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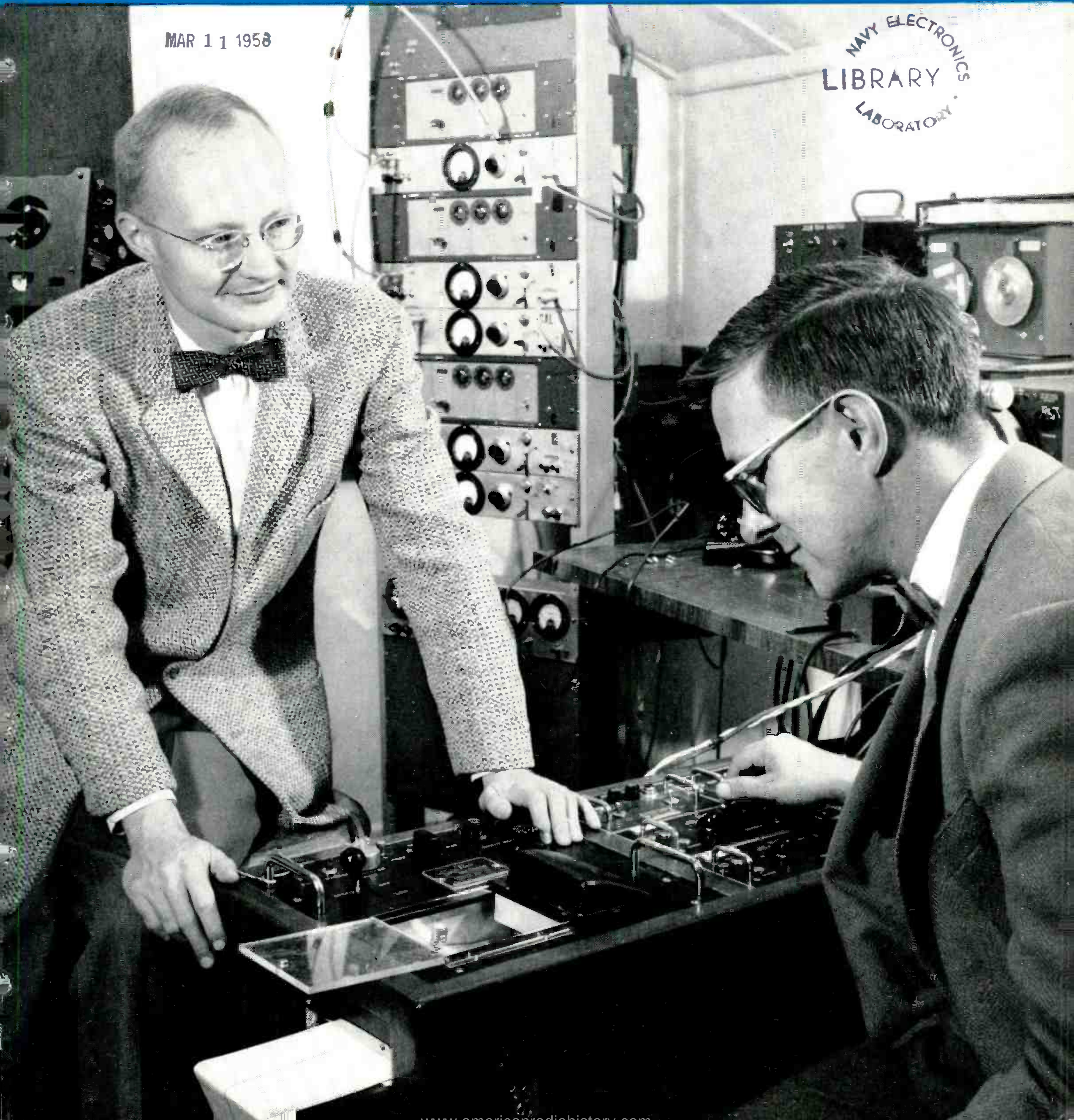

Bell Laboratories RECORD

CONTENTS

THE COVER: W. H. Kummer (left) and R. A. Semplak recording over-the-horizon microwave radio signal transmitted from a farm in Pharsalia, N. Y. (see story on page 114).

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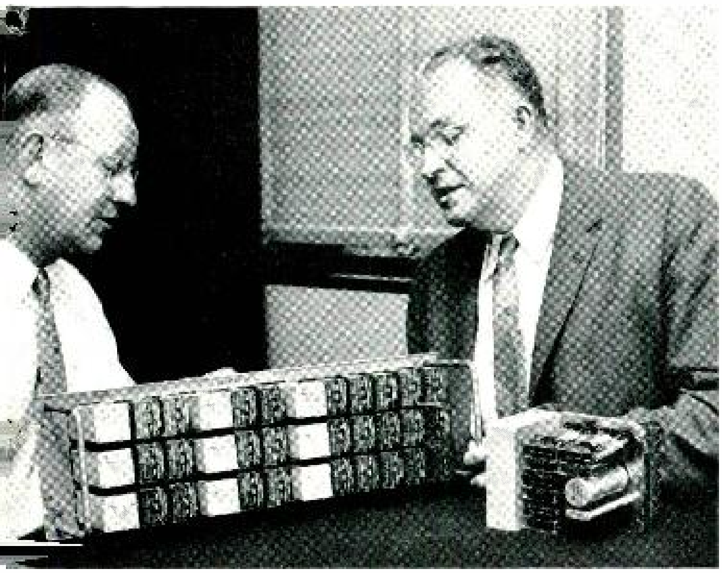


Key, or push-button, telephones have made the telephone station an almost universal tool for everyday communications. The 6A Key Telephone System, recently developed at Bell Laboratories, adds significantly to the intercommunication services, traffic capacity and special features already available with station systems.

A Versatile New Intercom System

H. T. CARTER *Station Apparatus Development*

Station apparatus – the telephones in an office or home and the associated equipment on a customer's premises – has become increasingly complex and dynamic. The many "direct-wire" telephones on the desk of the busy executive of the twenties has now been replaced by a single telephone capable of providing many services formerly impossible even with a number of special-purpose telephones at one's elbow.

This increased versatility of a single telephone has been brought about by the development of station systems using key telephones (Figure 1). Basically, station systems permit the customer, by pressing the proper button, to answer or make calls on any one of several different lines connected to his telephone. The customer can also operate a "HOLD" button to hold incoming calls on certain of these lines while making or answering a call on another of the lines.

In addition to these basic services, station systems provide intercommunication, private lines which connect to similar equipment at another location, and various visual and audible signals. Using a station system, a salesman, for example, may press the button on his telephone marked "LOCAL," dial a single digit, say "8," and be connected with his sales manager. By dialing any of the eight remaining one-digit numbers (the salesman has a number and the digit "1" is not used), the salesman can connect with any of the eight other peole on his intercommunicating circuit. This very popular feature of present station systems is called "dial-selective intercommunication."

Intercommunication, as well as the other station-system facilities, is made possible by "key telephone units" as well as key telephones. The key telephone shown in Figure 1 is a familiar sight in most offices, and is characterized by a row of push-buttons on the front of the base. Key telephone units – probably not so familiar because they are generally remote from the telephones – contain the switching, signaling and transmission equipment and circuitry necessary for the various station-system services.

A recent improvement in the circuitry of key-telephone systems has made dial-selective intercommunication available for larger groups of stations and at the same time has made it more economical to install. This improvement led to the incorporation of many new station service features. Actually, the new circuit has become a comprehensive new system, designated Key Telephone System No. 6A.

In any type of telephone equipment, particularly

Fig. 1 — Speaker phone-equipped key telephone with six push-buttons and additional "pad" of keys.

station apparatus which the customer both sees and uses, improvements are generally made with a two-fold objective. To the Bell System, the redesign must mean more versatile and economical plant equipment; to the customer it must mean tangibly better service.

For the customer, the 6A system offers many entirely new and very useful communication services. One of these new services, a "long-line circuit," makes it possible to have intercom stations located beyond the fifty-ohm limit of local cable. The only practical limitation on the number and distance of these remote stations is a financial one — the cost of private lines to the distant points. Also, our same salesman, in addition to selecting stations by dialing, will be able to use "SIGNAL" buttons on his telephone and on separate "pads" of push-buttons (Figure 1) to signal stations he frequently calls. By pressing one of these buttons, he can signal his secretary. A second button may signal another location, say, the warehouse. The salesman may also use this button to call a particular person at the warehouse by "code-calling" — pressing the button in a predetermined pattern of long or short rings. By pressing a number of "SIGNAL" buttons, the salesman may also call several stations into a conference arrangement.

Two other conferencing arrangements are also made available by the new 6A circuit. A sales manager, using the "preset" conference arrangement, may set up a conference connection with his six salesmen, or any other predetermined group, by pressing the "LOCAL" button and dialing a one-digit, conference code. If he is away from the office, the sales manager can still confer with the salesmen in the office by using a new feature called "add-on," or "inward" conference. Here, he calls Salesman A and tells him with whom he wishes to confer. Salesman A then operates his "HOLD" button to maintain this connection, establishes intercom connections with say, Salesman B and Salesman C, and then "conferences-in" the sales manager by pressing the "ADD-ON CONF." key.

Important, too, to the customer, is the increase in the number of dial-selective stations to 36 — four times the present capacity. Theoretically, the maximum is ninety, but this many stations would probably overtax the traffic capabilities of the system.

Service to the customer has been extended by two other features: "camp-on" and an improved "common-audible ringing" arrangement. If he has an urgent call to make to one of his salesmen, the sales manager can dial the salesman's station, and even though he receives a busy signal, he can "camp-on" the busy line until the system is free and automatically connects him to the salesman's station. Improved common-audible ringing permits arranging the system to have any telephone ring when any of the lines with which it is concerned – central office, PBX extensions, or other intercom lines – is signaled.

Historically, intercommunication has been one of the basic services of the telephone. The demand for services in addition to a telephone line with simple extension-stations resulted in the development of many special circuits designed to meet specific requirements. Different circuits were often developed in different localities to meet almost identical service requirements. The more popular of these circuits were eventually standardized and made available to all customers as "wiring plans." These wiring plans were quite inflexible, however, and continuing requests for additional combinations of service features led to the development of "Key Telephone Systems."

The designation "key telephone" for what is popularly known as a "push-button telephone" has been retained to avoid possible confusion with telephones equipped for push-button dialing. The term key telephone also more logically includes telephones or auxiliary "key boxes" that may use key types other than push-buttons.

The original key telephone system, No. 1A,* was developed at Bell Laboratories in 1938. In 1952, the 1A1 system† was designed to furnish services similar to those of the 1A system for medium- and large-size installations, and to make the installing of key telephone systems easier and more economical. The first key telephone systems that offered intercommunication services were generally equipped for push-button signaling with buzzers, although a few used automatic signaling when only two stations were involved. The 1A1 circuit introduced dial-selective intercommunication between as many as nine stations, a service later incorporated into the 1A system also.

This service has become even more popular than originally anticipated. Figure 2 shows how sharply the use of key telephone systems has increased in the past few years. Field experience with the new dial-selective intercommunication feature, however, indicated the desirability of some changes. Rearrangements and expansions of station-system installations frequently called for connecting stations of 1A systems to intercommunicating circuits of the 1A1 system, but the dial-selective signaling circuit was not compatible. In addition, the circuit limited the dial-selective feature to nine stations, and there were frequent requests for increasing the number of stations that could be dialed.

A redesign of the intercommunicating circuit, therefore, was recently undertaken to expand the dial-selective feature, and to simplify installations. The redesign also made it convenient to offer the new features already mentioned. As the design developed, the new circuit became so comprehensive that it no longer seemed a logical part of the 1A and 1A1 Key Telephone Systems, since it could actually be used as an isolated system with conventional single-line stations.

The basic unit of the new 6A system, and of the earlier dial-intercommunicating circuits as well, is the selector circuit (207B key-telephone unit). This unit appears in the right foreground of the photograph on page 81. Physically, this selector circuit consists of a ten-point selector switch with four wire-spring relays, and the associated circuits. These circuits furnish pulsing, timing, control, and talking-battery supply for the minimal nine-code dial-selective system of the 1A1 and 1A key telephone systems as well as the 6A system.

With the 6A system, the minimum service can be expanded, either in number of interconnecting codes or additional service features, by adding key-

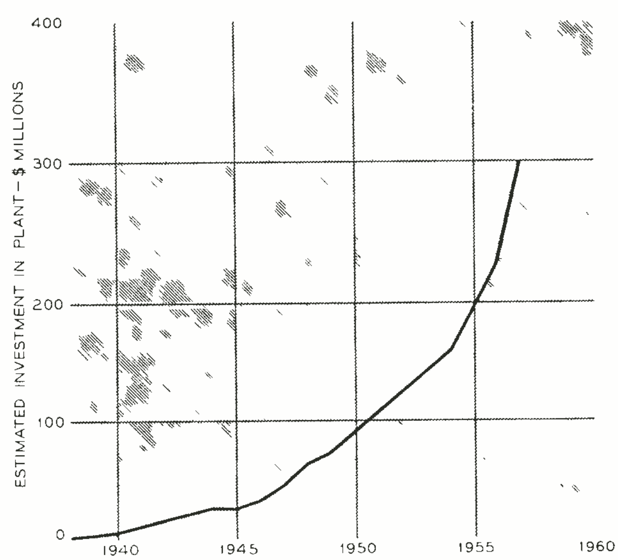


Fig. 2 — Line chart showing increased Bell System investment in key telephones since 1938.

* RECORD, *June*, 1940, *page* 315. † RECORD, *April*, 1956, *page* 210.

telephone units – the building blocks of the system – and by optional wiring. Through the use of these modules, the 6A system offers three grades of service, each geared to a different level of intercommunication requirements.

