor pressure contaminants. These might create leakage paths on the spacer micas or place impurities on the cathode; these impurities, in turn, might form insulating compounds between the cathode metal and its coatings. We purchase all our materials to specifications, sometimes requiring all impurities to be less than 0.005 per cent. Concurrently efforts may be made to control the presence of beneficial impurities to levels up to 0.2 per cent.

Another contaminant of great concern is the gas adsorbed or absorbed in the materials of construction. In electron tubes, such gases are obviously important, since it is desired to obtain a good degree of vacuum with some of the parts operating at temperatures as high as 1200°C. Equally important, some of the gases, even though in a high vacuum, may be reducing and others oxidizing in nature. These gases constantly influence the thermionic activity of the electron tube. In the past we learned to optimize these effects, but in newer designs ability to maintain a useful coexistence of these effects has been severely challenged. As a consequence, techniques had to be developed to de-gas parts more thoroughly and to reduce their potential for generating gas. The measurement and control of these contaminants is not simple; it requires fairly complex equipment such as the mass spectrometer shown in the illustration on page 291. The spectrometer reveals not only which gases are present but in what quantities.

An important element in any cleaning operation is to prevent recontamination of parts after they have been cleaned. Containers have been developed that can be cleaned and tested as though they were parts. We are able to store clean parts in these containers for periods as long as a month without recontamination. Tools, fixtures and heat-treating boats are also cleaned as though they were device parts.

A convenient method for evaluating the cleanliness of the container is to insert a fresh, doubly split piece of mica. The mica test piece is removed periodically to determine whether it continues to pass the atomizer test.

Having studied electronic device contaminants and evolved methods for determining the level of their presence and techniques for their removal, let us now briefly review how useful these activities have been. Following are a few representative results of cleaning electronic device parts by the methods outlined above: (a) Air conditioning in the assembly area for the high-vacuum pentode used in submarine cable amplifiers significantly improved their thermionic activity and reduced the range of variations. Hoods and lintless gloves reduced the lint count to one half its former low value and reduced the inspection time to detect lint by two thirds. (b) The use of ultrasonics to remove physical contaminants reduced the carbon content of tungsten heaters (considered clean by former standards) from 0.01 per cent to 0.002 per cent. (c) In a gas-filled thyratron, the use of ultrasonic washes to remove loose carbon from the carbonized anode provided the margin of difference needed to operate this tube under certain stringent conditions. (d) Careful washing of silicon in boiling deionized water reduced the surface recombination velocity to the more desirable low values experienced with germanium. (e) Removing the physical, water-soluble and organic contaminants of a traveling-wave tube resulted in nearly tripling its thermionic emission. (f) Yields in a silicon rectifier were increased ten-fold by removing chemically bonded contaminants near or across the junction.



H. M. Cleveland measures the conductivity of the water from a mixed-bed deionizing column, while D. E. Koontz washes parts immersed in extractor.

Many more examples could be cited as a significant improvement in device performance as a result of using these careful cleaning processes. It appears evident that these techniques may be used to improve the performance and life of devices in many applications, and even make it possible to use a particular device in an application that was heretofore impractical.

The rediscovery of the magnetic amplifier as an electronic device has opened new fields for static control. One application — switching — takes advantage of the bi-state feature of this type of amplifier. The bistate magnetic amplifier has many uses in the Bell System.

D. Katz

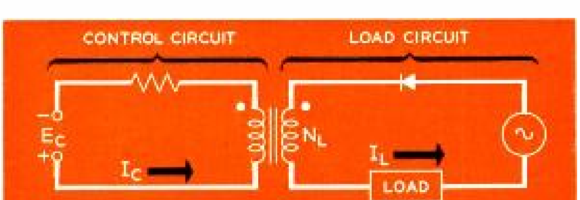
MAGNETIC AMPLIFIERS

Bistate Operation and Application

A modern and useful class of magnetic amplifiers is characterized by its switching or bistate action. With bistate magnetic amplifiers, two widely different but stable output levels are obtained — a quiescent or zero state, and a saturated or full-output state. That is, the amplifier can be switched "on" and "off."

Generally, this type of magnetic amplifier may be viewed as a contactless switch having some functional similarity to a relay. Without any moving parts, this static switching device can electrically isolate inputs and outputs, can provide high-power amplification, and can be electrically set or biased to switch at a precise net-signal value appearing in several control windings. Because of their ruggedness, reliability, power handling capacity, stability, accuracy and sensitivity, bistate magnetic amplifiers have increasing use in the Bell System.

In general, all magnetic amplifiers consist of magnetic cores with power and control windings.



One basic magnetic amplifier circuit — the half-wave circuit — which furnishes two output levels.

The power windings are connected to a load circuit in such a way that the transfer of power derived from an alternating voltage source is controlled by the state of the magnetic cores (Record, *January*, 1958). The magnetic state of the cores is, in turn, determined by control signals applied to control windings on these cores through a control circuit. In linear magnetic amplifiers, the control signals may set the cores at any point between the fully unsaturated and fully saturated states. Thus the corresponding amplifier output from the zero to the full state is directly proportional to the control signals. By contrast, in bistate magnetic amplifiers, either the control signal or the output circuit limit the magnetic core to only two distinct states — fully unsaturated and fully saturated. The bistate amplifier then, can exhibit only the two corresponding states — zero output and full output.

One basic magnetic amplifier circuit — the half-wave circuit — is shown at the left. Its electrical behavior, and the behavior of the many multi-core magnetic amplifiers built around this circuit, is described by a transfer characteristic like that of part (a), illustration opposite page, which is a plot of the average load current as a function of the average control ampere-turns. This characteristic shows that two radically different output levels are possible. These are the full output "1" state and the zero output "0" state levels indicated as CD and AB respectively on the transfer characteristic. The "1" state of the magnetic amplifier represents the output with the cores fully saturated; it is the region in which the cores exercise no control. At the other extreme, the "0" state represents the cores as fully unsaturated. Here the magnetic amplifier blocks the power from the power-voltage source so that the output is made negligibly small. The "0" output of a bistate magnetic amplifier is commonly made less than one per cent of the "1" output.

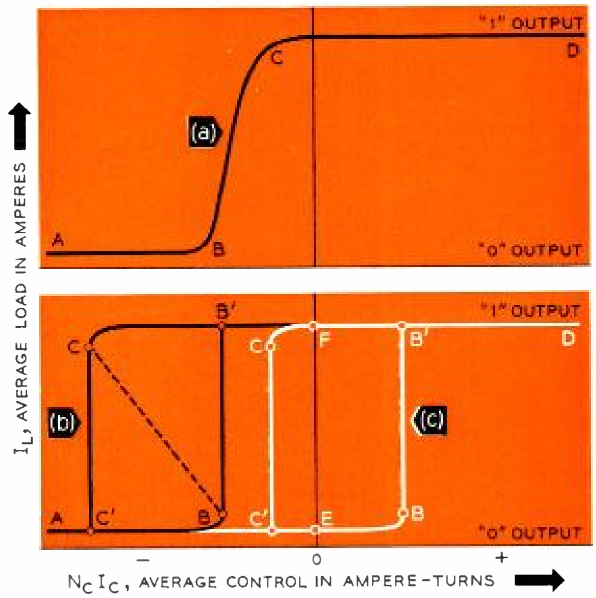
In the characteristic of the illustration, the two output states — the "1" and "0" — are connected by the steep but stable linear segment BC. Such an amplifier acts as a switch, displaying only the two distinct output states when the control signals are quantized (divided into discontinuous "bits" of information).

In a digital or switching system, the signals normally have a switching nature and usually appear in binary form. The switch having the characteristic illustrated is then designed and biased so that the quantized control signal switches it from one extreme state to the other — from A to D or vice versa. In this case the control circuit limits the amplifier output to two states. This operation, requiring the amplifier to be either on or off, is called "bistate" even though the amplifier is capable of linear operation with continuous (instead of quantized) signals in the linear region, BC, of its characteristic.

Where a switch requires a sharp "threshold" value, or memory, positive feedback is incorporated in the magnetic amplifier to obtain the transfer characteristic shown in part (b) (black lines) of the illustration at right. Here the output circuit, rather than the control circuit, limits the amplifier to the two distinct output states. For a magnetic amplifier, increasing positive feedback increases the slope of the linear section of the transfer characteristic, part (a) of the figure, through the vertical until it bends back upon itself. This is shown by the dashed line in part (b). Since the dashed section of the characteristic with a negative slope is unstable, the steady-state transfer characteristic takes the form shown by the solid lines of the curve.

There are no stable points between the "1" and "0" output levels shown as CD and AB respectively on the curve. This means that as the ampere-turns of the signal are increased from A toward positive values, the output is determined by line AC′B and at B there is an abrupt change (a switching action) in output to B′ and thence toward D. For a decreasing signal, the operating point moves along DB′C, changes in state to C′ and then moves toward A. The hysteresis, or horizontal spread between points B and C, depends on the amount of positive feedback and is tailored to specific needs.

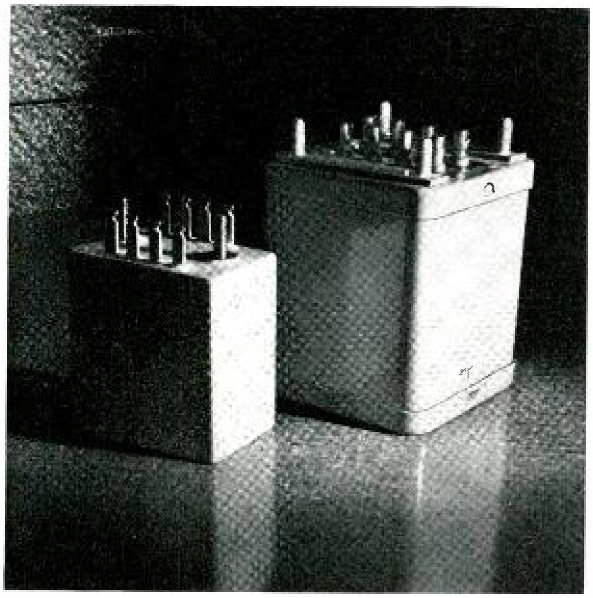
Magnetic amplifiers with these switching characteristics may be used with continuous control signals as boundary detectors which have a switching action at a specific value of signal. Biasing this type of amplifier, within the hysteresis loop of its characteristic, offers still another mode of operation which displays memory and permits control with pulsed signals. A bistate magnetic amplifier is considered to have memory if the output state is retained after the signal that caused it is removed. This type of amplifier is biased with separate bias windings so that the ordinate of the transfer characteristic is shifted within the hysteresis loop.



Transfer characteristic (a) describes electrical behavior of half-wave circuit. Circuit with positive feedback results in transfer characteristic of (b). Shifting transfer ordinate within the hysteresis loop (c) furnishes a memory feature.

The result is the transfer characteristic shown by the white lines in the figure above. With this characteristic, if the operating point is at E for zero signal, a positive signal pulse greater than a value equal to EB would drive the operating point along EBB′D, and then, as the signal pulse declines to zero, along DB′ to F. Thus, the positive signal pulse causes a change in output state from E to F — or from "0" to "1" in binary terminology. This change in state is retained after the signal is no longer present. It would require another signal pulse — a negative one of magnitude greater than FC — to change the output state of the amplifier back to "0".

Bistate magnetic amplifiers with memory are used for over-current and over-voltage protection. For example, if the current or voltage output of any of the power supplies in a system exceeds safe limits, the bistate amplifier switches to monitor the current or voltage. When the



Packaging arrangements for bistate magnetic amplifiers used in many Bell System projects.

bistate "monitor" switches, its output energizes a trouble-indicating lamp and operates a circuit switch to disconnect the prime power from the supplies. Because the bistate magnetic amplifier has memory (it is biased within its hysteresis loop), its output is maintained to keep the trouble lamp lit and to prevent a power-switch closure until the amplifier receives a reset signal indicating that the fault has been corrected. Where fuses and relays are unsatisfactory, a system may use bistate magnetic amplifiers instead, to take advantage of their increased reliability, precision, and flexibility.

In this protective system, the bistate magnetic amplifiers which monitor currents and voltages are identical except for their control windings. The control turns of the current monitors are few, usually a single turn, for this winding must carry the full output current of a power supply without inserting an additional impedance or loss in the power load circuit. Voltage monitors, however, have many turns in their control winding so that this winding represents a high-impedance circuit which draws a very small current proportional to the load voltage. Both monitors have broad hysteresis in their transfer characteristics and are biased within these loops so that they switch from a "0" to "1" output only when the signal current — either the power-supply load current or a current proportional to load voltage — exceeds the predetermined allowable limit.

The right hand unit in the photograph above is the bistate magnetic amplifier used in the Bell System TH Microwave Radio project for power-supply protection. The left unit in the figure is a bistate magnetic amplifier which is cast in an epoxy resin. It is representative of bistate units used for logic testing, boundary detection, timing and protective switching.

A less conventional application of magnetic amplifiers in switching is for binary decoding of digital computer outputs. In one simple form, the magnetic amplifier decoder takes a two-digit binary word from a computer and decodes it to a one-out-of-four output. With a two-digit binary word, the binary numbers, 0 and 1, can be combined in four different ways — four bits of information can be represented. For this example, the four bits of information are the compass points, North, East, South and West (see diagram, next page). For each of the four binary inputs shown, the magnetic amplifier energizes one of the leads designating N, E, S, or W.

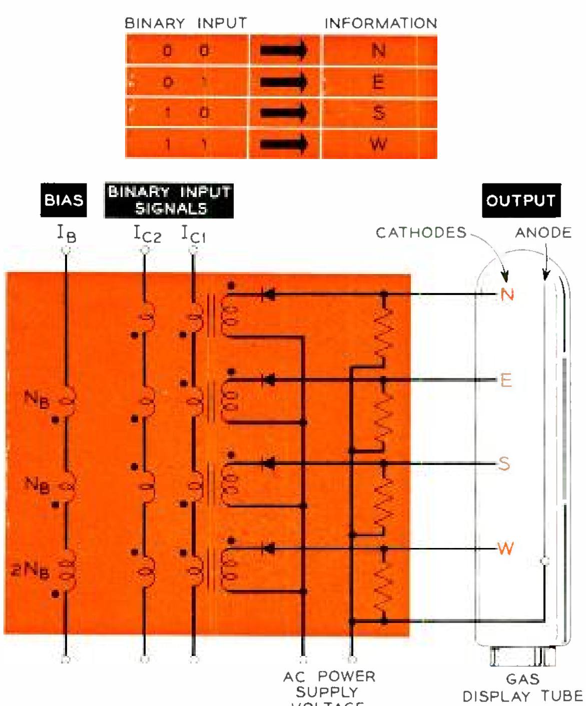
In effect, the magnetic amplifier decoder acts as a multiposition switch that distributes energy to one of four positions in response to binary signal information on two inputs. To obtain a visual display, each output lead of the magnetic amplifier is connected to a cathode element which is formed into a letter, N, E, S, or W, in a neon gas tube. The cathode letter energized by the magnetic amplifier has a red-orange neon glow.

The binary-to-quaternary magnetic decoder shown in the diagram consists of four of the half-wave circuits shown in the drawing on page 294. Each core and associated winding, diode and resistor comprise a half-wave amplifier. With the winding polarities shown by the dots (the diagrams on page 294 or 297), a control current is in the direction to switch the half-wave amplifier off (zero output) when it enters a winding at the non-dotted end. On the other hand, control current entering a winding at the dotted end is in the direction to saturate the core — it drives the amplifier on (full output). In the drawing (right), the bias current, I_B, enters the bias windings at the non-dotted end, and biases three of the four half-wave circuits in the decoder to a zero output. The "0" and "1" binary input signals appear as the absence or presence of a signal current to the magnetic amplifier. I_{C1} represents the least significant binary digit in the right hand column and I_{C2} represents the more significant digit.

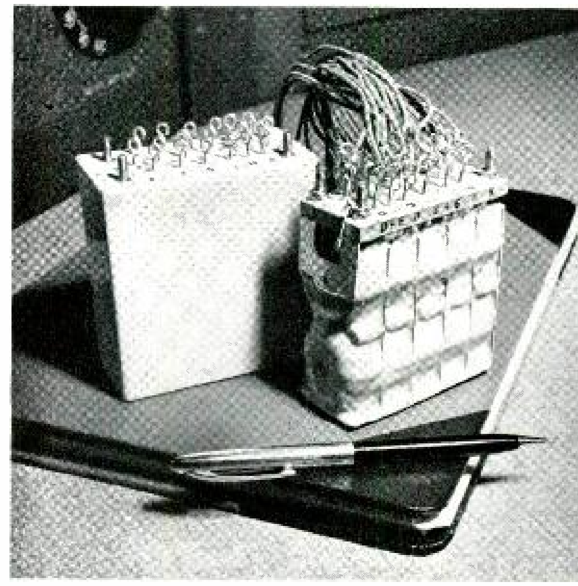
With a (0, 0) binary input, I_{C2} and I_{C1} are both absent (are zero) and only the first half-wave unit, having no bias, is on. This magnetic unit, the N-unit, acts as a closed contact switch when on, so that the display-letter N is energized. With a (0, 1) input, the current I_{C1}, representing the "1" input, turns the N-unit off. The second magnetic unit, with its signal winding in the I_{C1} column oppositely poled to the N-unit's signal winding, is turned on because I_{C1} cancels its bias. The display letter E is then energized. Although I_{C1} acts to drive the S-unit further off, the signal winding of the W-unit is poled so that I_{C1} is in the direction to turn it on. However, the W-unit remains off because the turns in its bias winding ($2N_B$) are weighted to twice that of the others. It therefore requires two binary one signals, a (1, 1) input, to cancel its bias and turn it on. In this manner, with proper polarities and bias weighting, a unique one of the half-wave magnetic amplifiers in the array is switched on with each binary input.

To take computer information in the form of a four-digit binary code and decode it to a one-out-of-ten decimal number, the half-wave units in the switching array are increased to ten and the columns of signal winding are increased to four. This new switching array is a direct extension of the principles used in the binary to quaternary decoder. In contrast to the simpler decoder, however, the binary to decimal decoder takes four-digit binary coded numbers on four input leads and energizes one of ten output leads to decode the binary number into a decimal number. The output powers a display tube with ten cathode elements, each of which is a formed number 0 through 9. The second photograph shows a model of a binary to decimal decoder before casting and in final form after casting.

These decoders underscore some of the special characteristics of magnetic amplifier switches. With little effort, the input signals may be algebraically added and subtracted in multiple-control windings. With this feature, it is often



Schematic of magnetic amplifier decoder to convert two-digit binary code to one-out-of-four code.



Compactness of a magnetic amplifier permits decimal decoder to be enclosed in a small package.

possible in a control system to process all the information directly in the signal windings of power-output magnetic amplifiers. This flexibility of circuitry and control, however, is somewhat offset by the inability to make multiple switches with a single unit in the manner of the single relay with multiple contacts.

In addition to higher capabilities in signal processing, a bistate magnetic amplifier can be far more sensitive than a relay. Bistate units have been built that switch with signals of less than one microampere. In some applications, however, this sensitivity is offset because bistate magnetic amplifiers, although faster than relays, are slower than transistors or electron tubes.

A most significant aspect of magnetic switching is its static character — there are no moving parts and no contact transfers. The widely used term "static magnetic switching" was coined to describe switching with bistate magnetic amplifiers. The basic building-block circuits and arrangements of magnetic amplifier switches have many forms. For example, the power-supply frequency of bistate magnetic amplifiers ranges from fifty to more than one million cycles per second. Although the speed of operation, the functions, and the circuitry vary according to required performance, the basic principles remain the same: a switching function is achieved by the abrupt change in state of a magnetic core.

Static magnetic switching is the product of advances in magnetic materials, semiconductor rectifiers and circuit techniques during the last decade. The bistate magnetic amplifier permits an unusually flexible and sensitive method for the control of switching operations.

Dr. Kelly Praises Achievements of H. S. Black, 1957 Lamme Medalist

Dr. M. J. Kelly, speaking at ceremonies honoring H. S. Black, declared that Mr. Black is "endowed with one of the most creative minds of his generation of electrical engineers." The occasion was the recent presentation to Mr. Black, by the American Institute of Electrical Engineers, of the 1957 Lamme Gold Medal.

While many of Mr. Black's inventions have had a large impact on electronics, the negative feedback amplifier is the most outstanding. "It easily ranks coordinate with deForest's invention of the audion as one of the two inventions of broadest scope and significance in electronics and communications of the past 50 years." Dr. Kelly stated in reviewing the career of the Medalist.

In accepting the Medal, Mr. Black, Systems Research Engineer at Bell Laboratories, discussed his own efforts over the years in developing and applying the negative feedback principle, and commented on the work of others in this field.

Summing up, he said, "These reminiscences illustrate that inventions solve problems, that sometimes one invention may be the genesis of hundreds that follow, that upon occasion an invention may lead to the discovery and development of a new principle, that invention fosters research and vice versa leading to advance after advance, that the present-day programmatic approach with its organized teamwork both stimulates and encourages contributions by individual inventors, and lastly, that the importance of an invention is measured by the difficulty and significance of the problem it solves. The most important technological advances imply solutions to the most difficult problems of our times, and in our concentrated, persistent, enthusiastic efforts to resolve these problems we find everlasting encouragement and inspiration in Lamme's own words, 'The Engineer Views Hopefully the Hitherto Unattainable.' "

As reported in the July issue of the RECORD, the 1957 Lamme Gold Medal was presented to Mr. Black at the June 23 opening session of the Summer General Meeting of the A.I.E.E. in Buffalo, N. Y. Walter J. Barrett, President of the A.I.E.E., and a member of the New Jersey Bell Telephone Company, made the presentation following an outline of the Medalist's career by Dr. Kelly.