"Selector Only" service offers a "farm line" arrangement – a single circuit for both selection and talking – similar to the simplest service available with 1A and 1A1 systems, plus most of the *new* features of the 6A system as optional additions. It is designed for small or low-traffic installations requiring only minimum intercommunication facilities. Typical applications are large residences and small businesses with one or two central-office lines and several intercom stations.

The intermediate class of service – the "Single Talking Link" arrangement – provides all of the features of "Selector Only" service plus flashing line lamps to indicate incoming calls and an "automatic cutoff" feature which gives the customer privacy on established connections. With automatic cutoff, if Salesman A, for example, is talking to Salesman B, a third party on the intercom circuit could not interrupt this connection by merely pressing the "LOCAL" button.

This class of service also permits signaling over the talking pair, which generally simplifies installation. The single talking link is intended for small- and medium-size installations that have associated central-office and PBX lines. Probable uses of this class of service would include elaborate residence installations, small businesses, groups of stations served by a PBX, schools and motels. The circuit apparatus required for a typical single talking link installation is shown in Figure 3.

Fig. 3 — Typical station-system installation for single talking link class of service with twelve stations and some associated 1A1 system equipment.

The third class of service – the "Two Talking Links" arrangement – gives all stations on the system access to two talking paths in addition to all the features of the single talking link. Because of the normal statistical distribution of calls, the two talking paths, or links, are capable of carrying about eight times the traffic of the single talking link. The customer establishes calls on the primary link in the usual way. If the secondary link is idle, his call is transferred to it, leaving the primary link and selector available for new calls. If the secondary link is busy, however, the customer's call remains on the primary link until the secondary link is freed. When this happens, the call automatically transfers from the primary link to the secondary link, making the primary link available once more.

With the two talking-link arrangement, it is possible that the called stations may be busy on the secondary link, so it is necessary to supply a busy tone. The tone is generated by a vibrator and is interrupted by the lamp-flashing relay. Another option of this class of service is camp-on. Busy-tone and camp-on are also features of the single talking link, and are particularly desirable when long-line circuits or other stations without signal lamps are part of the installation.

The two talking link circuits will serve larger groups and heavier traffic in much the same situations as the single talking link arrangement. It is designed to be used extensively with push-button signaling for executive intercommunicating service (Figure 4), and for installations making considerable use of special arrangements for connecting central-office or PBX lines to stations not arranged to pick them up directly.

Any major addition to existing telephone service also affects closely associated systems. Station systems have had to operate on 14-to-26-volts dc supplied over feeders from a 24-volt battery in the central office. The scarcity of feeder cable pairs, however, has meant that in many cases it has been necessary to substitute local rectifiers such as the 101G power plant. The power arrangements usually used with older installations would be inade-

Fig. 4 — A. F. Bennett using an experimental modular key telephone for executive intercommunication.

quate for many of the 6A system installations. Major economies in the 6A system – particularly in the number of components – were achieved by designing the system to operate on 20- to 26-volts dc. To do this it was also necessary to develop a new rectifier power-plant (101J) for the larger station-system installations. New station systems will be designed to operate in this more limited voltage range, so other regulated power plants are also under development for the newer arrangements.

Most stations of a 6A system will probably have one or more lines of 1A1 or 1A systems which will have to be picked up, and for which a ringer is needed. The new common-audible circuit has been equipped with diode logic-circuits that permit as many common-audible ringers on a system as desired, without mutual interference. A maximum of two were previously available. Ringing requirements, particularly for conferences and multiple common-audible signals, also made it necessary to develop a new frequency generator (107C) with more power than the existing (107B) units.

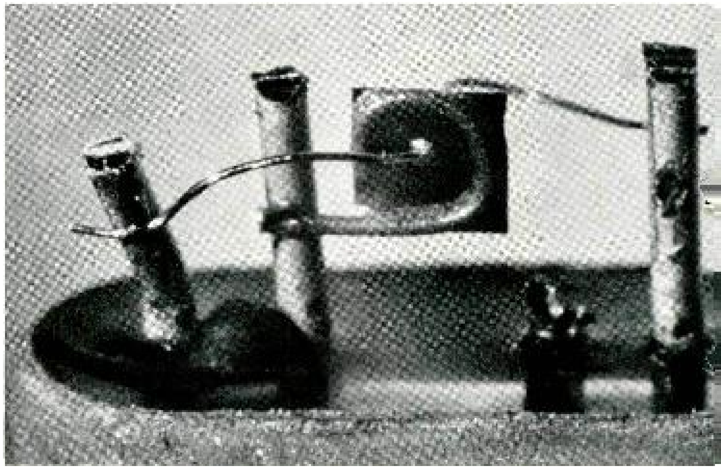
In telling the story of how an existing system was redesigned to meet the changing needs of telephone customers, there seems inevitably to be a paragraph which starts, "Still under development . . . " In the present case, two additional features currently under development are an arrangement to permit a particular off-premise station to make and receive calls over a central-office or PBX line, and a trunk circuit to permit two-way dialing to or from another 6A installation or PBX. Still in the investigation stage are a method for automatic answering at a speakerphone-equipped station, provisions for various paging arrangements, and audible ringing-tone for the calling stations.

Large-scale production of all the key telephone units of the 6A system started early this year. To the key systems already in use, the 6A circuit adds an extremely flexible intercommunication system, adaptable to a variety of special control functions.

THE AUTHOR

H. T. CARTER was born at Zanesville, Ohio. He attended Muskingum College and Ohio State University where he received the B.E.E. degree in 1930. He then joined the Development and Research Department of the A.T.&T. Company, and his work there and after transfer to Bell Laboratories in 1934 was primarily concerned with field studies of the performance of station instrumentalities, and the development of special testing equipment for such studies. During the war years, he designed transmission measuring systems and apparatus for the underwater sound-reference laboratories and field laboratories. Mr. Carter transferred to the station systems group in 1949, and he has recently been responsible for the circuit design of all station systems except those designed for military applications.

The Intrinsic-Barrier Transistor — How It Works



J. M. EARLY *Solid State Device Development*

The now familiar transistor structure typically includes three semiconductor layers of the negative and positive types. There are, however, certain limitations in this structure — principally the extent to which the thickness and resistivity of the central or base layer can be reduced. An "intrinsic" or neutral layer incorporated between the base and collector layers has permitted transistor operation at higher voltages and higher frequencies.

The demand of circuit engineers for better components – to perform circuit functions faster, better, cheaper and at lower power levels – has stimulated development of high-frequency transistors. Although point-contact transistors had for some time better frequency response than junction transistors, the regular characteristics, low noise, and good theoretical understanding of junction transistors led to speculation concerning their high-frequency response. This speculation was aimed at determining ultimate limits of junction transistors for VHF service, for broadband circuits, and even for microwave work.

Speculations necessarily started with what we knew. The junction triode in its original grown-junction form and in its alloy form was fairly well understood. Units were being produced with alpha cutoff frequencies of 5 to 20 mc; these units would oscillate at frequencies up to about 30 megacycles. Such transistors, however, were by no means the ultimate high-frequency designs of these general types. Because the operation of a transistor is largely determined by its structure, an examination of the structure to see whether better performance could be obtained seemed logical. This examination led to a reasonably accurate estimate of ultimate capabilities of alloy and grown-junction types of transistors and to the invention and development of a new type of transistor triode, the intrinsic barrier transistor or p-n-i-p.

Consider, for example, a junction transistor in a typical circuit, as shown in Figure 1(a). Here the transistor is connected with the emitter grounded – the so-called common emitter circuit. A current is introduced into the base to control the current flowing from emitter to collector. The control current is very much smaller than the controlled collector current – see Figure 1(b) – and it acts by charging and discharging the base with electrons. It thus changes the potential between the base and emitter and controls the flow of current from emitter into base and across the collector. As the frequency of operation rises, the amount of control current required increases — this in much the same way that the required current to the grid of an electron tube increases with increase of frequency.

In the transistor, of course, the base must be charged and discharged rather than the grid. Now, this charging current to the base depends at high frequencies on the transit time for charge carriers (holes in the case of this p-n-p transistor) to move from the emitter region to the collector region. If this transit time is reduced, the required control current is also reduced, thereby increasing the useful amplification — the ratio of controlled current to control current.

Two other factors are important in transistor operation at high frequencies. First, note that the control current enters the base at one side and must flow to all parts of the base to charge it with electrons. This control current encounters a resistance in flowing to the various regions of the base; the average resistance may be anywhere from 50 to 5000 ohms, depending on the particular design of the transistor. This resistance, multiplied by the square of the control current, represents control power, and to keep the control power as small as possible, the control current should flow into a low resistance.

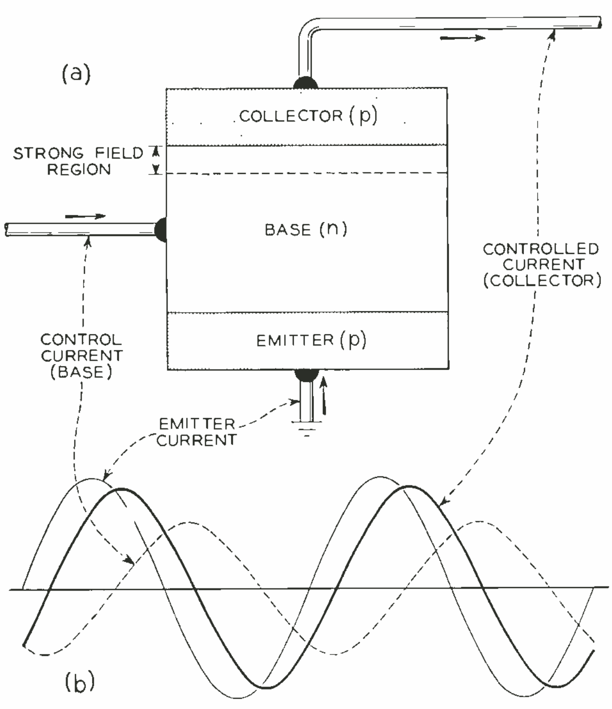


Fig. 1 — (a) Junction transistor in a common-emitter circuit; strong-field region is narrow; (b) relationship of emitter, base, and collector currents for this type of transistor circuit.

Second, there is a capacitance between the collector and base. This capacitance occurs across the "strong-field region", see Figure 1(a), separating the collector and base; it decreases as the strong-field region becomes wider and it increases as this region becomes narrower. Such capacitance should also be as small as possible, since any voltage across the load will also appear between the collector and base. A load voltage causes a current to flow through the capacitance and thereby induces an unwanted control current in the base. This gives rise to unwanted collector and emitter current. In other words, collector-to-base capacitance acts as an undesirable feedback element within the transistor.

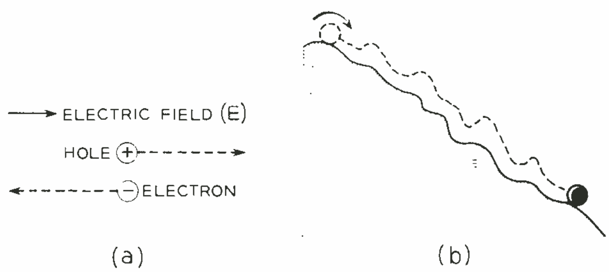


Fig. 2 — (a) In electric field, holes and electrons drift in indicated directions, but (b), they move like a stone rolling down a hill.

These facts are fundamental to transistor action, but before we see how they affect the p-n-i-p, we must examine two kinds of motion of charge carriers (holes and electrons) in the more familiar junction transistor. The more obvious of these two kinds of motion — drift — is illustrated in Figure 2. In Figure 2(a) we indicate that a hole or electron, when placed in an electric field, will move because of that field: the hole will move in the direction of the field from plus to minus and the electron against the field from minus to plus.

In the transistor, the drift of charge carriers (holes in this instance) occurs in the strong-field region, where the holes move very rapidly from the base region to the negatively biased collector region. Furthermore, the holes moving through this strong-field region are not simply uniformly accelerated by the field — as is a falling body in the gravitational field of the earth or an electron between the grid

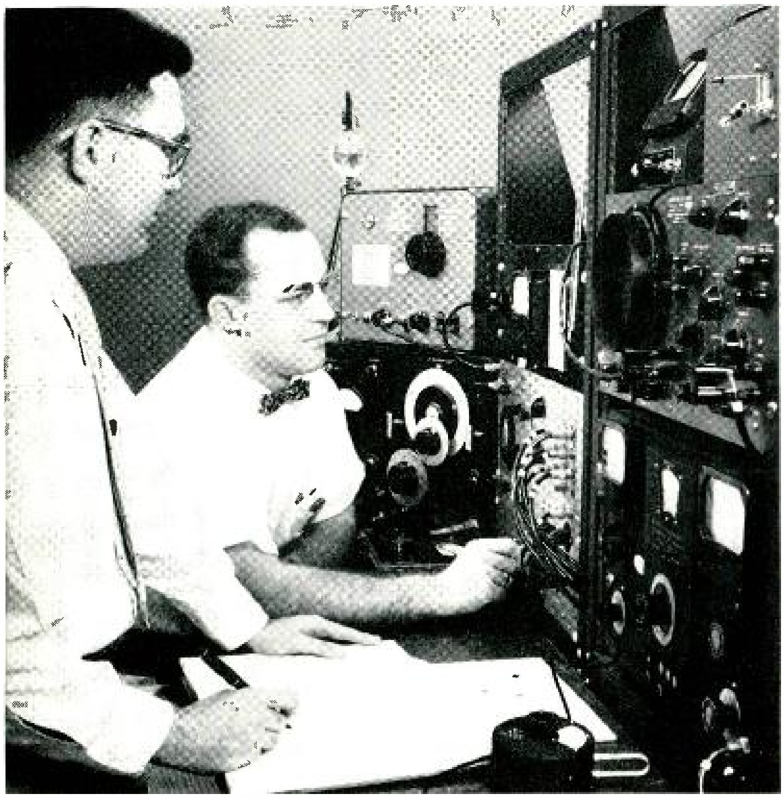


Fig. 3 — The author (left) and J. A. Wenger making electrical tests of intrinsic-barrier structures.

and plate of a tube — but rather they are continually retarded by collision with the germanium atoms and with other holes or electrons. They perhaps act more like a stone rolling down hill, as illustrated in Figure 2(b).