Mr. Black received the award for his "many outstanding contributions to telecommunications and allied electronic arts, especially the invention of the negative-feedback amplifier and the successful development and application of the negative feedback amplification principle." A U.S. Patent issued to him in 1937 covers this principle.

Before the presentation of the Medal, H. I. Romnes, Chairman of the A.I.E.E. Lamme Medal Committee and Vice President for Operations and Engineering of the A.T.&T. Company, spoke on the history and establishment of the Medal.

H. S. Black, 1957 Lamme Medalist, center left, receives congratulations from Dr. M. J. Kelly, left, Walter J. Barrett, President of the A.I.E.E., center right, and H. I. Romnes, A.T.&T. Vice President for O.&E.

Two military telephone systems developed with very severe requirements by Bell Laboratories for the Signal Corps will operate under worldwide climatic conditions. Transformers were protected from high temperatures and humidities through the use of many of the latest materials and newest techniques of construction.

H. E. Vaiden and L. J. Steinbach, Jr.

Transformers for Military Communications Systems

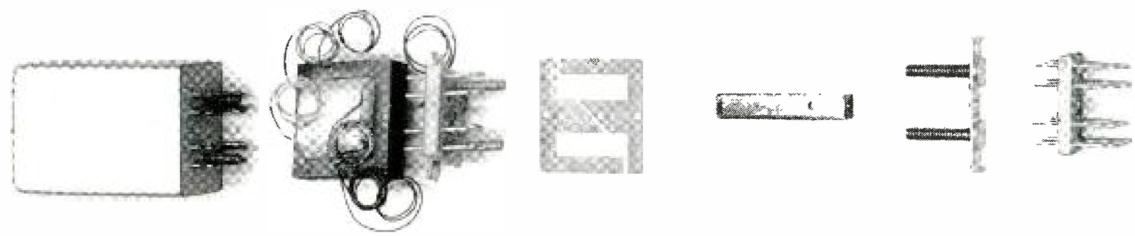
Two telephone communications systems bearing AN/TRC and AN/TCC designations (RECORD, *July* 1955, *August*, 1955) are now in production for use by the armed services. These systems permit four- and twelve-channel telephone circuits to be set up in the field over either cable or radio.

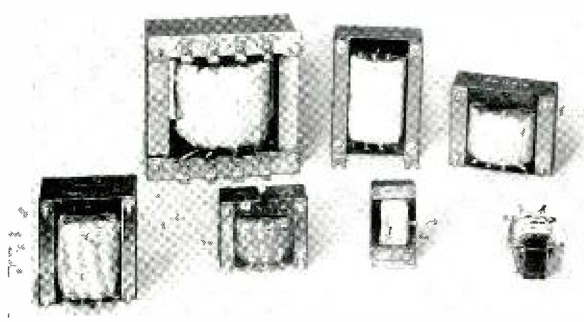
The transformers employed in this new system are in some respects quite unlike their counterparts in the Bell System. This is not surprising, for while they perform similar electrical duties, they must meet different requirements made necessary by the nature of military operations. The AN/TRC and AN/TCC equipment comprises a portable system that is set up and taken down quickly. It supplies various types of service and lends itself to easy rearrangement. It may be stored unused for long periods, and then again it may be transported, set up, and taken down frequently. In transit, the portable equipment may be subjected to rough handling. Because it must be portable and capable of operating over wide ranges of temperature and relative humidity, its transformers had to be as small and as light as possible, yet still exhibit exceptional ruggedness, reliability and resistance to climatic damage and corrosion.

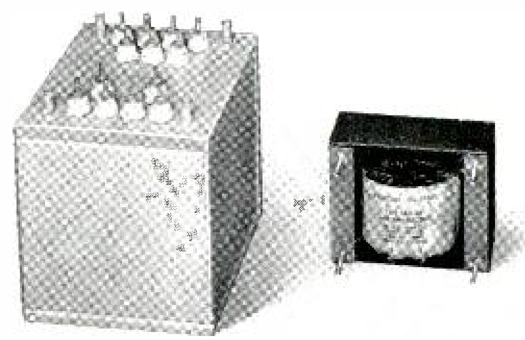
Transformers used in carrier and radio systems may be divided into two basic categories: transmission transformers and power transformers. Transmission transformers are used as components for matching impedance values or for electrically isolating one circuit from another. To mention a few more examples, they may also be used as elements in oscillators, and in networks for separating or combining frequencies and for balancing networks. Because such operations are carried on at low power levels, these transformers do not heat up in service. It is essential, therefore, that they be carefully protected from moisture, especially since they are quite small and are wound with very fine wire (about 0.002-inch in diameter).

Power transformers, on the other hand, transmit relatively large amounts of power, and their losses, while small, tend to heat up the unit and dry out any moisture accumulations. As a result, the degree of moisture resistance required is not so critical as with the transmission types. Whereas the limiting size of transmission transformers is a function of sealing and of the delicacy of fine wires, small size in power transformers is a function of allowable heat dissipation and operating temperatures. In view of this, there is quite naturally a marked divergence in the final designs for the transmission and power types.

At first glance, it would appear that a hermetically sealed construction would be required for the transmission transformers. This construction would provide the necessary moisture protection at a cost of a slightly larger product. Hermetic







Transmission transformer (top), exploded view: (r to l) terminal plate, stud and plate, bracket, laminations, core and windings added, and the finished transformer potted in aluminum can.

Range of sizes (lower left) of Class H power transformers and (lower right) a comparison of Class A transformer in relation to the Class H transformer version of same rating.

sealing, however, requires the use of special terminals or combinations of gaskets and porcelain parts to insulate the current-carrying conductors from the metal case. Such terminals are usually the mechanically weakest parts of the design, since each added terminal increases the danger of a moisture leak or low-resistance path to the case. Because these terminals project to the outside of the case, they are also vulnerable to physical damage during handling and shipment. And lastly, such terminals project into the case, where additional space must be provided to permit the connection of lead wires to them.

The transmission transformers have therefore been designed along new lines that eliminate the need for sealed terminals. They employ an epoxy type of casting resin (a thermo-setting plastic) in place of asphaltic potting materials and hermetically sealed construction. This material cures into a hard mass which adheres to metal surfaces and which is substantially impervious to moisture.

The transformers are provided with heavy wire terminals, accurately aligned by imbedding them in a plate of stypol, which is another type of thermo-setting plastic. These terminals project above and below the plate. The inside parts fit snugly around the transformer and rest against the insulated covering of the transformer windings. After the windings are connected to the terminals, tape is applied around the entire assembly to anchor the terminals securely to the windings. Because of the rigidity of this assembly, the fine wires of the winding may be attached directly to their corresponding terminals, thus eliminating any intervening lead wires.

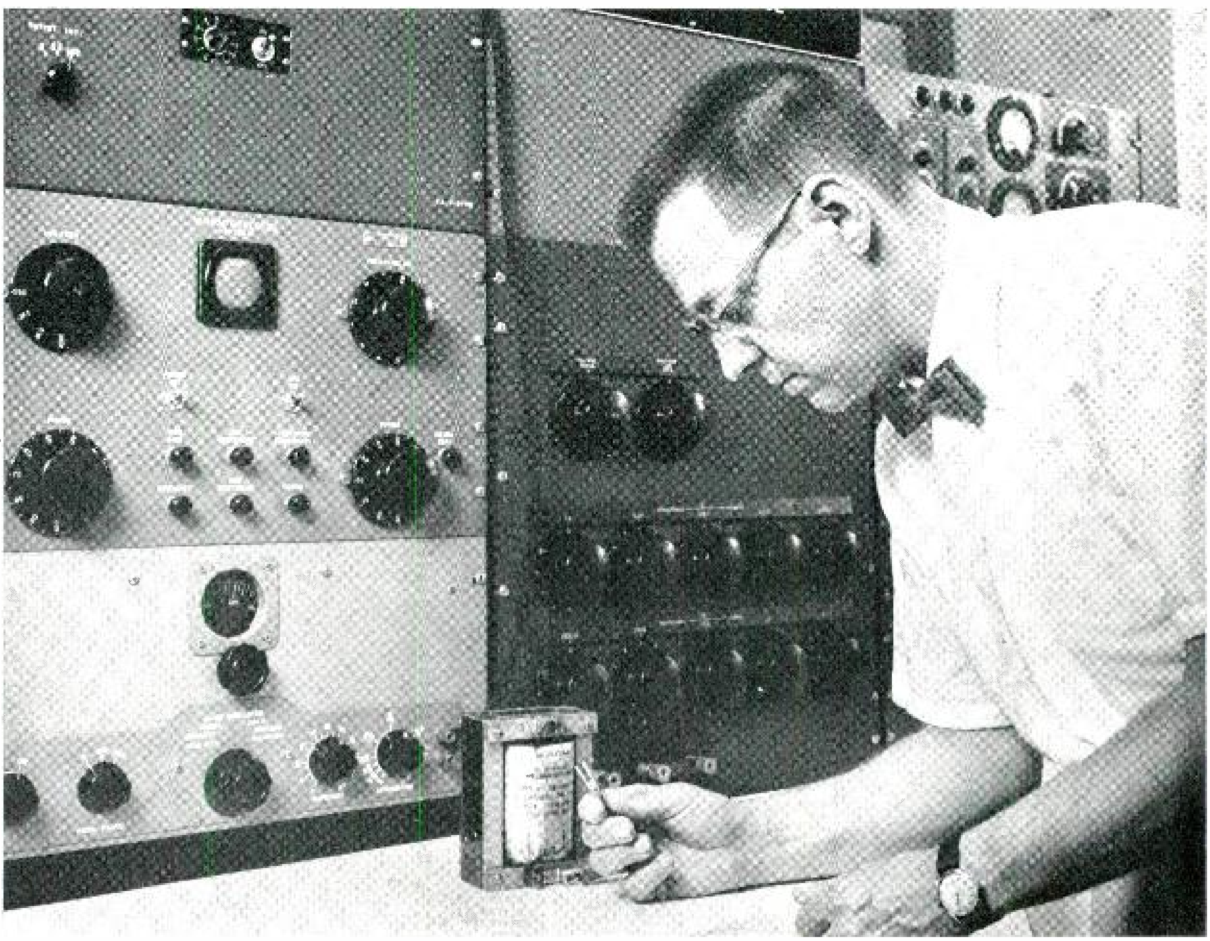
This type of construction has had an evolutionary development. The earliest forerunner was an output transformer developed for a hearing aid. Heavy, straight copper wires having a knurled section were pushed into holes in phenol-fibre terminal blocks. These assemblies were taped to either side of the winding, and the projecting ends served as terminals. Later, this transformer was followed by a construction having all terminals and mounting inserts molded into a single terminal plate. The plate was assembled to the winding by forming the terminals into a cradle, into which the winding could be slipped. These construction types were vacuum-impregnated in wax and potted with asphaltic compounds in a metal case.

Neither of these older designs could be used for the present transformers, because the epoxy casting resins do not adhere very well to phenol-fibre or to molding materials, and because terminals with hooks and eyelets are difficult to handle in injection molds. The use of a stypol terminal plate, however, retains the advantages of simplified transformer assembly, accurate terminal alignment, and elimination of internal lead wires. At the same time, it makes possible the use of hook-type terminals. In addition, the epoxy casting resin forms a chemical bond with the stypol, effectively eliminating mechanically weak internal cleavage paths between terminals.

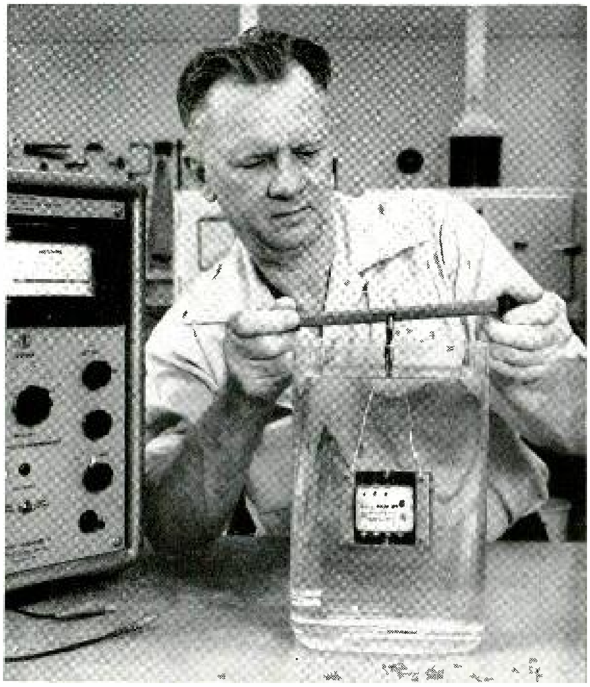
Mounting studs are welded to a bracket having sharp tongs which dig into the can sides and so provide a good electrical contact between can and studs. The bracket is also fastened to the laminations and to the stypol terminal plate so that the entire unit is mechanically supported by the mounting studs.

After the transformers have been assembled, they are placed in an oven for drying. Epoxy resin is then poured into the can, completely filling the voids and covering the windings, laminations, stypol terminal header, and bracket. The resin polymerizes in a short time and thus seals the transformer and binds all parts securely into a solid unit. After a short period of baking to improve the electrical properties of the resin, the transformers are marked and then tested to insure that they will comply with their individual requirements.

Transformers built in this manner have been subjected to thorough electrical and climatic tests. These tests have been introduced in recent years to assure reliable service life in actual use. For example, sample transformers are placed in a controlled atmosphere, and different voltages are applied. While the relative humidity is maintained at a high level, the temperature is cycled from sub-freezing range to the hottest temperature expected to be encountered in service. This test is continued through ten or more cycles, after which the transformers are retested to insure that no



L. J. Steinbach, Jr. attaches lead wire clip to an inductor prior to measuring its inductance. Thorough tests have been used in recent years to assure a long life with high quality of product.



H. I. Van Doren immerses a transformer in water. Class H insulation permits normal operation.

damage has been done. Following this test, the transformers are alternately chilled and heated by rapid transfer from −55° to +185°F to make certain that thermal shock will not injure them. The transformers are also subjected to various vibration tests. Following the tests, the transformers must still meet various electrical tests to insure that they are satisfactory.

Miniaturized elements naturally lead to equipment arrangements wherein components are mounted closer together. This has resulted in increasing the severity of the crosstalk problem associated with components having a magnetic circuit. To overcome this difficulty, a few of the transmission transformers had to be wound so as to minimize crosstalk from inductive pickup, and others had to be provided with magnetic shields. For the most part, however, the eddy current effect in the aluminum cans is sufficient to provide satisfactory magnetic shielding, especially at carrier frequencies. Electrostatic shielding is obtained by grounding all transformer cans through the mounting studs.

As mentioned earlier, power transformers are in a somewhat different category and involve a separate group of considerations. The power supplies used in the AN/TRC and AN/TCC military carrier systems were designed to operate at 115 or 230 volts plus or minus 10 per cent, 50 to 60 cycles, from either a commercial supply or an engine-driven generator.

Although radically different from the transmission types, the design of the transformers and inductors used in these power supplies was influenced by the same two objectives, namely, the apparatus had to give reliable service under adverse conditions, and it had to be as small and light in weight as possible. Relatively small size and weight were achieved by designing the windings to withstand a temperature of about 185°C. This temperature was fixed as the maximum at which the available insulation would be used to provide reliable operation under adverse conditions. The insulation referred to is between windings, between layers of the windings, between turns, and between the windings and the core. To provide the smallest practical size, insulation designated by the A.I.E.E. as "Class H" was used. This class consists of inorganic materials with binding substances composed of silicone compounds or of materials with equivalent properties.

The transformers and inductors are nonencased structures (that is, no metal can) using grain-oriented silicon steel laminations, mica insulation and copper wire with ceramic or Teflon coatings. Silicone varnish, a transparent high-temperature compound, was used to impregnate and coat the apparatus. Silicone varnish also serves to bind the insulation, wire and laminations into a rigid mass. This construction results in a product with a life expectancy of at least five years under the most adverse operating conditions and will even operate satisfactorily after immersion in water.

In the illustration on page 300, the nonencased "Class H" construction may be compared with ordinary hermetically sealed construction, which gives comparable life at maximum 125°C instead of 185°C for "Class H". It is apparent that the former is ⅓ to ½ the size and weight of the latter. If the power apparatus required for the terminal equipment for the combined system were of the ordinary sealed type, its size and weight would have been 724 cubic inches and 89 pounds. This may be compared with the 293 cubic inches and 34 pounds for the nonencased type that was used. Also, similar reductions were realized in both the size and the weight of the terminal equipment cases.

Transformers, because of their dependence upon steel laminations and because of their power-handling requirements, are generally among the larger and heavier components of a carrier system. Consequently, the smaller designs described here were an important factor in achieving reduced sizes in the new military systems.

Ferromagnetism Without Ferromagnetic Elements

A new type of ferromagnetic material has been discovered at Bell Laboratories. At low temperatures, a compound which does not contain any of the commonly known ferromagnetic elements exhibited ferromagnetic properties. This discovery was made by B. T. Matthias, Physical Research, while studying the properties of a zirconium zinc compound ($ZrZn_2$) at low temperatures.

The behavior of this compound indicates that ferromagnetic, and perhaps "anti-ferromagnetic," compounds may be formed by the combination of many more metals than had been previously supposed. The discovery thus opens up an entirely new field for scientific exploration.

Heretofore, there has been no known intermetallic compound with ferromagnetic properties that did not contain a ferromagnetic element—iron, cobalt, nickel, chromium, manganese, or a few rare-earth metals. This had led to the tacit assumption that ferromagnetism could not exist in an intermetallic compound unless it contained at least one strongly magnetic element.

Zirconium zinc becomes ferromagnetic below 35 degrees K. Its ferromagnetic characteristics are somewhat similar to, and of the same order of magnitude as, those exhibited by some ferrites at room temperatures. Discovery of these new properties in zirconium zinc provides a powerful new tool for the study of the fundamental characteristics of magnetism and magnetic materials.

B. T. Matthias adjusting samples of zirconium zinc in a cryostat preparatory to measuring its magnetic properties at very low temperatures.

Dr. M. J. Kelly (right) receives the Certificate of Merit Award from Rear Admiral John Quinn.

Laboratories Receives Navy Citation For Missile-System Work

Bell Laboratories has received a Navy Certificate of Merit for its development work in the field of guided-missile control systems. In a brief ceremony, held on June 27 at the Whippany, N. J., location of the Laboratories, Dr. M. J. Kelly accepted the certificate from Rear Admiral John Quinn, Deputy Chief of the Bureau of Ordnance, who made the presentation on behalf of the Secretary of the Navy.

The award cited the Laboratories for "outstanding service to the Department of the Navy in the field of guided-missile control systems."

"Assigned the task of developing the Weapon Direction Equipment for the first U.S. Navy ships to be equipped with guided missiles," the citation reads, "Bell Telephone Laboratories brought to completion a highly complex family of devices which permit full utilization of anti-aircraft armament of the Navy's guided missile ships. Reports from Fleet Commands attest to the remarkable performance of Designation Equipment Mark 7 and the high calibre of the development program."

The Mark 7 equipment was developed for the Navy by the Military Systems Development Department of Bell Laboratories.

A ten-year report: from the invention of the transistor to today's major research and development programs, with a glance at the future.

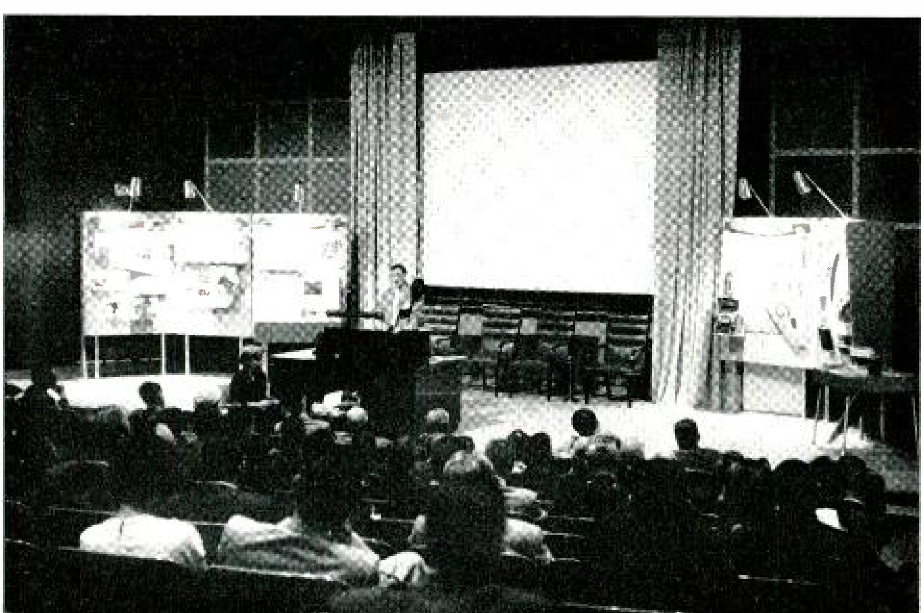
LABORATORIES MARKS A DECADE OF TRANSISTOR PROGRESS

Representatives of the nation's leading newspapers and magazines recently convened at the Murray Hill, N. J., location of Bell Laboratories to hear a full report by scientists on ten years of semiconductor progress, and to mark the tenth anniversary of the transistor.