The second important kind of carrier motion is diffusive motion of holes. In the junction transistor, holes and electrons are continuously in motion because of thermal energy. This motion, similar to the Brownian motion observed for illuminated particles, consists of movement in random paths, as illustrated in Figure 4(a). The particles simply wander around, colliding with each other and with the germanium atoms and moving in all possible directions. Even though the particles individually show no choice of direction, it is possible to use this motion to obtain a current. For example, as shown in Figure 4(b), if there is a high concentration of particles at one point and a very low concentration at another nearby point, this random motion will carry the particles from the heavily populated region to the lightly populated region. Now, if at the edge of the lightly populated region all of the particles are pulled away completely, a continuous flow of particles is established from the heavily populated region to the lightly populated region. This, then, is a net flow of particles from left to right in the illustration.

The diffusive type of motion gives rise to current flow through the base region of the junction transistor. A high concentration of holes is created within the base at the emitter side by the forward potential applied to the emitter, and the strong-field region between the base and collector pulls away all holes which wander at random to the edge of that region. Thus, by the mechanism illustrated in Figure 4, there is a diffusive flow of holes from the emitter side of the base region to the collector side. This diffusive flow is far slower than the flow by drift, however. In alloy junction transistors, holes take about 100 times as long to cross the base region as they do to cross the strong-field region.

Since carriers take little time in crossing the strong-field region, it seems that we might make this region much wider without increasing very much the total transit time for carriers from emitter to collector. On the other hand, we might make the base region very much narrower so as to make the transit time for carriers through the base more nearly equal to the transit time through the strong-field region. If we attempt such a reduction of base thickness, however, we find that we increase the resistance to the flow of base current from the base contact into the central regions of the base. This increases greatly the base resistance and tends to increase the required control power. We can reduce the base resistance if we reduce the resistivity of the base region's material, but this tends to decrease the thickness of the strong-field region. The result is an increase in the unwanted feedback capacitance and a reduction in the maximum voltage that can be maintained between collector and base.

Therefore, while we can obtain significant improvement in the design of alloy p-n-p and n-p-n transistors by reducing the thickness of the base region, by reducing the resistivity of this region, and by reducing the area of the transistor in an effort to reduce the feedback capacitance, there are very definite limits to such modifications of design. Design calculations indicate that a transistor oscillating at 300 megacycles might be built, but that it would have a very small area and a low power dissipation.

You will note that we were prevented from going to thinner base regions and lower base resistivities because of the decrease in the width of the strong-field region and the associated larger capacitance and smaller permissible maximum voltage. An examination of the factors affecting the width of the strong-field region leads to the concept of the intrinsic-barrier transistor. First, we note that a relatively wide strong-field region is necessary in the transistor if we are to apply high and useful voltages between collector and base. In Figure 5 (a) we see sketched the distribution of charges in an ordinary p-n junction. Indicated here is the fact

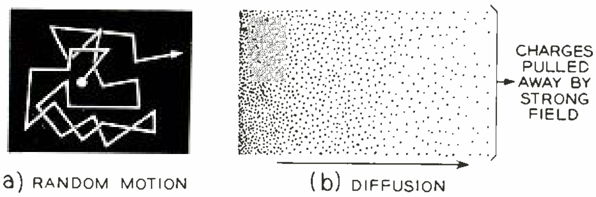


Fig. 4 — (a) Random motion of holes and electrons implies no direction for diffusion, but (b), they will diffuse from region of high concentration to region of low concentration.

that the field in the strong-field region builds up to increasingly higher values as the boundary between the n and the p regions is approached from the n side. Then, as the p-n boundary is crossed, the field decreases abruptly in the p region, because of the very high concentration of fixed negative charges in this region. In conventional p-n-p transistors designed for very high frequency operation, the field not only decreases abruptly going into the p region, but also increases very rapidly through the n region toward the junction. Thus, there is a strong but very narrow field region whose faces are close together. Capacitance is high, since the closely spaced faces act like a parallel-plate capacitor. Furthermore, the maximum voltage which can be sustained across the narrow field region is small.

In the intrinsic-barrier unit of Figure 5(b), the n and p region are separated by a wide region of intrinsic material — material which is neither n type nor p type and which contains substantially no fixed-charge centers. For this configuration, the field increases rapidly from the interior of the n region to the edge of the intrinsic region. Then the field remains at a constant value throughout the intrinsic region and decreases very quickly within the p region. The capacitance of this structure, this n-i-p junction, must be small, since the faces of the strong-field region are widely separated. In addition, the maximum voltage which can be maintained across this region must be high, since high voltages can be impressed across wide distances without exceeding the breakdown field.

The intrinsic region shown in Figure 5(b) is the distinguishing feature of the intrinsic-barrier transistor. It is incorporated into the transistor structure as illustrated in Figure 6. We see immediately the similarity to the conventional structure in Figure 1: holes are injected into the base region toward the collector; control current flows into the base region to determine the emitter and collector current; and the collector region is of p-type material. But we now see also some differences: the collector and base regions are separated by an intrinsic "layer" which acts as a strong-field region. The base layer may now be made much thinner and at the same its resistivity may be reduced. Thus, the transit time is lowered without raising the base resistance.

We have in this manner obtained several features of value. Feedback capacitance from collector to base has been reduced and the maximum voltage which can be sustained between collector and base has been greatly increased. This latter, of course, permits the transistor to operate at higher power levels than would otherwise be possible.

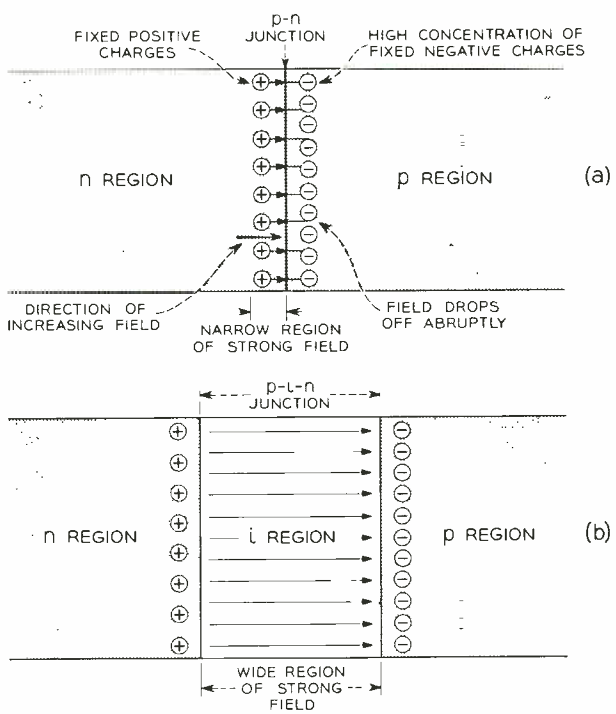


Fig. 5 — (a) Conventional p-n junction has narrow strong-field region; (b) n-i-p junction has constant field through wide intrinsic layer.

Also, because transit time from emitter to collector is reduced, emitter and collector currents are controlled by small base currents to much higher frequencies. Furthermore, smaller input power is required for any given value of control current because base resistance is reduced.

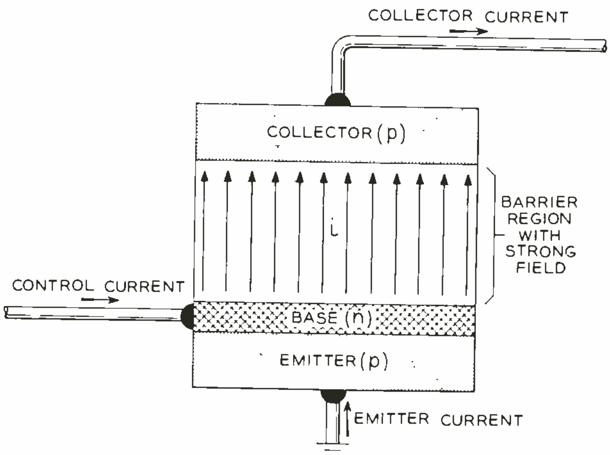


Fig. 6 — The p-n-i-p transistor in a common-emitter circuit: relatively thick i-layer has been introduced between base and collector.

An oscillator circuit in which intrinsic-barrier transistors have been operated at a frequency of 465 megacycles per second has been built. The circuit employed is a common-base circuit in which a tuned circuit is placed between the collector and base electrodes, a feedback capacitor between collector and emitter, and a tuned circuit between emitter and base. In circuits of this type, very substantial powers have been obtained at frequencies as high as 260 megacycles.

It should be emphasized that despite the reduced capacitance possible in intrinsic-barrier transistor structures, the high-frequency transistor remains a very small-area device. For example, all of the electronic action in the 465 megacycle oscillator takes place in a region which is only 0.010 inch in diameter and 0.001 inch thick. A structure so exceedingly small is, of course, difficult to construct. Nonetheless, this tiny structure promises to help solve the problem of application of the transistors to broadband systems and to tuned high-frequency systems like mobile radio.

THE AUTHOR

J. M. EARLY was born in Syracuse, New York. He received the B.S. degree in pulp and paper manufacturing from the New York State College of Forestry in 1943. After two and one-half years of military service, he joined the staff of the Department of Electrical Engineering at Ohio State University, from which he received the M.S. degree in Electrical Engineering in 1948 and the Ph. D. degree in 1951. Since joining Bell Laboratories in 1951, he has worked on junction-transistor development, particularly on high-frequency transistors. Mr. Early now heads a subdepartment working on germanium and silicon diffused-base, high-frequency transistors. He is a member of the American Physical Society and a senior member of the I.R.E.

Present and Future of the Bell System

Recently, the *Christian Science Monitor* asked Frederick R. Kappel, President of the American Telephone and Telegraph Company, to write a series of short articles dealing with the activities and aims of the Bell System. The following includes excerpts from the series, reprinted by permission.

"When I ask people outside of our business what they think the goals of the telephone company ought to be, they make practical, down-to-earth answers," F. R. Kappel, President of the A.T.&T. Co., said in introducing a series of six articles published recently in the *Christian Science Monitor*.

"Give us good service, they say, at reasonable prices. Be human and considerate in your dealings. Play fair with employees and share owners and bondholders. Look ahead – be progressive. Don't ever be complacent or self-satisfied."

SIZE AND GOOD PHONE SERVICE

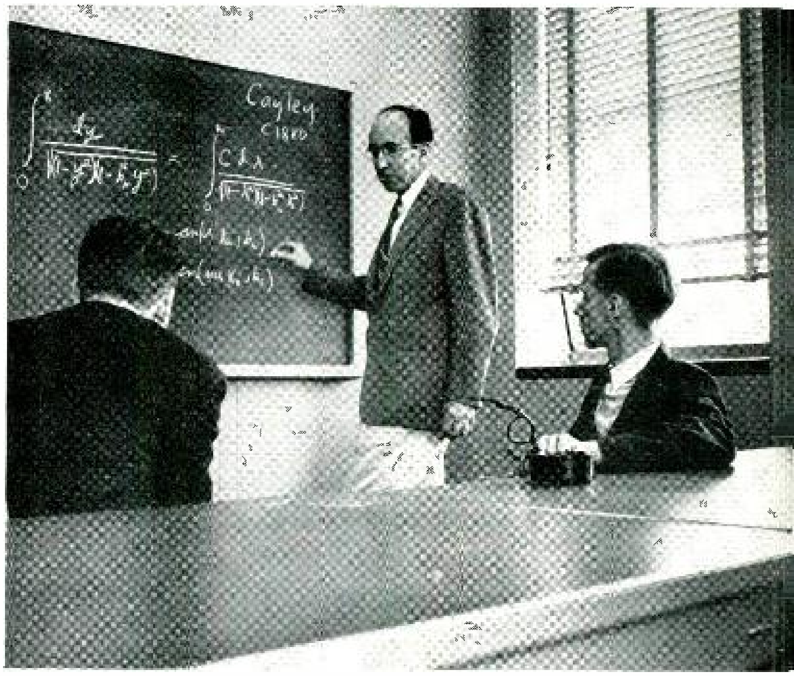
After reviewing some of the history and organization of the Bell System, Mr. Kappel went on to discuss why a big business is necessary in supplying communications service. Even though the Bell System is the biggest business of all by a considerable margin, Mr. Kappel said, "The great bulk of our work is in handling one conversation after another, and most of these are local within the community calling area.

"So, big as we are, at the same time we are a local retail business in each community. No distributor or middleman comes between us and our customers. We must live in the midst of each city or village we serve and know and heed the interests and wants of local people. We are a big business, in short, which must be a small business too in every home-town we serve. When I say 'be,' I mean just that; this is not something that can be accomplished by make-believe."

The need for bigness, Mr. Kappel said, "grows out of the very nature of our service." Since a telephone is useless by itself, "its value is in reaching other people. . . . So all the millions of telephone instruments, and the vast network of lines, and the thousands of switching offices, mean that we can give more value to each customer. In fact, this very size and abundance are really indispensable to a complete and fully satisfying service."

RESEARCH AND DEVELOPMENT

In the second of the six articles, Mr. Kappel listed the need for extensive research and development as an additional advantage of a large organization. "To begin at the beginning," Mr. Kappel said, "telephone service is based on scientific discovery. It is the fruit of basic research that has brought much new knowledge, and of thousands of inventions. These inventions have then had to be organized into systems. All of this takes a mas-



". . . telephone service is based on scientific discovery." Mathematics research at Bell Laboratories is but one area advancing the communications art.

sive coordinated research and development effort, and requires a great deal of money. Without this big-scale effort, telephone progress as we have seen it could never have come about. . . .