The ceremonies, held on June 17, drew more than one hundred reporters and editors, and the next day the highlights of the conference were news in the nation's press. Scientific and technical magazines scheduled additional reports. At the conference, members of the Laboratories surveyed the semiconductor field and told of the impact of the transistor on the Bell System, on the military communications systems, and generally on this country's industry and economy.

In his keynote speech, Dr. M. J. Kelly said that transistor technology has so advanced in the last ten years that it is now technically possible for semiconductor devices to do about 70 per cent of the work done by electron tubes. He also said that the immediate obstacle to the coming dominance of transistors and semiconductor diodes was the present relatively high cost of manufacturing them for high reliability and long life. He stated, however, that he confidently expects further research and its application to result in lower costs.

Dr. Kelly said further that since the announcement of the transistor in 1948 there had been an "unprecedented expansion" of transistor technology, and that today almost one-half of the development effort of the nation in device elec-



W. J. Pietenpol tells group how transistor has influenced the Bell System and other industries throughout the United States.

E. D. Reed points out characteristics of a diode amplifier to group visiting laboratory locations.

tronics is devoted to semiconductors. The transistor, he stated, "will be the driving force in the creation of many new facilities and services, some of them as yet undreamed."

He said these predictions were possible because of the advantages of transistors — low power and voltage, the small size of semiconductor components, the long life of the devices, and the likelihood that transistors will one day cost less than electron tubes.

These advantages, he continued, have been possible in part because of at least three significant contributions by Bell Laboratories: the understanding of conduction of electricity in semiconductors that resulted from the work of W. H. Brattain, J. Bardeen and W. Shockley, who shared the 1956 Nobel Prize in Physics for their discovery of the transistor effect; techniques of growing single crystals of silicon and germanium and the "zone melting" method of purification; and the diffusion process of manufacture which permits uniformity and very high frequency operation. Diffusion is also essential to the low-cost manufacture of transistors.

In outlining semiconductor progress, Dr. Kelly explained that electron tubes operate in systems over an 11,000-megacyle frequency range, and that transistors could be designed over a frequency range of 1,000 megacycles. But within that latter range, he said, "perhaps 90 per cent of electronic systems operate." He also disclosed that recent research has demonstrated the possibility of semiconductor amplifiers for frequencies "as high or even higher than attained with advance design electron tube structures."

He believes that fundamental research will make possible low-cost manufacturing processes and bring about the "massive application" of semiconductors in electronics. "The only uncertainty, in my judgment, is the time when this goal will be reached," Dr. Kelly said.

J. P. Molnar, Vice President of Bell Laboratories in charge of military development, spoke on "Military Applications of Transistors." He said that the reliability and life of transistors developed thus far have rescued the Armed Forces from the possibility that "some fine day the Military would have its warehouses loaded with electronic equipment nobody could operate or maintain."

Mr. Molnar told the conference that before the transistor, electronic systems for weapons had become "complex monsters," which too often failed to function because of a single defective or worn out component. As a result, many people saw the possibility of electronics "going the way of the dinosaurs in the past ages."

"That day has been postponed," he said, "for at least another decade or two by the advent of the transistor." The simplicity, small size and reliability of the transistor have given military electronics in its more complicated forms "a new lease on life." He credited the transistor with making possible the building of weapons systems which require control and data processing at speeds and in volumes previously unheard of.

"Thus, we can foresee new weapons," Mr. Molnar said, "which will give us some measure of safety and defense in the missile age — even perhaps against an attack of ICBMs with hydrogen bomb warheads."

Importance of Transistor Computers

He pointed out that probably the most important military application of transistors will be in the general area of computers, the heart of systems for the control of missiles. The forerunner of the present transistorized digital computers was the TRADIC computer, first demonstrated by Bell Laboratories in 1954.

All guidance systems for the Air Force ICBMs now under development make extensive use of transistorized digital computers. Mr. Molnar said these computers are under development for the military services in at least ten different industrial laboratories for ballistic-missile guidance, anti-missile missile guidance, air defense, bombing and navigation, interceptor control and other similar purposes.

He said that while this country may have lagged behind the U.S.S.R. in the over-all field of ballistic missiles, "we are certainly not behind and perhaps even ahead in the field of computers required for guiding these missiles."

In presenting "Some Thoughts About the Future," J. A. Morton, Director of Device Development, said it is difficult "to predict the long term future in fields where there has been and is apt to be frequent and important research breakthroughs." He went on to say that the "close and sensitive interrelationship" between development and research "has resulted in development effort which has responded quickly to research accomplishments."

Even without any further important research accomplishment in the field of semiconductors, Mr. Morton said that there is this outlook for growth: simplification of designs for transistors; mechanization and automation in production to lower costs; and development of new circuit and equipment techniques that will lead to high-level, economical manufacture of large, high-speed, digital systems for computing and switching, and data transmission and processing systems.

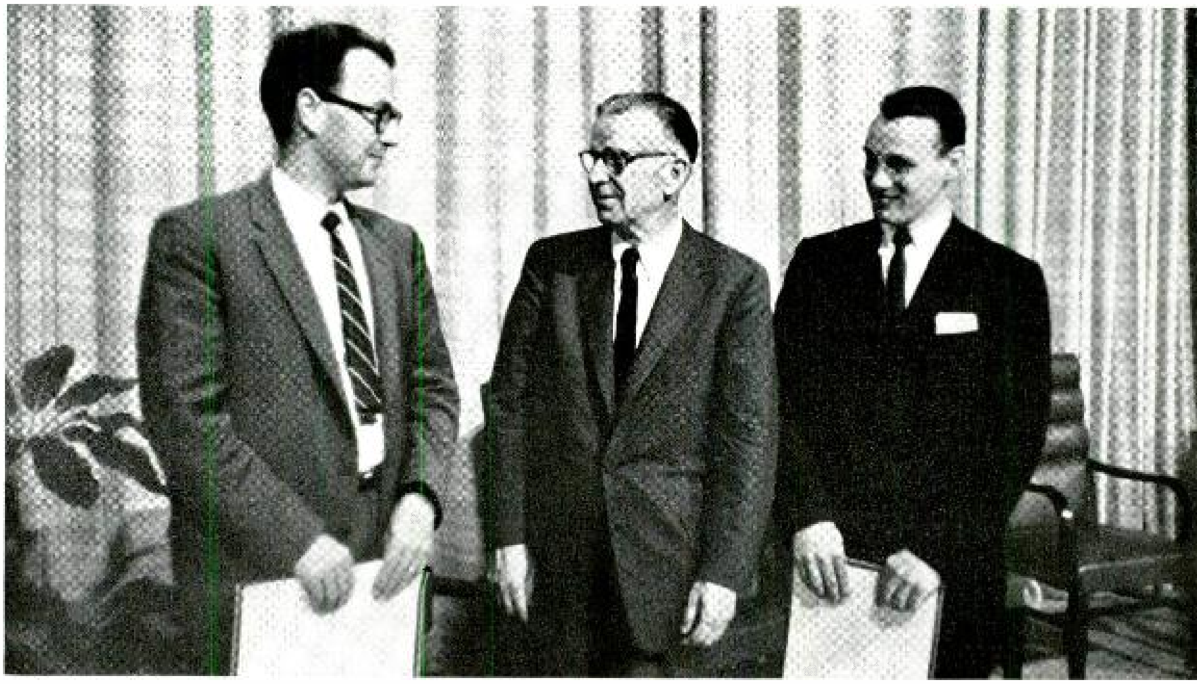
"But with the basic research achievements that may come," he said, "the future is so broad and diverse as to stagger the imagination. . . . It may well be." Mr. Morton concluded, that the extensions to man's mind from solid-state electronics "will yet have greater impact on society than the nuclear extension of man's muscle."

Some of the impact of the transistor and solid-state electronics on the Bell System was described to the gathering by W. J. Pietenpol, Director of Solid State Device Development at the Laboratories. He said "the reliability and performance of transistors have improved by leaps and bounds over the past five or six years," making designers of circuits and systems more and more confident in their use of the devices.

In addition to outlining the present uses of transistors in the telephone plant, Mr. Pietenpol mentioned equipment and systems still in the testing stages. Some of these systems, which will make large-scale use of transistors, are amplifiers of voice signals to maintain high quality telephone transmission, a transistorized "short-haul" carrier system, an electronic switching system and "TASI." TASI, which abbreviates Time Assignment Speech Interpolation, is a time-sharing transmission scheme for making more efficient use of undersea telephone channels.

As part of the activities, the group saw demonstrations of how transistors and other semiconductor devices are fabricated, and how they are being applied in the Bell System and military areas. They also had an opportunity to visit certain work areas of the Laboratories to gain some insight into current experimentation in this field.

In lobby of the Arnold Auditorium at the Murray Hill location, representatives of newspapers and magazines view exhibits of work on semiconductors and talk with Bell Laboratories experts.



Dr. M. J. Kelly, center, congratulates Fellowship winners, H. H. B. Martens, left, and F. K. Manasse.

C.D.T. Ceremonies Held at Murray Hill

Sixty-Five Receive Certificates

Sixty-five members of Technical Staff received certificates marking their successful completion of the Communications Development Training Program. Graduation exercises were held June 30 at the Murray Hill, N. J., location of Bell Laboratories. Dr. Eric A. Walker, President of Pennsylvania State University, addressed the graduates. His topic was "Your Challenge for Development."

Certificates were presented by Vice President E. I. Green. As part of the exercises, S. B. Ingram, Director of Education and Training, delivered a citation to the first C.D.T. class, the class of 1948. The citation commemorated the first ten years of the C.D.T. Program. E. E. Sumner, Transmission Systems Development Engineer, a member of the 1948 group, responded.

Dr. Kelly Awards C.D.T. Fellowships

Two Fellowship awards were also made at the ceremonies by Dr. M. J. Kelly. Recipients were Fred K. Manasse of the Special Systems Exploratory Development Department, and Henrik H. B. Martens of the Transmission Studies Department.

Known as the C.D.T. Fellowships, the grants permit recipients to acquire their Ph.D. degrees while continuing as regular Laboratories employees. They are awarded in recognition of excellent work in the C.D.T. program, and in anticipation of the candidate's promise as a member of the Laboratories Technical Staff. Fellows receive full salary and benefits while pursuing their studies at institutions of their choice.

Mr. Manasse joined the Laboratories in 1956 after receiving his bachelor's degree in electrical engineering from the City College of New York. In addition to his C.D.T. work, Mr. Manasse has completed courses leading to the M.E.E. degree, which he expects to receive this summer at C.C.N.Y. He proposes to work on his doctorate in solid-state physics at Princeton University.

Mr. Martens plans to carry out his doctoral studies in mathematics at New York University. He joined the Laboratories in 1954 as a Technical Assistant, after completing part of his undergraduate work in electrical engineering at Cooper Union. Subsequently advanced to Technical Staff Associate, Mr. Martens completed requirements for his B.E.E. degree in 1956 through evening work at Cooper Union. He was reclassified Member of Technical Staff to enter the C.D.T. Program. In addition to his C.D.T. studies, he has continued graduate work in mathematics at N.Y.U. and has participated in the Laboratories Digital Techniques Laboratory program.

Mrs. Darleen Olsen of New Jersey Bell using the new coin telephone. "Edge-on" slot is at top of box.

New Station Apparatus Being Field-Tested

Two important advances in station equipment, developed at Bell Laboratories, are currently undergoing field-trials.

In Woodbridge, N. J., a limited number of experimental coin telephones with important changes in appearance and internal operation have been placed on trial for a few months at various locations. The purpose of this trial, being conducted with the cooperation of the New Jersey Bell Telephone Company, is to test the operation of the new equipment.

A major feature of the trial telephone, developed under the direction of W. Pferd in the Station Apparatus Development Department, is the elimination of the usual gong and chime which sound when coins are deposited. They have been replaced by an electronically generated coin signal that gives one "beep" when a nickel is deposited, two when a dime is put in and five when a quarter is deposited.

Another important feature is the single, vertical "edge-on" coin slot, located at the upper front of the box, which will accept any of the three coins. This eliminates the three coin slots marked for nickels, dimes and quarters that have been on Bell System pay telephones for more than 50 years. A number of other internal and external changes have been made also.

A new repertory dialing unit will be product tested by a group of 75 businessmen in Akron, Ohio, for three months. The development of this new dialer was initiated under the direction of H. F. Hopkins, Station Instrumentalities Engineer, and was completed under the direction of W. Kalin at the Indianapolis location of Bell Laboratories.

This electrically operated device has a capacity of 50 thirteen-digit numbers. It will be used for both local and direct-distance dialing of frequently called numbers. Up to 50 separate telephone numbers can be pre-set on the dialer by "notching" codes on circular discs inside the unit. Number changes and additions to the repertory can be made by inserting new discs.

All the customer has to do to reach one of the preset numbers is move an indicator to the name he wants to call, and lift the receiver of his regular telephone. After hearing dial tone, he presses a bar, as shown in the photograph below, and the automatic dialer does the rest.

NEWS BRIEFS:

New TRADIC System Turned Over to Air Force

Two transistorized bombing and navigation systems, developed at the Laboratories, have recently been turned over to the Air Force for further evaluation. The computer for these systems is the latest version of TRADIC—the first all-transistor digital computer—announced by Bell Laboratories three years ago (RECORD, *April*, 1955).

The basic principles of this earlier computer were applied to a new computer, and then expanded into the new TRADIC System by engineers in the Military Systems Development Department. In addition to the transistorized digital computer, the system includes a partially transistorized radar, encoding and decoding devices, decimal-display devices, the plane's instruments, and navigational equipment.

The new TRADIC is the fastest airborne digital computer system presently available. It can perform 62,500 basic computations per second and it processes flight and other data fed to it by the operator and the aircraft instruments. The system makes available to the Air Force a completely new approach to achieving the accuracy, reliability and ease of operation required of modern, airborne weapons systems.

Bell System Honored for National Defense Work

The Reserve Officers Association of the United States recently presented to the Bell Telephone System ROA's highest award, the "Distinguished Service Citation," for outstanding contributions to national defense.

Brig. Gen. Delesseps S. Morrison, ROA's national president, cited the Bell System for providing a "bulwark of security behind such scientific developments as the DEW Line and numerous defense projects, many of them still secret."

The award, first to be presented to an industrial organization by the Reserve Officers Association, cites the Bell System for "establishing the concept of national defense as a primary function of the nationwide communication service in which it is engaged." The award also notes that the Operating Companies have made their resources readily available to the civilian and military services when needed.

The citation lists several defense projects that Bell companies have been requested by the defense authorities to carry out. These projects include development of the NIKE guided missile system for protection of American cities, the DEW Line warning system across the Arctic regions, an all-weather military communications system for Alaska (*see article on White Alice, page 278*), development and design of atomic weapons at the Sandia Laboratories, and work on guidance for long-range missiles, including an anti-missile missile.

Drs. Kelly, Morton and Brattain Participate in Dedication of New Semiconductor Plant

Dr. M. J. Kelly, J. A. Morton, Director of Device Development, and W. H. Brattain of the Physical Research Department participated in the dedication of a new semiconductor - components plant of Texas Instruments Incorporated, in Dallas, Texas.

Dr. Kelly delivered the keynote address on Industry Day, June 24, the concluding day of the three-day, plant-opening program. Later in the day, Mr. Morton, along with several other leaders in the field of semiconductor development and applications, participated in a symposium on the technological future for solid state devices and their impact on various fields.

The new building was formally opened following an address from Washington by Dr. James R. Killian, Chairman of the President's Advisory Committee on Science. The traditional ribbon-cutting ceremony was performed by Mr. Brattain and Mark Shepherd, Jr., Vice President of Texas Instruments in charge of the Semiconductor-Components Division. They simultaneously pressed buttons which closed a delay line where a signal from the Vanguard satellite had been kept circulating. The Vanguard signal then actuated an electronic ribbon-cutting device.

The new 310,000 square-foot plant, located on a 300-acre tract in northeast Dallas, represents an expansion of Texas Instruments' facilities and houses the Semiconductor-Components Division. It is the first of a number of buildings planned for the site to serve research, manufacturing and administration.

W. O. Baker Elected Trustee of Mellon Institute

W. O. Baker, Vice President for Research at Bell Laboratories, has accepted election as a Trustee of the Mellon Institute. The announcement was made by Gen. Matthew B. Ridgway, Chairman of the Board of Trustees, who also announced at the same time the acceptance of Dr. Lee DuBridge and Dr. Warren C. Johnson as Trustees of the Institute.

Members of the Board of Trustees of Mellon Institute participate actively in the consideration of important administrative questions in the Institute's programs of fundamental and applied scientific research, and they also participate in relevant policy making.

NEWS BRIEFS (CONTINUED)

Three New Books Written By Laboratories Authors

Three books by Bell Laboratories authors have been published recently.*

The first of these, Volume I of a projected three-volume series on transistor technology, is edited by H. E. Bridgers of the Allentown location of the Laboratories, J. H. Scaff, of the Metallurgical Research Department and J. N. Shive of the Personnel Department, formerly a member of the Semiconductor Device Development Department.

Transistor Technology is an exposition of the principles of germanium transistor fabrication. Considerable original material on this subject, prepared by the Laboratories for use by Western and its licensees, has been reviewed and revised in the light of current practice. Volumes II and III of this work are scheduled for publication later this summer.

An allied phase of semiconductor technology is taken up in *Zone Melting*, written by the inventor of this important process, W. G. Pfann of the Metallurgical Research Department. The book covers both the theory and practice of zone refining and contains comprehensive descriptions of the construction and operation of zone refiners. Applications of the method to metals and chemicals as well as to semiconductors are discussed. It also covers some of the as yet unexploited potentialities of crystallization and gives extensive coverage to solidification methods for growing and controlling the properties of semiconducting crystals, and also for making p-n junctions.

The third book, *An Introduction to Combinatorial Analysis*, was written by J. Riordan, mathematical consultant in the Systems Engineering I Department. This is an up-to-date exposition of ideas in its field, covering developments over the past half century. The emphasis is on enumeration, the treatment of which is unified by the systematic use of generating functions (of several kinds). The book deals principally with the solution of practical combinatorial problems.

* *Transistor Technology, Volume I* (Bell Laboratories Series) H. E. Bridgers, J. H. Scaff and J. N. Shive. 661 pp., $17.50, D. Van Nostrand, Princeton, N. J.; *Zone Melting*, W. G. Pfann, 236 pp., $7.50, John Wiley & Sons, Inc., New York; *An Introduction to Combinatorial Analysis*, J. Riordan. 224 pp., $8.50, John Wiley & Sons, Inc., New York.

Bell System Plans Eight One-hour Color TV Shows

Eight special, hour-long programs, in color, will be sponsored by the Bell Telephone Companies on television during the 1958-59 season. Four of the programs will be live, musical "specials" which will feature the best in music by the world's great classical, popular and folk artists, outstanding dance and choral groups, as well as Donald Voorhees' orchestra.

The other four programs will be Bell System Science Series film productions. The first of these will be "Gateways to the Mind," the story of the human senses, being produced by Warner Brothers in Hollywood. This film will be ready for an air date this fall, probably in October. Three other science programs will be televised during the winter and spring. As tentatively planned, two of these, "The Strange Case of the Cosmic Rays" and "The Unchained Goddess," will be repeats of programs produced for the science series by Frank Capra.

"Our Mr. Sun" and "Hemo the Magnificent," the first two Science Series programs, recently were given awards by *Scholastic Teacher* magazine as outstanding educational films. These awards were based on classroom use during the 1956-57 school year.

"The Unchained Goddess," the fourth program in the Science Series, won a "Chris" award as an information-education film at the Columbus Film Festival in Ohio this year. "Our Mr. Sun" won a "Chris" award last year.

J. C. Lozier Vice-Chairman of New Control Group

J. C. Lozier of the Military Systems Studies Department has been elected Vice-Chairman of the American Automatic Control Council. This newly formed group was set up by the constitutent societies to represent the United States in the 22-nation International Federation for Automatic Controls, and to coordinate the activities of these societies in the field of automatic control.

The constituent societies are: The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Institute of Radio Engineers and the Instrument Society of America.

W. T. Rea Chairman of New York Section, A.I.E.E.

W. T. Rea, Director of Data Processing Development, has been elected 1958-59 Chairman of the New York Section of the American Institute of Electrical Engineers. The Section, with a membership of more than 6,000, is the largest such division of the Institute.

He is past chairman of the Communication Division of the New York Section, and has also served as Member-at-Large, Treasurer, Secretary and Vice-Chairman of the Section.

Following is a list of the authors, titles, and places of publication of recent papers published by members of the Laboratories.

Barnes, M. W., see Basseches, H.

Basseches, H., and Barnes, M. W., *The Gassing of Liquid Dielectrics under Electrical Stress, Influence of Voltage and Pressure*, Ind. and Engg. Chem., 50, pp. 959-966, June, 1958.

Bemski, G., *Recombination in Semiconductors*, Proc. I.R.E., 46, pp. 990-1004, June, 1958.