"One man, Alexander Graham Bell, invented the telephone. This was one of the great inventions of all time. But it was a beginning, not an end, and Bell himself observed that to create a telephone *system* was the work of many minds. Today some 10,000 people, including more than 3,000 scientists and engineers, work in Bell Telephone Laboratories. Many in the group work on defense projects for the Government, but the main emphasis is on improving telephony.

"Bell Telephone Laboratories is one of the largest research and development organizations in the world. What I am saying here is that effort on this very large scale is absolutely vital to telephone progress. . . . Very likely you have heard of the transistor. The basic transistor discoveries were made by three members of our Bell Laboratories. But they were made as part of a far-reaching effort to explore the nature of various solid materials and learn how they could be used to advance the art of communications. From this effort has come a whole new spectrum of developments which in the next generation will revolutionize telephony.

"Big research has already brought many big results in telephone service. It is this that has brought about long distance services; local and long distance dialing systems; coaxial cable and radio relay systems which can carry TV programs as well as thousands of telephone conversations simultaneously over the same route.

"It is this also that has enabled us to bring and keep the price of telephone service within the reach of millions. A telephone system is not like a water or electric power system, which can use the same line to serve additional customers. Whenever we serve a new customer, *we must also provide additional facilities so that everyone else can reach him.* So there is an inherent tendency for costs to go up as the telephone system grows. To combat this, Bell System research has continuously produced more efficient equipment, and our success in this respect goes to the very heart of telephone progress.

"I conclude therefore that large-scale research by the Bell System is not merely an advantage. It is a necessity. And I might just add here that keeping ahead in research also gives us opportunity to use the discoveries of others, in exchange for our giving them the right to use our inventions which are important to them. Clearly this too helps to keep the cost of telephone service down.

"Perhaps it hardly needs to be said that projects big in design also have to be big in execution. A timely case in point is the development of transoceanic telephone cables.

"The first of these was placed in service across the Atlantic in the autumn of 1956. Another, between the U. S. mainland and Alaska, was opened a few months later. A third, between the mainland and Hawaii, began operation last October. A fourth – also across the Atlantic – is scheduled for 1959.

"These cables are a great step forward. They are free from atmospheric disturbances which sometimes trouble the radiotelephone, and talking over them is as easy as on any other call. This is the result of some 25 years or more of Bell Laboratories work in developing and testing reliable underwater 'repeaters' which amplify the voice currents as much as a million times. But the cables are equally the product of heavy investment. The first transatlantic cable, for instance, cost nearly $40 million, and the cable to Hawaii about the same.

"To give another example, we now have in operation about 50 long distance switching systems in as many different cities to handle long distance calls which are dialed by operators and telephone users. These are key units so to speak, in the overall arrangements we are now making to enable all our customers to dial anywhere. Investment in these 50 units is already in the hundreds of millions of dollars, and there are more still to be built.

"The meaning I think is clear. If we are to have the better, faster and more convenient service that systems like these permit, we need organization on the scale that can plan and coordinate them; research on the scale that can bring them into being; and investment (with earnings to support it) on the scale that can pay for them and put them in the public service."

MANUFACTURE AND SUPPLY

In addition to the coordination of the Operating Telephone Companies and the need for large-scale research, Mr. Kappel pointed to the work of the Western Electric Company as the third function of the unified enterprise of the Bell System. "By folding this in as part of the entire Bell System job," Mr. Kappel said, "we get three-way teamwork. This to my mind is the key to success in serving the public. . . .

"The basic fact," Mr. Kappel said, "is that manufacture, like research, is embedded in the service organization. Western Electric people are just as devoted to the goal of giving service as their associates in the telephone companies. There is no dividing line, no divergence of interest, no motive at odds with the service motive. All work to the same end, and more closely than they could possibly do otherwise.

"What is the practical result?

"We continuously compare Western Electric equipment with that made by others, both as to quality and price. By every available test the equipment is superior and the price is less. No doubt Western's being the largest producer is an important factor in reducing its costs.

"Western Electric earnings over the last five years have averaged three and one-half per cent of sales. That these earnings are moderate, to say the least, every other manufacturer well knows."

In this third article of the series, Mr. Kappel also covered the work of Western Electric in such areas as supplying and distributing thousands of telephone items, and performing vital military work for national defense. Going back to the early history of Western Electric in the Bell System, Mr. Kappel pointed to the great need in those days to set standards, "and so the Bell organization bought Western and asked it to make equipment that would work at both ends, so to speak. In my own judgment, after having spent more than 30 years in the telephone companies and about three years as president of Western, I think this action, plus continuing research, has done more to give this country the best telephone service in the world than any other factor."

SERVICE AND EARNINGS

In the fourth article, Mr. Kappel emphasized that in order of importance, the Bell System puts service ahead of profits.

"The whole matter can be put in two very short sentences. They are: we must serve well to prosper. We must prosper well to serve. . . . I think we should earn enough so that in the long run the cost of the service will be *lower* than if we earned *less*.

"At first this may seem a bit of a paradox. But is it? Just consider: Only with good earnings can we conduct the business most efficiently. Only with ample resources can we push research in such a way that we will get better and more efficient equipment at the earliest possible moment. Only if we have enough money can we spend money in ways that will reduce the cost of service in the long run. . . .

"Big research has already brought many big results in telephone service." Underwater repeaters being developed for use in transatlantic cable.

"Under present conditions," Mr. Kappel continued, "I believe that earnings in the neighborhood of 8 per cent on the capital invested in the Bell System will give the best long-run assurance of excellent service at the lowest possible price. Such a return, incidentally, compares with average postwar earnings of more than 12 per cent by large manufacturing companies, with which the Bell System must compete for new capital. However we believe our earnings need not be as high as theirs because the degree of risk in our business, while increasing, is not yet as great as in theirs.

"Eight per cent is more than we earn today and more than most regulatory commissions have been willing to allow. If the principle I have set forth above is correct, why then have the commissions for the most part held telephone earnings down?

"No doubt this is partly because many regulatory people have yet to be convinced that the thesis is sound. Moreover the immediate cost of getting started is quite a hurdle to clear. If a low-earning company hasn't the money to invest in economies, it will have to have a rate increase to start the expenditures that will reduce costs. This means asking the public to pay now for future benefits. . . .

"There is no law I know of that prevents reasonable freedom under regulation. There is none that requires regulation to be timid or slow, or to put its reliance in technicalities. And I want to say that the Bell System is in no way opposed to regulation. We are not merely not opposed to it, we are for it – and this is no lip-service. A business like ours, which doesn't have competition in the same degree as many others, has to be regulated. But this doesn't make us different from other people. We react to incentives and opportunity just as they do. We too need good earnings and ample resources to put in improvements and economies. We too need freedom – under regulation – to do our very best. . . . "

GOOD PAY PLUS OPPORTUNITY

"Good and considerate service can only be rendered by people who sincerely want to meet the needs of others," Mr. Kappel said in the fifth of the six articles. "To feel that way about their jobs, they must also feel that their own needs are being considered."

Among the things most important to the success of human effort in the Bell System, Mr. Kappel listed good pay, the chance to get ahead, and the spreading of authority as much as possible.

"Decentralizing not only provides opportunity, but helps people prepare themselves for more of it. I think it is well known that the Bell System is an up-from-the-ranks business. No large share-owning interest dominates the management or says who the top managers shall be. They have to come up the ladder step by step. So it is vitally important that we push out responsibility and authority as much as we can, and give able people the kind of training that comes from having to make decisions and live with them. . . .

"Good pay plus opportunity for personal growth, and with these, decentralized authority and a continuing effort to help people increase in understanding as well as in skill – these to me are some of the essential factors in the Bell System's human effort. No more than any other group of people are we free from human shortcomings. But I think these things I have been talking about have been helpful to a good telephone job in the past, and of course what we want is that they should be even more so in the future."

BETTER PHONE SERVICE

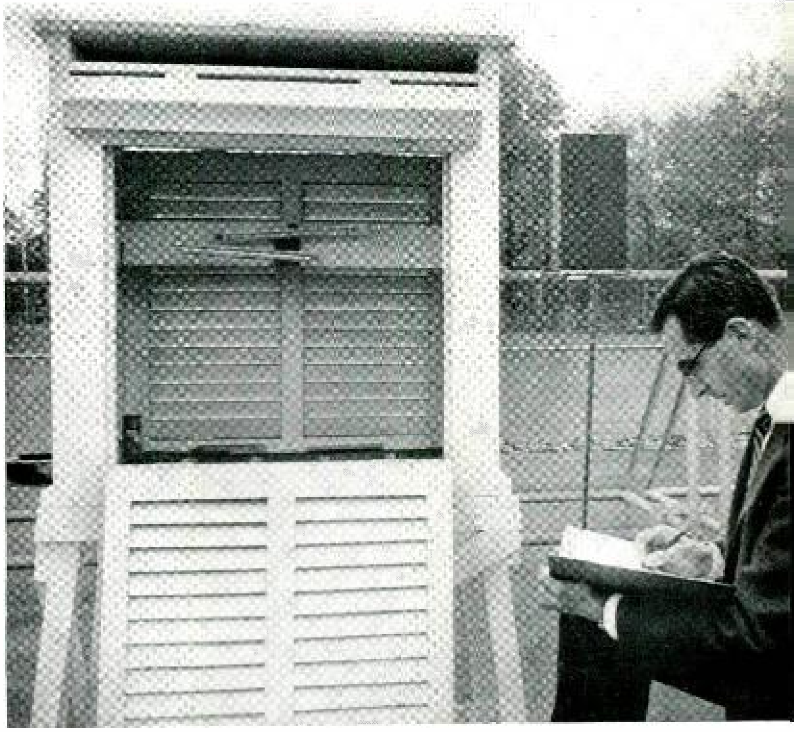
In the final article of the series, Mr. Kappel turned to the problem of making telephone service even better and more useful, and emphasized the importance of finding out what the public thinks and wants. "In addition to making our own continuous measurements of every phase of performance," he said, "we try to write down and analyze *all* criticisms and comments. We also go out and interview people to learn their attitudes and preferences. Many times, in order to make sure what a community's wishes are, we have visited every customer in town."

Mr. Kappel continued by pointing out that "If a business isn't progressive and forward-looking, it doesn't take the public long to find it out. This is as true for us as for any other business. While we may not compete in quite the same way retail stores do, or makers of shoes or sealing-wax, we don't lack spurs to a better job. We compete with other forms of communications, and with transport systems, and also with all other industry for our share of what the public has available to spend. This means too that we need to promote and sell. There is simply no basis for the old saw that 'everybody has a phone, so you don't need to advertise.' One of the main reasons for the growth of telephone service is the fact that we have promoted and sold it. Moreover this is indispensable to a vigorous and progressive spirit among employees. They compete with each other and the various Bell companies likewise compete with each other in every phase of the job. . . . "

"I am confident," he said, "that given reasonable freedom and good earnings, the telephone companies in years to come will be able to do even more in the public interest. In the last ten years our technical progress has been greater than ever before. Already millions of people can dial long distance calls directly, in a few seconds' time. By 1965 this will be the general practice for most everyone. As a practical matter, the difference between local and long distance service is beginning to disappear. . . . In the research laboratories, entirely new all-electronic switching systems are now under development. . . . Likewise, new methods will be available for transmitting all kinds of information, including person-to-person television."

In concluding the series of *Christian Science Monitor* articles, Mr. Kappel stated, "I want to say strongly that the Bell System does not intend to step outside its proper sphere of providing communications that serve the public interest. We have no wish to grow bigger merely for the sake of aggrandizement. Our job rather is to make our bigness – this vast network of lines and instruments and switching systems, which has no counterpart anywhere else in the world – to make this abundance more freely and easily useful to everyone; so that we can say to each telephone user in each community, 'All this is at your service – and there will be more.' "

Limiting the Temperature in Outside Plant Housings



H. E. PAWEL *Outside Plant Development*

New improvements in communications technology create new problems for the design engineer. Semiconductor devices, for example, ideally suit the size and power requirements for pole-mounted equipment, but are at the same time extremely sensitive to heat above certain levels. To protect such components from solar heat, the materials and finishes of future aerial housings may give these familiar boxes an entirely new appearance.

The continuous advance in the communications art has produced countless new devices, and the incorporation of these new components into the telephone plant frequently leads to entirely new requirements for many long-established items of equipment. One class of equipment thus affected is the ordinary box used to house outdoor telephone apparatus. These boxes, which are generally mounted on poles or on the sides of buildings, were originally designed to protect their contents from the entrance of moisture and from mechanical damage. Semiconductors and other heat-sensitive devices, however, put new demands on apparatus housings. In addition to simple protection, these boxes must now also ensure that the maximum operating temperature of the enclosed apparatus is not exceeded.

The importance of this new requirement for aerial housings becomes clear by noting, for instance, that 140°F is considered the highest safe operating temperature for many components of the P1 rural carrier system.* The temperature within a closed box exposed to the sun, however, may rise well beyond this limit in many sections of the United States during the summer months. To get some idea of what precautions might have to be taken to avoid this condition, studies were undertaken at Bell Laboratories with a twofold purpose: first, to determine efficient means of minimizing the temperature rise in aerially mounted boxes, and second, to establish the maximum box temperatures likely to be reached anywhere in the country.

These studies were concerned exclusively with housings for types of equipment which generate only negligible quantities of heat. This restriction was logical because low-powered semiconductor systems dissipate very little energy in the form of heat. Any rise in the temperature of

* RECORD, *August*, 1956, *page* 281; *April*, 1957, *page* 143.