Chirba, V. G., see Gibbons, D. F.

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Geller, S., see Knox, K.

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Howard, J. B., see DeCoste, J. B.

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Large, W. V. K., see Michael, H. J.

Levenbach, G. J., *Models in Electronic Component Qualification Tests*, Proc. of the NYU-RCA Working Conf. on Theory of Reliability, pp. 14-16, May, 1958.

Liehr, A. D., *Interaction of Vibrational and Electronic Motions in Some Simple Conjugated Hydrocarbons, I: Exact Calculation of the Intensity of the* $1_{A_{1g}} \rightarrow 1_{B_{1u}}$, $1_{B_{2u}}$, Zeitschrift für Naturforschung, 13A, pp. 311-335, Apr., 1958.

Lockwood, W. H., see Peters, H.

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Michael, H. J., and Large, W. V. K., *A General Purpose Selective Signaling and Control System*, Electrical Engg., 77, pp. 486-491, June, 1958.

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Moll, J. L., and Thomas, D. E., *Junction Transistor Short Circuit Current Gain and Phase Determination*, Proc. I.R.E., 46, pp. 1177-1184, June, 1958.

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Senitzky, B., see Moll, J. L.

Senitzky, B., and Moll, J. L., *Breakdown in Silicon*, Phys. Rev., 110, pp. 612-620, May 1, 1958.

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Sherwood, R. C., see Williams, H. J.

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Suhl, H., *Origin and Use of Instabilities in Ferromagnetic Resonance*, J. Appl. Phys., 29, pp. 416-421, March, 1958.

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Uhlir, A., Jr., see Moll, J. L.

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Wallder, V. T., see DeCoste, J. B.

Williams, H. J., and Sherwood, R. C., *Motion Pictures of Magnetic Writing on Thin Films of MnBi*, J. Appl. Phys., 29, p. 296, March, 1958.

TALKS

Following is a list of speakers, titles, and places of presentation for recent talks presented by members of Bell Laboratories.

North Carolina A.I.E.E. Midstate Subsection Meeting, Winston-Salem

Blanchard, T. G., *Computing and Metering Magnetic Amplifiers.*

Feldman, D., *Bi-State Magnetic Amplifier Operation and Application.*

Haines, A. B., *Modern Magnetic Amplifiers — Background and Basic Principles.*

A.I.E.E.-I.R.E. Solid State Device Research Conference, Ohio State University, Columbus, Ohio

Atalla, M. M., and Scheibner, E. J., *Stabilization of Silicon Surfaces by Thermally Grown Oxides.*

Bakanowski, A. E., see Cranna, N. G.

Cranna, N. G., Uhlir, A., Jr., and Bakanowski, A. E., *Diffused Nonlinear Capacitance Diodes for Microwave Circuits.*

Engelbrecht, R. S., *A Low-Noise Nonlinear Reactance Traveling Wave Amplifier.*

Howard, B. T., see Ross, I. M.

Mackintosh, I. M., see Ross, I. M.

Moll, J. L., *Studies of Breakdown in Silicon.*

Ross, I. M., Smits, F. M., and Howard, B. T., *Temperature Dependence of Transistor Alpha and pnpn Turn-On Current.*

Ross, I. M., Smits, F. M., and Mackintosh, I. M., *pnpn Current Limiter* (Presented by Smits, F. M.).

Scheibner, E. J., see Atalla, M. M.

Smits, F. M., see Ross, I. M.

Uhlir, A., Jr., see Cranna, N. G.

International Conference on Solid State Physics in Electronics and Telecommunications, Brussels, Belgium

Early, J. M., *Structure-Determined Gain-Band Product of Junction Triode Transistors.*

Hoover, C. W., and Raag, H., *New Techniques For The Measurement of Phosphor Characteristics.*

Hobstetter, J. N., see Pfann, W. G.

Indig, G. S., see Pfann, W. G.

Pfann, W. G., Hobstetter, J. N., and Indig, G. S., *Preventing Conductivity Fluctuations During Growth of a Semiconducting Crystal.*

Raag, H., see Hoover, C. W., Jr.

Scovil, H. E. D., *Some Performance Characteristics of a Solid State Maser* (Presented by Gordon, J. P.).

Suhl, H., *A Ferromagnetic Microwave Amplifier.*

Uhlir, A., Jr., *Semiconductor Diodes for Low-Noise Microwave Amplification.*

Wannier, G. H., *Band Dynamics and Zener Effect.*

American Physical Society, Ithaca, New York

Allen, F. G., and D'Asaro, L. A., *Field Emission from Silicon.*

Brady, G. W., *Structure in Ferric Chloride Solutions.*

Bridges, T. J., *Electron Beam Parametric Amplifiers.*

D'Asaro, L. A., see Allen, F. G.

Kleinman, D. A., see Logan R. A.

Kleinman, D. A., *Energy Bands in Bismuth.*

Logan, R. A., Pearson, G. L., and Kleinman, D. A., *Anisotropic Mobilities in Plastically Deformed Germanium.*

Pearson, G. L., see Logan, R. A.

Shulman, R. G., *NMR and Hyperfine Interactions in Paramagnetic Solutions.*

Spitzer, W. G., *Infrared Properties of Alpha and Beta Silicon Carbide.*

American Crystallographic Association, Marquette University, Milwaukee, Wisconsin

Abrahams, S. C., *A Comparison of the Degree of Refinement Obtained by Two Different Dimensional Least Squares Refinement Programs, in the Case of 4,4-dichlorodiphenyl Sulfone.*

Bond, W. L., see Geller, S.

Booth, D. P. (Miss), see Geller, S.

Geller, S., and Wernick, J. H., *Ternary Semiconducting Compounds With Sodium Chloride-Like Structure: $AgSbSe_2$, $AgSbTe_2$, $AgBiS_2$, $AgBiSe_2$.*

Geller, S., *Garnets — Some Crystal Chemical Studies.*

Geller, S., and Bond, W. L., *The Crystal Structure and Optical Properties of Copper Fluoride Dihydrate $CuF_2 2H_2O$.*

Geller, S., and Booth, D. P. (Miss), *The Crystal Structure of Guanidinium Gallium Sulfate Hexahydrate $C(NH_2)_3 Ga(SO_4)_2 6H_2O$.*

Wernick, J. H., see Geller, S.

Electron Tube Research Conference, Quebec, Canada

Cutler, C. C., *Diagonal Waves on a Thin Sheet Beam of Electron.*

DeGrasse, R. W., see Seidel, H.

Feinstein, J., *A Multi-Stream Analytic Approach to the Electron Beam Noise Problem.*

Herrmann, G. F., *A 500 mc, Low Noise Up-Conversion Amplifier.*

Olson, H. M., *Experimental Investigation of Magnetron Amplifier Theory.*

Schulz-Du Bois, E. O., *Paramagnetic Spectra of Substituted Sapphires.*

Seidel, H., and DeGrasse, R. W., *Slow Wave Structures for Maser Amplifiers* (Presented by DeGrasse, R. W.).

Uenohara, M., *A 6000 mc, Low Noise, Variable Reactance Amplifier.*

Summer Course in Advanced Theory of the Logical Design of Digital Computers, University of Michigan, Ann Arbor, Mich.

McCluskey, E. J., Jr., *Interactive Switching Networks.*

Moore, E. F., *A General Introductory Survey of Automata.*

Moore, E. F., *Reliable Circuits Using Less Reliable Relays.*

Moore, E. F., Minsky, M. (MIT), and Carr, J. W., III (U. of Mich.), *Can Machines Think?*

Other Talks

Albano, V. J., *Coulometric Analysis of Films on Metals,* Gordon Research Conference on Physical Metallurgy, New Hampton School, New Hampton, N. H.

Allen, F. G., *Cleaning of Silicon as Seen in the Field Emission Microscope,* Field Emission Symposium, University of Chicago, Chicago, Ill.

Babington, W., and Weissmann, G. F., *A High Damping Magnesium Alloy for Missile Applications,* A.S.T.M. Annual Meeting, Boston, Mass.

Barns, R. L., *A New Method of Measuring Contacts Directed Toward Predicting Their Reliability,* Seminar on Electric Contacts, Pennsylvania State University, University Park, Pa.

Barry, J. F., *The Importance of Vocational Skills in Industrial Projects,* Richlandtown, Pa.

Becker, J. A., *Some Experiments with Cu-Phthalocyanine on Tungsten,* Field Emission Symposium, University of Chicago, Chicago, Ill.

Bell, D. T., *Impact of High-Speed Digital Computers on Engineering Problems,* Computer Seminar, Pennsylvania State University, University Park, Pa.

Bolt, R. H., and Schroeder, M. R., *Frequency and Space Irregularities of Steady State Sound Transmission in Rooms,* Fourth All Union Congress on Acoustics, Moscow, U.S.S.R.

Chynoweth, A. G., *Some Recent Studies at Bell Laboratories on Ferroelectrics and, In Particular, on the Processes of Polarization Reversal,* Physics Seminar, Cornell University, Ithaca, N. Y.

Conrad, D. A., *Thermal Singularities for Cylindrical Shells,* Third U. S. Nat'l Congress of Appl. Mechanics, Brown University, Providence, R. I.

Danielson, W. E., McDowell, H. L., and Reed, E. D., *Design of 100 Milliwatt Helix TW Amplifier at 50 kmc.,* International Conf. on Microwave Valves, London, England.

David, E. E., Jr., *Artificial Auditory Recognition in Telephony,* San Jose Scientific Conf., San Jose, Calif.

Felker, J. H., *Inside Computers,* St. Louis Controllers Institute, St. Louis, Mo.

Ferrell, E. B., *Statistical Methods in Engineering Design,* 12th Annual Convention of the A.S.Q.C., Boston, Mass.

Foster, F. G., *Improving Image Quality in Photomacrographs,* Microscopy Symposium, Chicago, Ill.

Freudenstein, F., *Angular Accuracy of Precision Spur Gears,* Am. Gears Mfg. Assoc. Annual Meeting, Hot Springs, Va.

Galt, J. K., and Williams, H. J., *Magnetic Domains,* Joint Meeting of the Physical and Powder Metallurgy Groups of the New York Section of the A.I.M.E., New York City.

Gambrill, L. M., *"White Alice" — A New Communication System for Alaska,* University of Colorado, Boulder, Colo.

Geballe, T. H., *Investigations of Thermal Conductivity and Thermoelectricity in Germanium,* General Electric Research Laboratory, Schenectady, N. Y.

Gordon, J. P., *A Two-Level Solid State Maser,* I.E.E., Savoy Place, London, England.

Hamming, R. W., *Stable Prediction Correction Methods for Integrating Ordinary Differential Equations,* CEIR, Washington, D. C., and Argonne Laboratories, Lemont, Ill.