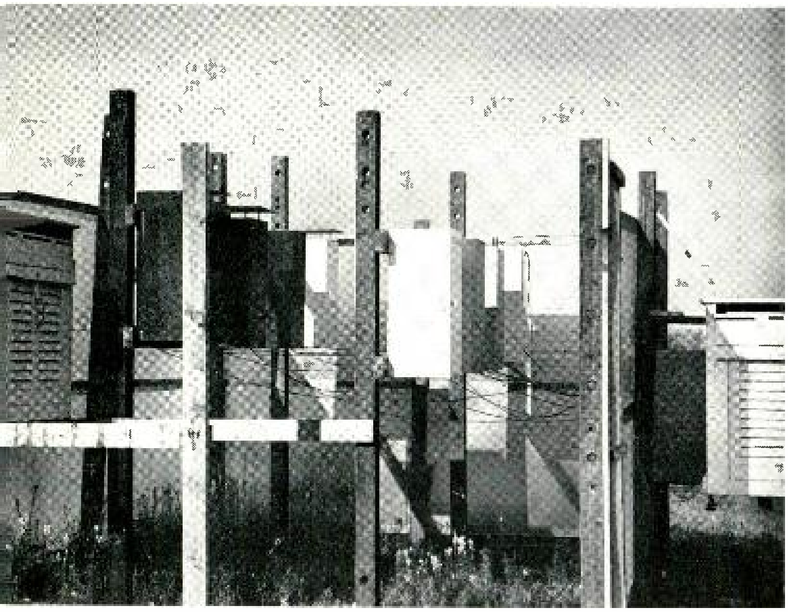


Fig. 1 — The test site at Chester, N. J. Screen in background cuts down effect of wind on temperature inside the boxes.

such outdoor-mounted, transistorized apparatus, therefore, could be attributed almost entirely to the effects of solar radiation.

The effect of solar heat on various housing designs was evaluated by box-temperature tests under conditions simulating service exposure. These tests were carried out at the test location of the Outside Plant Department in Chester, New Jersey, and at a special test site in Yuma, Arizona, where temperatures of 125°F are not uncommon. The testing at Yuma was done in collaboration with the Mountain States Telephone Company. Figure 1 shows a general view of the test setup at Chester.

Temperature measurements on the boxes at Yuma were taken at weekly intervals by means of maximum-registering thermometers suspended with their bulbs located at the center of the box. For the tests at Chester, a potentiometer temperature-indicator with iron-constantan thermocouples was used. To obtain a measure of temperature distribution, two thermocouples were installed in each test box, one at the ceiling and one at the box center.

For practical reasons, the tests at Chester were carried out in considerably greater detail than those in Yuma; however, Arizona peak temperatures are rarely exceeded anywhere in the United States, and the Yuma tests were, therefore, of substantial aid in compiling more representative data.

In devising the tests, economic and practical factors greatly narrowed the range of feasible housing designs. For instance, designs that employ forced ventilation, refrigeration, or any other system which requires power for reducing temperature, must be ruled out at once. In fact, of all the various structures considered, only two design features were found to be of practical significance — outside surface finish and sun shields.

Since these two design features proved to have the most influence on box temperature, a considerable part of the study was concerned with the effect of finish and sun shields on inside box temperature. A brief summary of the data is given in Figure 2. These data indicate that white enamel is far superior to all other exterior finishes in its ability to reflect solar heat radiation. A white finish is highly sensitive to weathering, however, and may require considerable maintenance to combat deterioration of surface reflectivity. Maintenance would be a particularly serious problem in industrial or seacoast atmospheres.

Anodized sheet aluminum behaves quite differently. Although its reflectivity is somewhat lower than that of white enamel, it will retain in

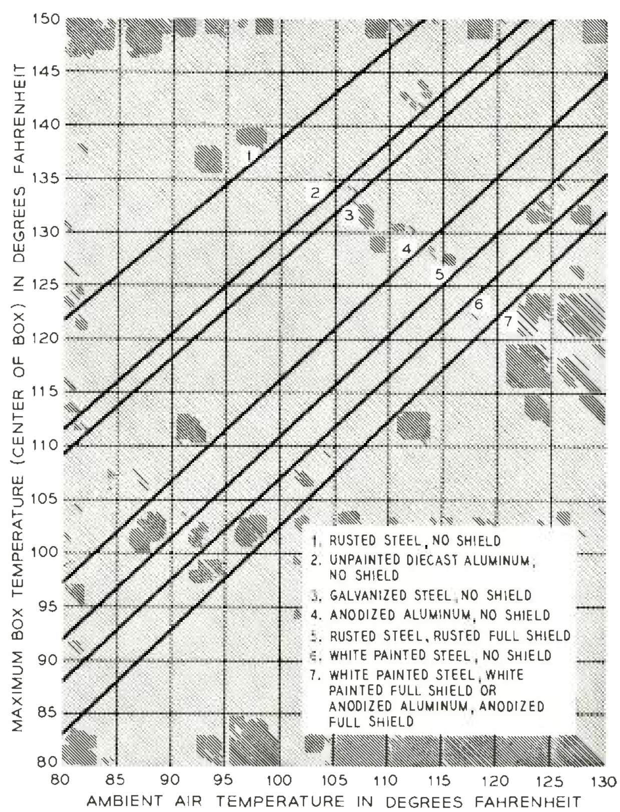


Fig. 2 — Summary of the test results. Only the most representative curves are shown.

substantial degree its heat-reflecting qualities even after weathering has changed its surface appearance to a dull gray. Also of interest is the remarkable contrast between sheet aluminum ("anodized aluminum" on curves 4 and 7, Figure 2) and diecast aluminum. Both may have practically the same smooth, mirror-like appearance to the eye, but, as Figure 2 illustrates, they are not at all identical in temperature performance. Indeed, in many parts of the country where a housing fabricated from sheet aluminum would safely remain below the required temperature limit, a diecast housing would be entirely inadequate. A galvanized finish, for years popular as a durable coating on aerial apparatus housings, is comparable to a diecast-aluminum surface and a rusted steel box closely approaches black-body behavior.

Along with the temperature at a particular point inside the box, the temperature distribution throughout the box must be considered. This distribution was found to be relatively uniform for a white-finished housing; the maximum temperature differential between the ceiling and the center of the box being about 3°F. The corresponding differential for a galvanized steel box, however, was more than 20°F.

The study also showed that the finish on interior surfaces has only a negligible effect on box temperatures. Similarly, the temperature behavior of boxes painted white on the outside is essentially the same whether the actual enclosure is made of aluminum, steel or Fiberglas. The material beneath the exterior surfaces thus has little bearing on box temperatures unless it is in the form of a heavy layer of heat insulation.

A structural feature which is practical, and which has a significant effect on inside temperature, is a sun shield. Appreciable reductions in temperature rise resulted from the use of sun shields consisting of panels mounted about two inches away from the box surfaces. A shielding arrangement similar to those used in the tests is shown in Figure 3. Regardless of surface finish, shielding prevents any direct solar radiation from reaching the box. Even a rusted-steel box protected by rusted-

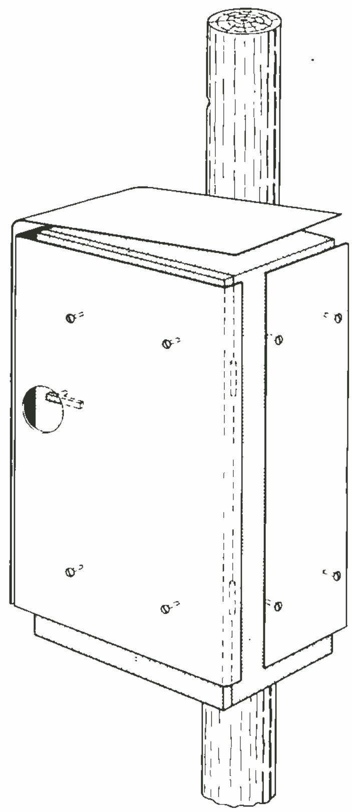


Fig. 3 — General form of sun shield used in the tests. Design details depend on shape of the specific box to be shielded.

THE AUTHOR

H. E. Pawel, a native of Breslau, Germany, joined the Outside Plant Development Department of the Laboratories in 1951, where he was concerned with cable joining and terminating problems. He left the Laboratories in 1955 and received the B.S. degree in M.E. from Newark College of Engineering one year later. Mr. Pawel is now again a member of the Outside Plant Department, engaged in fundamental development work on helix waveguides and is a second-year CDT student. He is a member of A.S.M.E. and Pi Tau Sigma.

steel shields performs remarkably well, as may be seen from curve 5 in Figure 2. A box-shield combination of anodized sheet aluminum was found to be entirely comparable to an unshielded, white-painted box, and such a structure would require far less maintenance.

Various designs of sun shields such as flat panels and hoods protecting only the box roof were also tested. Roof shields are of no essential benefit unless the vertical walls of the box have a relatively small area compared to the box ceiling. Boxes of such shape, however, are not practical for aerial apparatus housings.

Maps of the United States showing isolines of the highest temperatures ever observed for the two hottest months of the year (July and August) were used to correlate the experimental data with the conditions that might exist anywhere in the country. These maps showed that ambient air temperatures higher than 115°F are unlikely except in portions of Arizona, California and Nevada. The highest temperatures occur in the California desert where readings of 130°F are sometimes recorded.

The results of this study indicate that the temperature-sensitive outside plant equipment of the future probably could be housed in a white enclosure. Though this study did not go into the problems of maintenance economics, in certain environments a white exterior finish would undoubtedly require considerable care. As an alternative solution, an unpainted housing made of anodized sheet aluminum would be adequate in most sections of the country. In the few areas where the inside temperature of such a box might approach critical values, sufficient added protection could be provided by sun shields.

This and similar investigations were prompted by the design requirement of outside plant equipment-structures for the P1 rural carrier system. This transistorized system, which will be contained principally in outside housings, may start the trend toward a new look in equipment boxes.

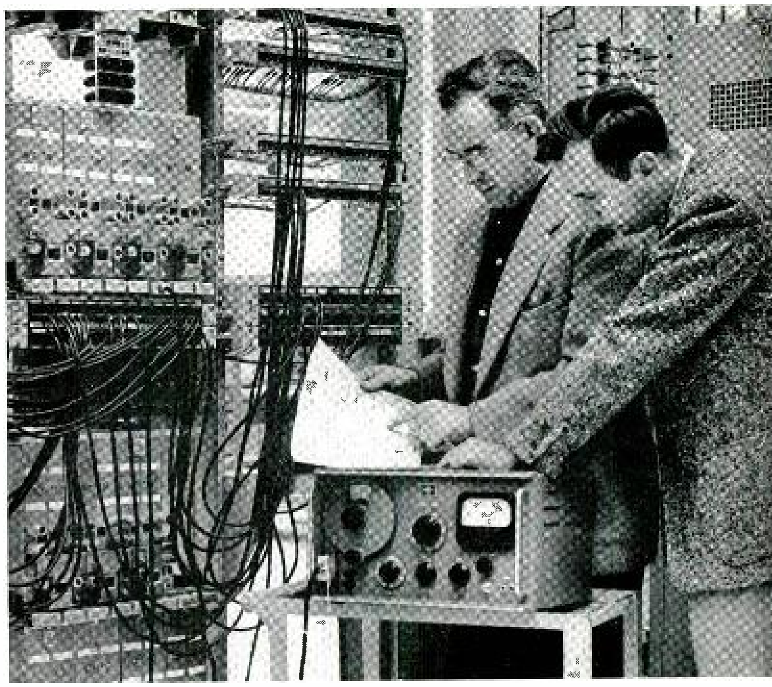
I. R. E. "Proceedings" Honors Karl G. Jansky

The special radio astronomy issue of the *Proceedings* of the Institute of Radio Engineers for January, 1958, carries a tribute to the late Karl G. Jansky for his discovery and identification at the Laboratories of extraterrestrial radiation. In an introduction to the issue, Editor D. G. Fink states:

"Radio astronomy is 25 years old, to the month. The *Proceedings* in December, 1932, carried a report by the late Karl G. Jansky that he had observed for several months mysterious atmospheric noise at the Bell Laboratories station at Holmdel, N. J. Less than a year later, he identified the source as extraterrestrial, coming from the direction of the Milky Way, and in October, 1935, he reported that the local galaxy was in fact the source. It is seldom that credit for the discovery of a new branch of radio science can be narrowed down to one man, but there is no room for doubt that Jansky was the first to show that radio emissions from the stars could be certainly identified from among all the other random noises in the spectrum."

In the same issue, Jansky's work is also commemorated in an article by his brother, I.R.E. Past President C. M. Jansky, Jr., who quotes from historic papers revealing the discovery. In 1932, Karl Jansky wrote of "a very steady hiss static, the origin of which is not yet known," and in 1933 was able to state that "data have been presented which show the existence of electromagnetic waves in the earth's atmosphere which apparently came from a direction that is fixed in space. The data obtained give for the coordinates of this direction a right ascension of 18 hours and a declination of minus 10 degrees."

Radio Links for ON Carrier



C. I. L. CRONBURG, JR., AND
C. W. SCHWIEGER

Transmission Systems Development

The versatility of Bell System short-haul carrier circuits has been greatly increased by the development of radio-link arrangements for the type-ON carrier system. Particularly in situations where open wire or cable systems are not practicable, ON on radio will permit economical extension of service.

The growing use of radio-relay as a transmission medium may be judged from the fact that within the Bell System at the end of the year 1951, about one-half million toll-circuit miles were installed, while at the end of 1957 this figure had risen to about thirteen million. A great part of these toll-circuit miles is a result of the completion of the nationwide TD-2 radio-relay systems, each carrying many hundreds of message circuits, but the less spectacular one- or two-hop systems – carrying as few as four or as many as forty-message circuits – are becoming increasingly useful. Type-ON carrier, a development that permits efficient use of type-O (open wire) carrier with type-N (cable), is used with microwave radio systems to furnish this "short-haul, light route" service.

The economy, usefulness and versatility of these short radio systems depend to a large extent on the method of applying the message circuits to the radio. As with most cable or open-wire carrier systems, this is usually done with frequency-division multiplex. With this method, a number of message channels share a common transmission medium by being stacked one above the other in the carrier frequency spectrum, so that each channel occupies a band of frequencies different from that assigned to any other channel of the system. This principle is used in type-ON carrier.

The twenty-channel type-ON carrier system is particularly useful for short-haul, light-route radio service because of its great flexibility of interconnection with open wire and cable, where wire extensions beyond radio terminals are needed. The system converts directly from radio to open wire or cable, and vice versa, without returning to voice frequencies – a feature which permits considerable savings in equipment at the radio transmitting and receiving points. This is especially advantageous when the radio equipment is in a location remote from a city or town.

Another feature which makes ON carrier especially useful for radio application is that as many as forty channels may be obtained by combining two twenty-channel groups. This yields a further advantage: at radio terminals and repeaters, groups can be split off to be transmitted over different radio routes or to be distributed to local wire circuits.

In type-ON carrier, as applied to wire lines, a twenty-channel group consists of twenty sidebands associated with ten carriers. Each carrier is shared,

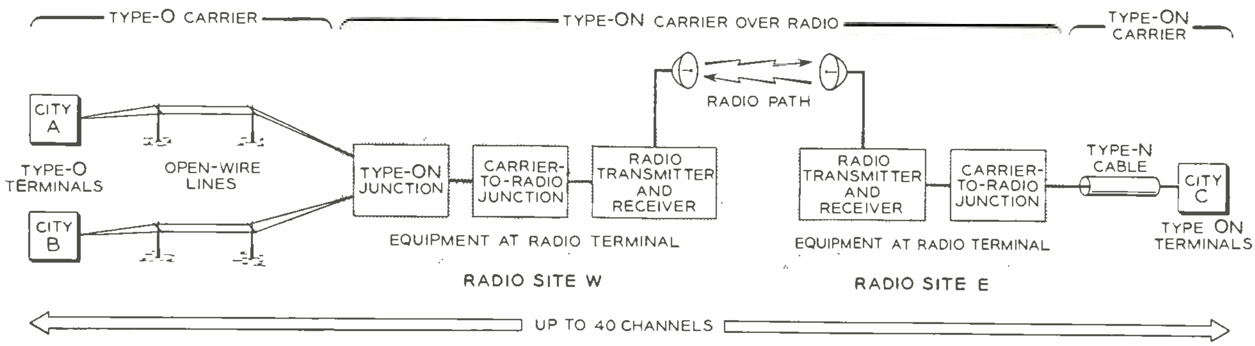


Fig. 1 — One possible arrangement of type-ON on radio in association with open-wire and cable.

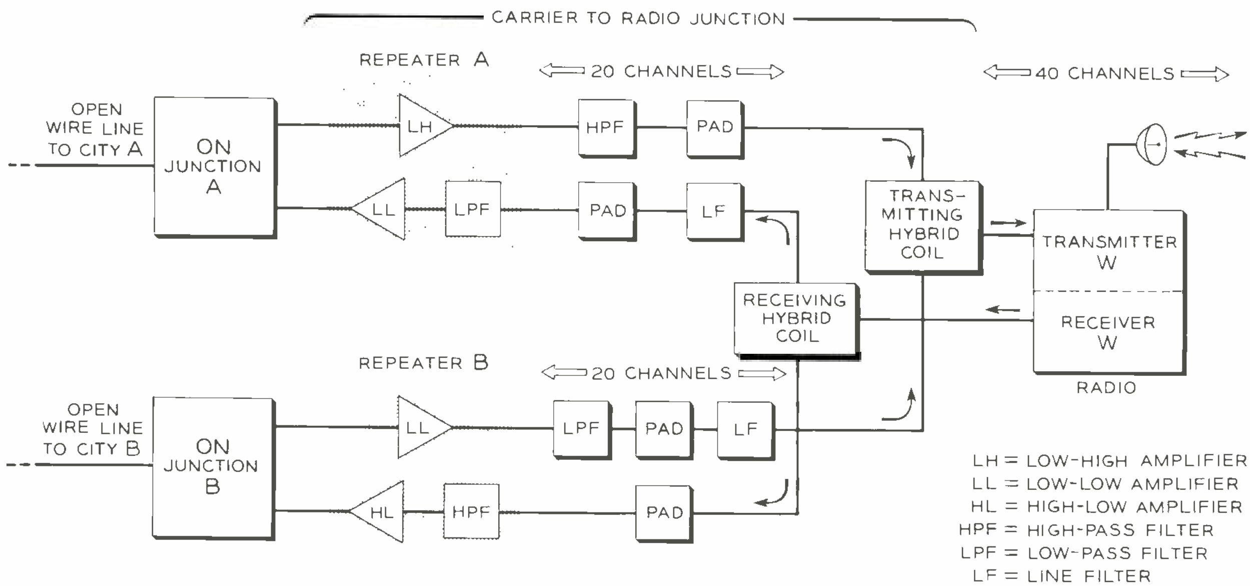


Fig. 2 — Carrier equipment at radio site "w" in Figure 1.

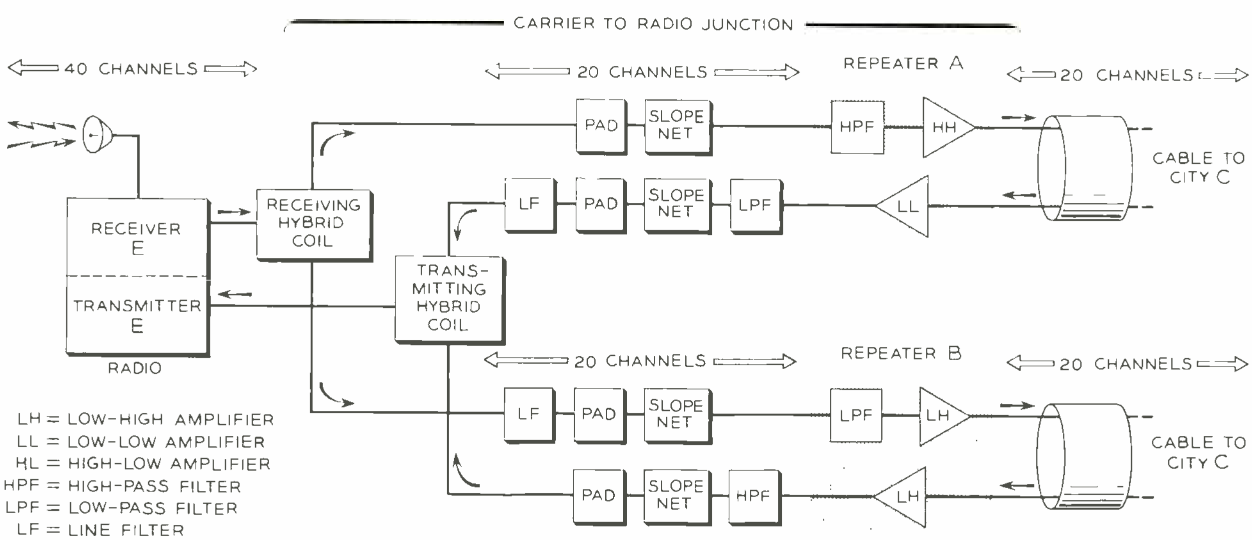


Fig. 3 — Carrier equipment at radio site "E" in Figure 1.

according to the "twin-channel" principle, by two channels — one as upper sideband, the other as lower sideband. Two twenty-channel allocations are available: 40 kc to 136 kc (type-ON low group), and 168 kc to 264 kc (type-ON high group). For stacking up to forty channels on the radio, both allocations are used: twenty low-group channels are combined with twenty high-group channels, and the resulting forty channels are applied to the input of the radio transmitter.

A typical application of type-ON carrier to radio is shown in Figure 1, which represents one of many possible arrangements of all three transmission media — open-wire, cable, and radio. Type-O carrier terminals at cities A and B are connected to type-ON terminals at city C by open-wire lines (between city A or B and radio site W), a radio path (between radio sites W and E), and cable (between radio site E and city C). The type-O and type-ON terminals and type-ON junction are no different from those used with all-wire-line systems as described in previous RECORD articles.* The wire and radio facilities are connected by the recently-developed "carrier-to-radio junctions" at the radio sites, which "stack" the two twenty-channel groups.

Two steps are required for stacking ON groups: first, one twenty-channel group must be shifted in frequency with respect to the other by modulation with a 304 kc carrier frequency, as in type-N repeaters.† Second, the two groups of frequencies are combined in a "three-winding transformer" or hybrid coil, which can transmit energy from two circuits to a third circuit with little interaction between the first two.

Figure 2 shows, in block schematic form, a detailed arrangement of the carrier equipment at radio site W of Figure 1. The input and output of ON junctions A and B toward the carrier-to-radio junction are in the ON low-group spectrum. The low-group output of ON junction A is applied to a modulating "low-high" (LH) repeater amplifier, which translates this band of frequencies to high group. The low-group output of ON junction B is transmitted through a nonmodulating "low-low" (LL) repeater amplifier without frequency change. After transmission through attenuating pads and filters, these two repeater outputs are applied to the two sides of a transmitting hybrid coil. Here they are combined, so that the input to the radio transmitter consists of frequencies in the ON low-group band for the twenty channels from city B, and frequencies in the ON high-group band for the twenty channels from city A. The high-pass and low-pass filters (HPF and LPF) suppress unwanted modulation products from the repeaters to reduce possible crosstalk. The pads which follow these filters adjust levels of signal strength and, to some extent, isolate the filters from the hybrid coils. The line filter (LF) in the low-group branch provides access to the transmission path for special low-frequency circuits (that is, below ON low group) for alarms or a maintenance-service telephone trunk.

After the two twenty-channel groups have been transmitted over the radio system, which is generally a frequency-modulation or phase-modulation microwave system, the output of the distant

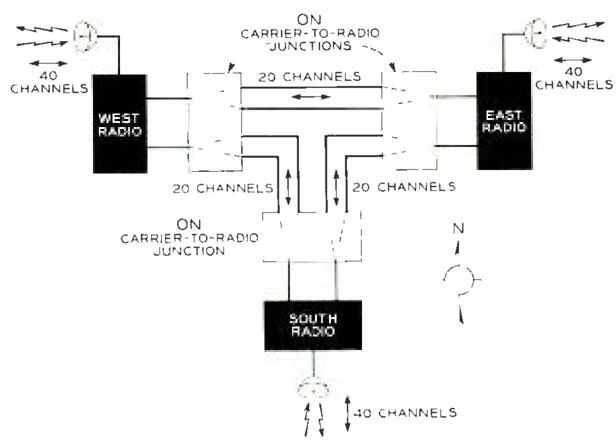


Fig. 4 — A "wye" (Y) configuration showing division of channels to form a north-south route.

radio receiver is applied to another carrier-to-radio junction similar to that in Figure 2. Figure 3 shows, in block schematic form, the arrangement of equipment at radio site E. The energy from the output of the radio receiver is split by a receiving hybrid coil between two paths, equipped with pads, slope networks, and (in the case of the lower branch) a line filter (LF). The pads adjust signal levels, and the slope networks provide pre-equalization as required for operating over the cable pairs equipped with type-N repeaters toward city C. The line filter provides access, at this end of the system, to the alarm or maintenance service telephone trunk.

From the combining circuit toward the repeaters, each path carries both low-group and high-group frequencies. Filters in the nonmodulating "high-high" (HH) repeater and modulating "low-high" (LH) repeater suppress the unwanted frequencies

* RECORD, *June*, 1954, *pages* 209 *and* 215; *July*, 1952, *page* 277. † RECORD, *September* 1953, *page* 347.

and pass the wanted frequencies, so that each repeater transmits to its cable pair the desired twenty-channel group. From this point, transmission to the ON terminals at city C is exactly the same as in an all-cable type-ON carrier system. One cable quad (2 pairs) is used with type-N repeaters for the two directions for each twenty-channel group.

Transmission in the opposite direction in Figure 3 is essentially like that described in the preceding discussion of Figure 2, but with minor differences. First, because the system at this point uses cable instead of open-wire, no type-ON junction is needed, but somewhat different repeaters are used. Second, slope networks are needed, as in all-cable ON systems, to remove slope which the cable imparts to the frequency characteristic of signals transmitted over the line. One twenty-channel group is translated from low group to high group by a modulating repeater (LH), while the other is transmitted without change, by a nonmodulating repeater (LL). After transmission through the slope networks, level-adjusting pads and line filter (LF in the low group branch) these two groups are combined in a transmitting hybrid coil and applied to the input of radio transmitter E. They are then set over the radio system to the receiver at ratio site W.

Returning now to Figure 2, we see that the output of radio receiver W is split between two paths by a receiving hybrid coil, each path carrying both low-group and high-group frequencies. Pads are used in each branch for adjusting signal levels, and in one branch, a line filter (LF) is used to derive the alarm and maintenance service trunk. Filters (LPF) and (HPF) in the LL and HL repeaters select the desired group of channels and reject the unwanted group. The nonmodulating repeater (LL) transmits the low-group channels toward ON junction A and the modulating repeater (HL) translates the high-group band to low group for transmission to ON junction B. From these points to the type-O terminals at cities A and B, operation is similar to that for all-wire-line type-ON and type-O systems.

On the radio system, the two directions of transmission for a given twenty-channel group lie in opposite frequency allocations. That is, if the channels for city A to city C are in the high group, the channels for city C to city A are in the low group.

THE AUTHORS

CLAUDE CRONBURG, JR., a native of Chicago, Illinois, received the B.S. degree at Fenn College, Cleveland, in 1936, and joined the Bell Telephone Laboratories that same year. For several years he was concerned with switching development, dialing studies in connection with panel and crossbar systems. During the war he worked on various aspects of radar systems. In recent years he has been associated with groups working on development of type-N, type-O and type-ON carrier systems. Mr. Cronburg received the M.S. degree from Stevens Institute of Technology in 1946. He is a member of the I.R.E. and Tau Beta Pi.