Ingram, S. B., *Off-Campus Resident Graduate Programs at Company Centers,* Conf. on Electrical Engineering Education, Sagamore Conference Center, Syracuse University, Rawuette Lake, N. Y.

Kinsburg, B. J., *Distribution Requirement Specification,* 12th Annual Convention of the A.S.Q.C., Boston, Mass.

Kolk, P. E., *Transient Voltage Problems Encountered in the Development of Power Supplies Using Silicon Diodes,* A.I.E.E. Summer General Meeting, Buffalo, N. Y.

Law, J. T., *The Surface of Semiconductors,* University of Liege, Belgium.

Matthias, B. T., *Superconductors and Ferromagnets,* Kamerlingh Onnes Low Temperature Meeting, Leiden, Holland.

McDowell, H. L., see Danielson, W. E.

McNally, J. O., *Status Report on the Ceramic Receiving Tube Development,* Electronic Components Conf., Los Angeles, Calif.

Murphy, R. B., *Setting and Obtaining Tolerances,* NYU-Industry Conf. on Reliability Theory, Gould House, Ardsley, N. Y.

TALKS (CONTINUED)

Reed, E. D., see Danielson, W. E.

Riesz, G. W., *The NIKE-AJAX Guided Missile System*, Northern New Jersey Section, I.R.E., Arnold Auditorium, Murray Hill, N. J.

Rosenthal, C. W., *Perspectives on Digital Computers*, Short Course and Conf. on Automation and Computers, University of Texas, Austin, Texas.

Schroeder, M. R., see Bolt, R. H.

Schulz-Du Bois, E. O., *Paramagnetic Spectra of Substituted Sapphires and Their Applications in Solid State Maser*, U. S. Army Signal Research and Development Laboratories, Ft. Monmouth, N. J.

Slepian, D., *Information Theory*, Institute Management Sciences, New York Academy of Sciences, N. Y. C.

Troussoff, G. B., *Maintainability of NIKE-AJAX Ground Equipment*, University of Pennsylvania, Philadelphia, Pa.

Uhlir, A., Jr., *Junction Diodes in Microwave Circuits*, International Convention on Microwave Valves, I.E.E., London, England.

Weissmann, G. F., see Babington, W.

Wilkinson, R. I., *Queueing Theory and Some of Its Industrial Applications*, A.S.Q.C., Boston, Mass.

Williams, H. J., see Galt, J. K.

Wood, D. L., *Infrared Spectra of Magnetic Oxide Crystals*, Symposium on Molecular Structure and Spectroscopy, Ohio State University, Columbus, Ohio.

Yokelson, B. J., *Low Level Switching Circuits*, Institute on Industrial Applications of Transistors, Marquette University, Milwaukee, Wis.

PATENTS

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

Anderson, F. B. and Edson, J. O. — *Communication System; Intermediate Relay Repeater Station* — 2,833,861.

Boyet, H. and Weisbaum, S. — *Field Displacement Isolator* — 2,834,945.

Boyle, W. S. and Smith, J. L. — *Low Voltage Arc Welding Circuit for Use with Percussion Hand Welder* — 2,836,703.

Edson, J. O., see Anderson, J. O.

Ellwood, W. B. — *Electric Switch* — 2,834,848.

Fox, A. G. — *Broad Band Directional Couplers* — 2,834,944.

Fuller, C. S. — *Manufacture of Semiconductive Devices* — 2,836,523.

Grisdale, R. O. and Rowen, J. H. — *Mechanically Coupled Electromechanical and Magnetomechanical Transducers* — 2,834,943.

Kaminow, I. P. — *Self-Quenching Oscillator* — 2,836,724.

Ketchledge, R. W. — *Optical Storage System* — 2,834,005.

Kompfner, R. — *Traveling Wave Tube* — 2,834,908.

Krantz, H. K. — *Rotary Relay* — 2,836,674.

Lakatos, E. and Och, H. G. — *Computing System and Method* — 2,833,471.

Lynch, R. T. and Speck, L. J. — *Method of Forming an Extruded Cathode* — 2,834,673.

Marrison, W. A. — *Heat-Controlled Acoustic Wave System* — 2,836,033.

McCarthy, J. A. — *Grid Structure* — 2,834,900.

McCrory, J. R. — *Automatic Continuous Zero-Setting of a Balanced Detector* — 2,833,921.

Och, H. G., see Lakatos, E.

Pierce, J. R. — *Interstage Coupling Network* — 2,835,872.

Rowen, J. H., see Grisdale, R. O.

Sansalone, F. J. and Weisbaum, S. — *Field Displacement Isolator* — 2,834,946.

Smith, J. L., see Boyle, W. S.

Smits, F. M. — *Process for Vapor-Solid Diffusion of a Conductivity-Type Determining Impurity in Semiconductors* — 2,834,697.

Speck, L. J., see Lynch, R. T.

Sullivan, M. V. — *Rectangular Wave Generator for Color Television* — 2,836,717.

Vaughan, H. E. — *Magnetic Core Signal Generator* — 2,835,741.

Vogelsong, J. H. — *Regenerative Transistor Amplifiers* — 2,835,828.

Waltz, M. C. — *Crystal Rectifier* — 2,835,810.

Weisbaum, S. — *Field Displacement Isolator* — 2,834,947.

Weisbaum, S., see Boyet, H.

Weisbaum, S., see Sansalone, F. J.

Wirth, H. J. — *Sealed Magnetic Relay* — 2,836,676.

W. H. Tidd

W. H. Tidd ("White Alice: New Radio Voice For Alaskan Outposts"), is a native of White Plains, N. Y. He was graduated from Cornell University in 1929 with a degree in Electrical Engineering. After joining the Development and Research Department of A.T.&T. in 1929, Mr. Tidd was engaged in the development of carrier telephone systems. With the merger of the Development and Research department of A.T.&T. with Bell Telephone Laboratories in 1934, this work was continued. It included the design and development of cable carrier, open-wire carrier, coaxial systems, and field tests in connection with them. During the war he was engaged in the development of radio countermeasures equipment for the Signal Corps. After the war he returned to carrier telephone work, specializing in development of transmission testing equipment. Currently he is interested in investigations of extended range radio propagation and the engineering of military radio communication systems. He is a member of the I.R.E., the A.I.E.E., Tau Beta Pi, and of Eta Kappa Nu.

David Katz is the author of "Magnetic Amplifiers: Bistate Operation and Application" in this issue of the RECORD. His home town is New York City and he received the Bachelor's and Master's degrees, both in Electrical Engineering, from the Polytechnic Institute of Brooklyn. Mr. Katz became a member of the technical staff at Bell Telephone Laboratories in 1953, after spending several years in development work on mechanical power rectifiers and

David Katz

on non-linear magnetic circuits at the Westinghouse Electric Corporation in Pittsburgh, Pa. Since 1953, he has been responsible at the Laboratories for the development of a variety of magnetic amplifiers and for the development of related non-linear magnetic circuits for control amplification, computation and power regulation and conversion. Mr. Katz is active in the program of the Magnetic Amplifiers Committee of the A.I.E.E.

J. E. Karlin was born in Johannesburg, Transvaal, South Africa and received the B. A. (1938) and M. A. (1939) degrees

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in psychology from the University of Capetown, South Africa, and, studying under a Commonwealth scholarship, received the Ph.D. degree (1942) from the University of Chicago. For the next three years he was engaged in military communications research at Harvard University's Psycho-Acoustic Laboratory, meanwhile taking night courses in electrical engineering at Harvard and Northeastern University. In 1945 he became the first research psychologist to join Bell Laboratories, and was engaged initially in studies of hearing. In 1949 he was part of a small group formed in the research department to look into methods of studying the needs and capabilities of telephone users. This work has been his primary concern ever since and he currently heads the Human Factors Engineering group. Dr. Karlin is a member of the Acoustical Society of America, the American Psychological Association and the Institute of Radio Engineers. In this issue, he is author of the article, "All-Numeral Dialing — Would Users Like It?"

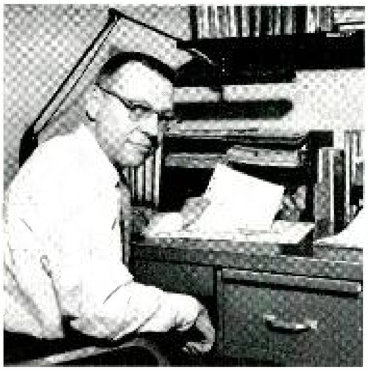
AUTHORS (CONTINUED)

F. J. Biondi

F. J. Biondi, who is a native of Bethlehem, Pa., received a B.S. degree in Chemical Engineering from Lehigh University in 1936 and an M.S. in the same field from Columbia University in 1940. He joined the Chemical Research Department of the Laboratories in 1936 and his early work was with plastic materials. He was then involved with the Laboratories' effort for the Manhattan District Project and later with the electron tube development group. Beginning with this latter association, he became increasingly concerned with the chemistry of electron tube materials and is today responsible for a group concerned with tube and transistor materials and processes. He is a member of the A.C.S., Vice-chairman of the A.S.T.M. Committee on Electronic Materials and is a past Vice-chairman for the Electronic Division of the Electrochemical Society. Mr. Biondi is the author of "Cleaning Electron Device Parts" in this issue.

Henry E. Vaiden, a native of Cleveland, Ohio, received his B.E.E. and M.E.E. degrees from the Polytechnic Institute of Brooklyn. Joining the Laboratories in 1936 after two years with the New York Edison Company, he was engaged with circuit problems in the Quality Assurance Department. From 1942 until 1952 he was a member of the Apparatus Development Department designing audio and special transformers. In 1952 he was assigned to a special project with the Magnetics Application group, returning in 1953 to supervise the special transformer design group. He has been on leave of absence since 1955 to supervise the Electronic Component Development Division of the Sandia Corporation. He is a member of Eta Kappa Nu and Tau Beta Pi. Mr. Vaiden is co-author of the article, "Transformers for Military Communication Systems", in this issue.

H. E. Vaiden



L. J. Steinbach, Jr.

L. J. Steinbach, Jr., a native of Philadelphia, Pennsylvania, joined Bell Telephone Laboratories in 1936. During 1936 and 1937 he attended Polytechnic Institute of Brooklyn and from 1938 to 1942 attended Newark College of Engineering where he received the Associate E.E. degree. Among his duties at the Laboratories, he was a Technical Assistant in the Quality Assurance Department during 1939 to 1945 and later worked on U and Y type relays in the Apparatus Development Department. During the years of World War II, he was engaged in a Naval Ordnance project and more recently, beginning in 1947, he has been associated, in the Bell Laboratories Military Apparatus Development Department, with work on power coils for both Bell System developments and Military projects. In this issue of the RECORD, Mr. Steinbach is the co-author with Mr. H. E. Vaiden of the article entitled "Transformers for Military Communications Systems."