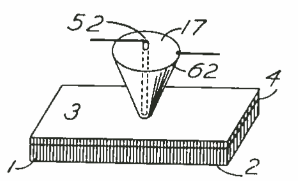
C. W. SCHWIEGER, a native of Billings, Montana, joined the Pacific Telephone and Telegraph Company at Los Angeles in 1940. Following the period 1942-1946, during which he served with the U. S. Navy as an instructor in the radio technicians training program, he returned to the Pacific Company's Transmission Engineering department at Los Angeles. Except for two loan periods with the O. & E. Department of the A.T. & T. Co. and the Laboratories, he has been with the Pacific Company since that time. Mr. Schwieger's assignments have included the design of carrier and microwave radio routes, including the Los Angeles - San Diego and the western end of the Amarillo - Los Angeles route. He is currently working on mobile radio - telephone systems design.

This method of frequency assignment derives from the type-N system, where it is used to minimize crosstalk on the line. Because ON-on-radio repeaters are similar to type-N repeaters, the method adapts well to the radio application, and, to some extent, serves to minimize crosstalk in this application also.

As mentioned above, the ON repeaters for radio terminal locations are quite similar to the type-N and type-ON repeaters. They are plug-in die-cast units and can be changed on an in-service basis. Like type-N repeaters, their power may be obtained either from a distant point, by dc supplied over the same cable pairs used for message transmission, or from a local power supply.

The flexibility of ON carrier and its radio application make possible many complicated circuit layouts. One such layout, used in an early installation in Oregon, involved the dropping of a twenty-channel group at a radio repeater. By such arrangements, part of the full complement of channels can be taken off the ON system and transferred to another system or terminated locally, while the remaining channels can remain on the radio system for termination at more distant points. Another circuit layout illustrating the versatility of ON-radio combinations is the so-called "wye" (Y) configuration, shown in Figure 4, by which radio channels can be distributed in two directions. With this arrangement, forty channels in an east-west direction can be divided at a radio repeater point so that twenty channels from the east radio, plus twenty channels from the west radio, are transferred to a north-south route.

Early installation of ON on radio have shown very satisfactory performance. Noise and crosstalk values on the channels at voice frequencies have been low, and transmission compares favorably with that obtained in type-O and type-ON installations. These radio capabilities have increased even more the ON carrier's usefulness to Bell System short-haul circuits.



Patents Issued to Members of Bell Telephone Laboratories During December

Abbott, H. H. — *Key Pulsing Circuit* — 2,818,558.

Blair, R. R. — *Apparatus for Testing Resistors* — 2,815,482.

Bowers, F. K. — *Asymmetrical Delta Modulation System* — 2,817,061.

Busala, A., and Meacham, L. A. — *Compensated Transistor Circuit* — 2,818,470.

Campbell, T. C. — *Ladder Seats* — 2,818,310.

Chen, W. H., and Lee, C. Y. — *Three-State Magnetic Core Circuits* — 2,818,554.

Custer, C. J. — *Triangular Wave Generator* — 2,817,016.

Dale, G. V., and Friis, H. T. — *Microwave Horn and Paraboloidal Reflector Antenna System* — 2,817,837.

Feinstein, J. — *Electron Discharge Device* — 2,818,528.

Feldman, C. B. H. — *Band Compression System* — 2,817,711.

Fox, A. G. — *Non-Reciprocal Hybird Structures* — 2,817,812.

Friis, H. T., see Dale, G. V.

Goertz, M. F., and Williams, H. J. — *Stressed Ferrite Cores* — 2,818,514.

Graham, R. E., and Mattke, C. F. — *Feedback Intensity Control for Continuous Film Scanner* — 2,817,702.

Haring, H. E. — *Semiconductive Translator* — 2,816,850.

Knoop, W. A. — *Servomotor Systems* — 2,817,052.

Kuchas, F. C., and Rosene, V. E. — *Service Observing Circuits* — 2,816,965.

Lee, C. Y., see Chen, W. H.

Lewis, W. D. — *Microwave Channel Dropping Filter Pairs* — 2,816,270.

Low, F. K. — *Multiparty Telephone System* — 2,817,710.

Mattke, C. F., see Graham, R. E.

McGuigan, J. H., and Murphy, O. J. — *Multifrequency High Speed Signaling System Employing Pulses of Signaling Currents of Predetermined Duration Based on Orthogonal Functions* — 2,817,828.

Meacham, L. A., see Busala, A.

Meyers, S. T. — *Negative Impedance Converter* — 2,817,822.

Murphy, O. J., see McGuigan, J. H.

Nadolski, P. M. — *Phase Indicator* — 2,816,266.

Pfeiffer, S. B. — *Binary Digital-to-Analog Converter for Synchro Devices* — 2,817,078.

Rosene, V. E., see Kuchas, F. C.

Rowen, J. H., and von Aulock, W. H. — *Measurement of the Complex Tensor Permeability and the Complex Dielectric Constant of Ferrites* — 2,817,813.

Shockley, W. — *Methods of Fabricating Semiconductor Signal Translating Devices* — 2,816,847.

Taris, C. M., and Woolam, F. J. — *Means for Erasing a Magnetic Record* — 2,816,176.

von Aulock, W. H., see Rowen, J. H.

Wadsworth, P. W. — *Fire and Police Telephone Reporting System* — 2,816,958.

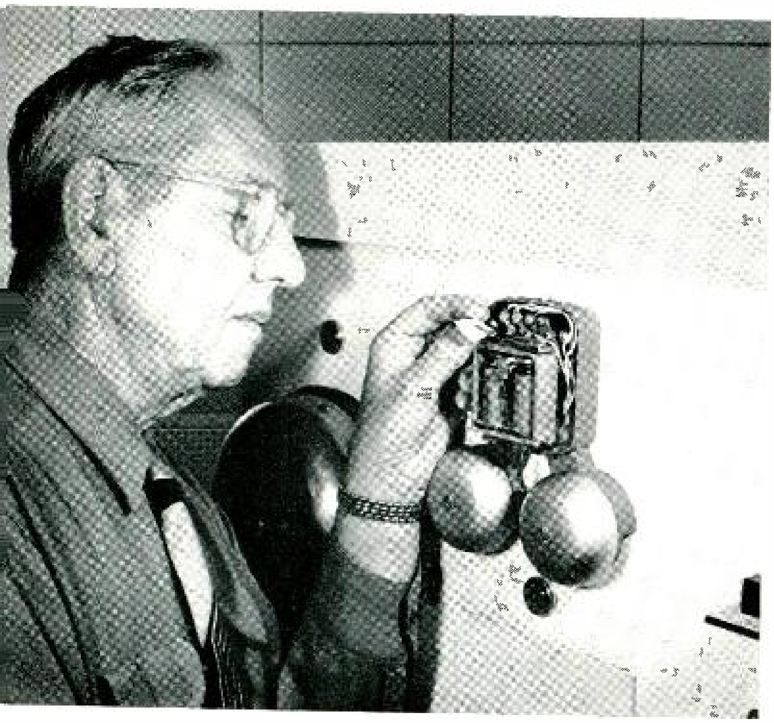
Weibel, E. S. — *Synthesis of Complex Waves* — 2,917,707.

Williams, H. J., see Goertz, M. F.

Williams, S. B. — *Electronic Computer* — 2,817,477.

Woolam, F. J., see Taris, C. M.

Young, W. R., Jr. — *Switching Network Using Diodes and Transformers* — 2,817,079.



An Experimental Signal for Centralized Calling

R. T. JENKINS *Station Apparatus Development*

Surveillance of ways to improve station apparatus is a continuous job at Bell Laboratories. In this area, a recent experiment was undertaken in light of telephone requirements for modern houses. It involves a combination sounder that might be used either as a bell or as a chime, depending on the type and size of house to be serviced.

The increasing popularity of split-level and ranch type architecture has resulted in the construction of many houses with spread-out living areas. To provide adequate telephone facilities for these houses, many of them are being wired for telephones at several locations. As a complement to this multi-set installation, a centralized ringing system would provide an adequate calling signal to any point in the building.

To meet the requirements for such a calling device a combination sounder was proposed which could be used either as a loud-ringing vibrating bell or as a chime. The calling signal would be pitched to have harmonious tonal quality for pleasant sounding. Also, it could be advantageous in most cases of hearing deficiency. For smaller homes, where distance listening is not a concern, the chime signal would be more pleasing than the calling bell. Either the vibrating bell or chime signal could be selected by the customer by a switch associated with the sounder.

The Laboratories has completed exploratory design of the required circuits and mechanism for this bell and chime signal arrangement, and approximately 150 models have been constructed in the Western Electric model shop at Indianapolis. These are undergoing product testing in areas served by the Southern Bell Telephone Company. The device operates satisfactorily for one-party and two-party selective, and four-party semi-selective ringing installations.

Exploratory work was based on the properties of the 592-type customers' set, which is widely used in the Bell System as a loud-extension ringer. Two 3-inch gongs, with resonators to amplify the fundamental frequency output of 1100 cps, are used in this subset. For the new signal, gongs and resonators are modified to secure the pleasant tonal relationship of a musical third – that is, a frequency ratio closely 4:5. The thickness of one of the gongs is reduced from 0.072 inch to 0.058 inch, which lowers the fundamental frequency to 880 cps. This frequency, along with that of the other unchanged gong, provides the necessary 4:5 ratio.

Resonators were designed to amplify both the 880 cycle and 1100 cycle fundamental frequencies.

The motor element of the signal accommodates a larger clapper, which is loosely mounted on the rod. The clapper is constructed of hard rubber with a brass core and is mounted on the supporting rod attached to the armature. This relatively light clapper insures good operational performance and tonal quality. The experimental bell and chime structure, showing the resonators over which the gongs are mounted, is shown in Figure 1.

The bell operates on the twenty-cycle current used for conventional ringing. With the standard two seconds on and four seconds off, the ringing sequence is identical to that of the ordinary telephone set. The chime, however, uses a single-stroke type of operation. At the beginning of the two-second "on" interval, the clapper strikes the higher-frequency gong, and at the end of this interval the clapper strikes the lower-frequency gong. Instead of the rapid striking typical of telephone-bell sounds, the chime produces a distinctive and harmonious "ding-dong" signal. As shown in Figure 2, this type of operation is accomplished by rectifying the alternating current and by applying direct current to the winding of the ringer magnet. At the start of the current cycle, this arrangement forces the clapper in one direction, and at the end of the current cycle a spring associated with the armature forces it in the reverse direction.

Measurements indicate that when the system is used as a vibrating bell, the level of sound power (total radiated power) is about 36 db above 1 microwatt. This level of sound power is about 10 db higher (about 10 times the acoustic power) than that of the 500-type telephone set ringing signal. A substantial part of the 36 db output level is contributed by the fundamental frequencies, which are resonated to give a 28 to 32 db level. The resultant acoustic signal has a pleasing tonal quality with a dominant fundamental-frequency pitch.

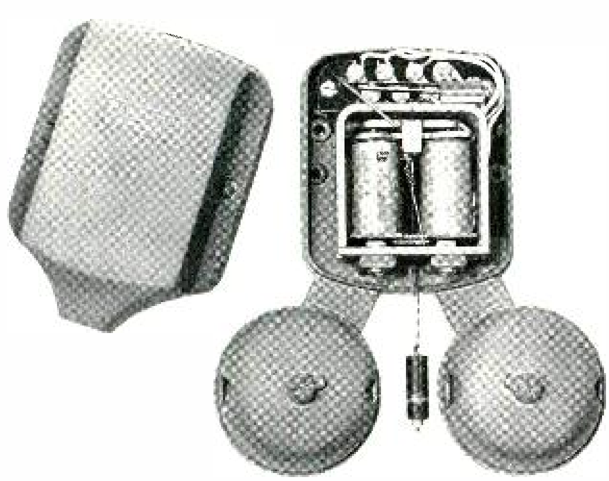


Fig. 1 — Basic bell and chime structure. A pleasant ringing tone is achieved when the thickness of one gong is reduced, thereby relating the gongs in a four-to-five pitch ratio.

The use of a rectifier to obtain single-stroke operation of the sounder offers a way to control the operating cycle of the chime. A shunt-connected capacitor and resistor are employed in the dc circuit of the chime so that each of the gongs is struck within the "on" period of the ringing cycle. The interval between strikes is a function of the capacitance in the circuit and of the electrical and mechanical constants of the chime motor element.

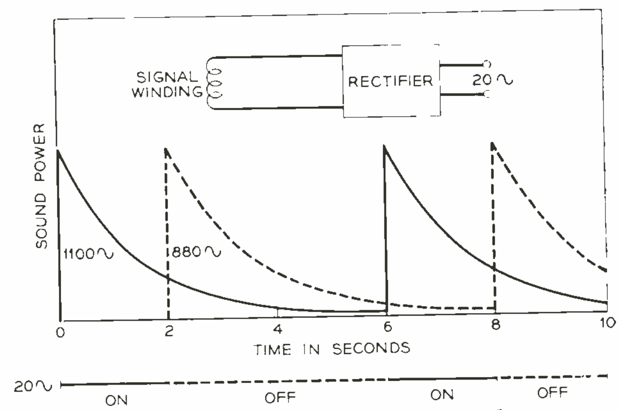


Fig. 2 — Chime operation conforms to the conventional ringing cycle of two and four seconds.

The circuit and schedule for this operation are shown in Figure 3(a). At time t=0, when ringing voltage is applied to the rectifier, the resistance of the capacitor to dc flow is small and the chime operates, resulting in a gong strike. The capacitor is then charged, and at time t_1 the current in the ringer coil falls below the value needed to maintain operation. This releases the armature and results in a strike of the opposite gong. The selected capacitance value results in a time, $t_1 - t_0$, of about 0.5 second. The shunt resistor discharges the capacitor during the "off" period of the ringing cycle. At this time the armature is in the non-operate position and the chime is ready for the next application of ringing voltage. The resistance used must be high enough to allow the capacitor to charge sufficiently when voltage is applied and to allow discharge of the capacitor during the period when the voltage is off.

An interrupter contact, actuated by the armature, obtains repetitive chime operation, as shown in Figure 3(b). A rod attached to the armature operates the contact. At time t=0, the interrupter contact closed and the capacitor discharged. Voltage

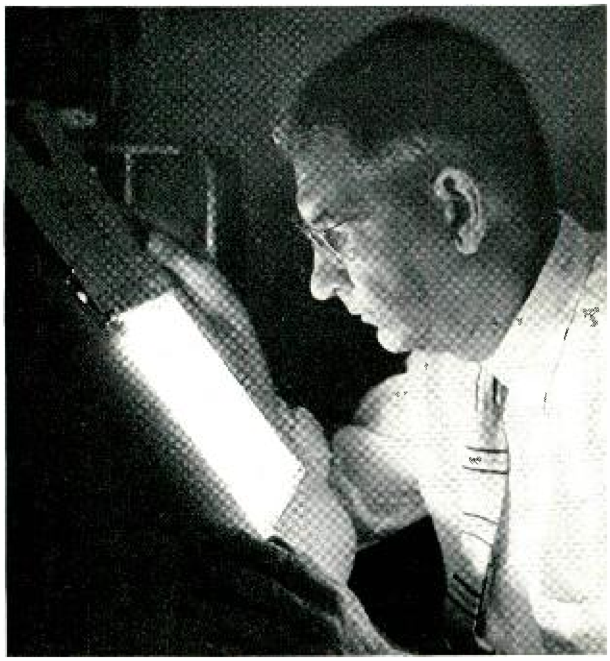


Fig. 1 — V. J. Rutter inspecting construction of the traffic-usage camera for photographing registers.

corded information in a form readily usable by the traffic engineering department of an Operating Company. Some large central offices have had these recorders in operation for the last two years.

As a second step in the program, a new recorder – the No. 1 Portable Traffic-Usage Recorder – has now been developed. This recorder has the same general features as the permanently wired frame, and is intended primarily for use in dial offices whose small size does not justify the permanently installed recorder, or in older offices where space limitations or other factors are controlling. Its capacity makes it suitable for measurements usually made on up to 2000 lines. Its portability and flexibility, however, permit it to be used up to its rated capacity, or on the basis of sampling, in any size office, and of course more than one machine can be used as required.

The portable recorder equipment is conveniently housed in four separate units: (1) a scan cabinet, (2) a traffic-register cabinet, (3) a container for carrying various types of connecting cords, and, optionally, (4) a standard camera for photographing the traffic registers. All of these units can be readily moved about and transported from office to office. The scan and register cabinets are identical in design and are arranged so that the outside panels themselves comprise the carrying cases.

When properly cabled and connected to the equipment on which traffic-usage measurements are to be made, the recorder, using the switch-count method, "looks" at each circuit and automatically detects and records its busy condition. This method requires repeated scannings of the busy-test terminals at a regular rate, and also requires the cumulative scoring on traffic registers of the number of busy conditions encountered. When all test points are scanned every 100 seconds, the total recorded "busies" at the end of one hour (36 scans) will indicate the traffic load in standard traffic-usage units (CCS) per hour for all circuits under study. In measuring usage on some common-control equipment such as markers, decoders and transverters, a greater degree of accuracy may be required. For these circuits, a 10-second scan rate may be used, with a smaller measurement error. In this case, the readings on the traffic registers are divided by 10 to maintain the standard CCS unit.

A step-by-step switch performs the scanning operation. This switch is physically equipped with four banks of two hundred terminals each and with four associated "wiper" assemblies (consisting of two springs or contacting brushes each). From a circuit viewpoint, however, the eight hundred terminals are regarded as 8 banks of 100 each

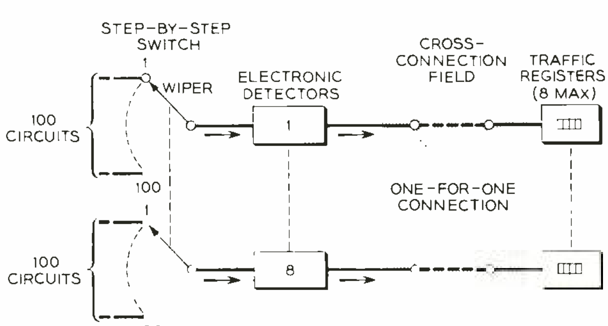


Fig. 2 — The maximum-capacity "fixed" arrangement of usage recording: 100 circuits are assigned to each detector in this method of operation.

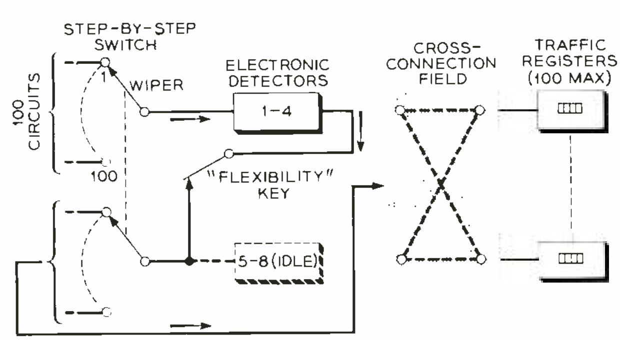


Fig. 3 — The reduced-capacity "flexible" arrangement: 100 circuits are assigned to a pair of detectors for this type of usage recording.

with 8 associated wipers. With a "fixed" arrangement, as indicated in Figure 2, each wiper is connected to an electronic detector, which in turn is cross-connected to a single traffic register. Thus, as a wiper passes over its bank of 100 terminals, each busy condition is detected and causes the corresponding register to score. This is the arrangement for maximum input capacity. It can only be used for eight groups of circuits, each group including up to 100 circuits. Usage is scored on a maximum of eight registers; this arrangement is used where large traffic groups are to be measured.

For maximum flexibility in handling smaller groups of various sizes, the recorder can also be arranged to measure traffic usage on as many as 400 input circuits, with the usages scored on 100 registers, the maximum that can be equipped in the portable register cabinet. This "flexible" arrangement is indicated in Figure 3. Here, 400 step-by-step bank terminals, composed of four banks of 100 terminals each, are connected to the circuits to be measured. The four wipers associated with these banks of terminals are connected now to the inputs of only four of the detectors, and the outputs of the detectors are wired to the other four wipers. The terminals associated with these output wipers are arranged in a cross-connecting field for grouping and assignment to registers.

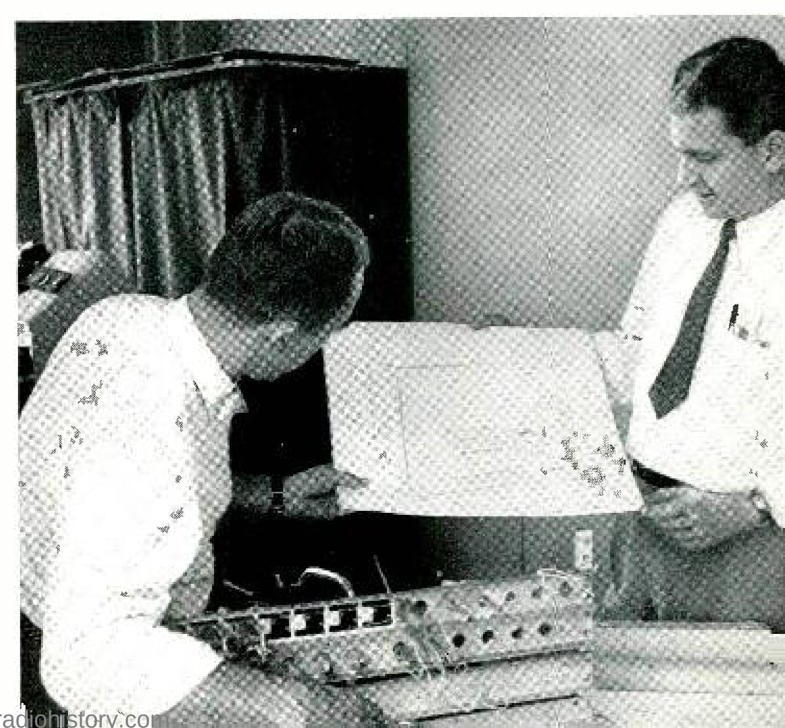
This arrangement of grouping registers is under control of four "flexibility" keys, one for each pair of wipers and associated detectors. One of these keys is indicated in Figure 3. With the keys normal, the recorder is set up to handle 800 input circuits, considered as eight fixed-traffic groups. As each key is operated, one hundred input circuits are transferred from the "fixed" to the "flexible" arrangement, and the maximum number of circuits handled by the recorder is reduced by 100. For example, if one key is operated, 100 input circuits can be associated with a pair of switch banks and handled by the flexible arrangement, while the remaining six banks can accommodate 600 input circuits handled on a fixed basis of 100 circuits per group. Consequently, if all four keys are operated, all input circuits (400 maximum) are handled by the flexible arrangement.

When the step-by-step switch is in the process of scanning, each detector can recognize a ground potential as the busy condition. By the operation of "battery-transfer" keys, however, four of the detectors can be arranged to recognize a –48 volt battery potential as the busy condition. Circuits requiring this type of detection must be assigned to the switch bank terminals served by these four "universal" detectors. Although the presence of ground or −48 volts on the test leads generally indicates a busy condition, some circuits present a ground as an idle indication. Traffic usage can still be measured with the ground detector, but the readings on the traffic registers must be interpreted inversely, by taking into account that the associated register scorings represent units of idle instead of busy time.

When it is desired to measure any of the circuits at a 10-second scan rate, as mentioned earlier, such circuits must be assigned to the first two levels of terminals on each bank, and the eight wipers on the scanning switch "look" at all the bank terminals once every one hundred seconds. This breaks down into ten 10-second periods, each of which is the allotted time for a wiper to step up, scan through one level of its associated bank and return to its starting position. Actually, in the fast-scan condition only a fraction of the 10 seconds is required to complete the scanning process for one level. As illustrated in Figure 5, the remaining time is used to generate repetitive scans on levels 1 and 2 in addition to one of the other eight. During the first and last 10-second periods, only levels 1 and 2 are scanned. This arrangement gives a 100-second scanning rate for circuits assigned to terminals on levels 3 to 10, concurrently with a 10-second scanning rate for those circuits assigned to terminals on levels 1 and 2.

The scan cabinet contains all the control equipment: relays, timers, detectors, keys and miscellaneous apparatus, as well as the step-by-step switch used for scanning. Connectors are located at the

Fig. 4 — The author (left) and R. F. Dusenberry discussing experimental "breadboard" model of detector circuits.



rear for access via cords to the circuits under test and for interconnecting the scan and register cabinets. The cords that connect the circuits to the scan cabinet have individual clips or multicontact connectors at the circuit ends for attaching to the test leads at convenient terminal points of the central office equipment.

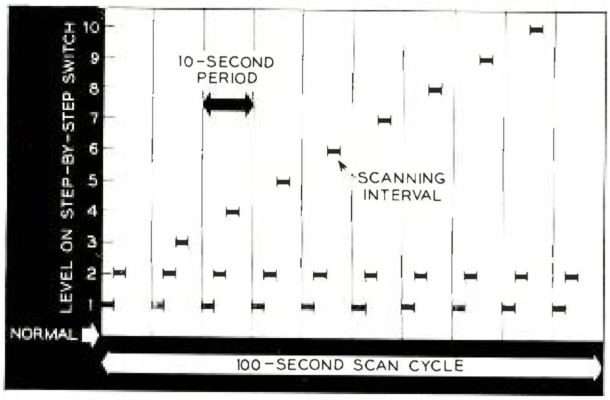


Fig. 5 — Levels of terminals on scanning switch versus time; plotted are scanning periods on the various levels of the switch.

The register cabinet contains 100 traffic registers for scoring busy conditions, and is equipped to accommodate the standard traffic-usage camera. This camera photographs all the traffic registers simultaneously. A lamp and a cycle-count register, also mounted in the camera's field of view, are used for photograph identification along with a clock dial and designation card located internally in the camera. Mounted at the rear of the cabinet are multi-terminal plugs to accommodate the intercabinet cords, and a cross-connection field for the flexible grouping and assignment of registers.

To set up the recorder for actual operation, the scan and register cabinets are interconnected and placed side by side with their covers removed. The cabinets are positioned as close as practicable to the point at which connections to the circuits under study will be made. The camera is mounted on the register cabinet, and, in accordance with the grouping of traffic registers, terminals are wired in the cross-connection field. The circuits to be measured are assigned to the bank terminals of the scanning switch, taking into account the size of groups, the type of busy indication required, and the need for 10-second scanning.

A program timer, which is an electrically driven 24-hour clock, is set to the correct time of day and is adjusted to start the recorder at the beginning of a particular 15-minute interval. It will continue to run for any set number of hourly periods and may be adjusted to omit preselected days of the week, such as weekends and holidays. The first operation of the start key primes the recorder, and when the timer closes contact at the selected setting, the circuit goes into operation and continues for the set number of hourly periods. If the start key is not restored, a new recording period will automatically begin when the timer again reaches the initial time setting on the next day. Photographs of the register readings, taken automatically at periodic intervals, give a permanent record of equipment usage for traffic engineering or administrative studies.

Test features are incorporated in the recorder circuit to permit checking the integrity of the cordage, connectors, scan-switch terminals, and the operation of the detectors and registers. In addition, the scan cabinet has equipment for testing the operation of the camera.

Newer developments using computer techniques at the Laboratories will advance the mechanization of traffic usage recording and result in an even greater over-all saving in data-analysis time.

THE AUTHOR

G. E. LINEHAN, a native of Long Island City, New York, joined Bell Laboratories in 1936. He was concerned initially with laboratory layout work for the Switching Development Department and attended Polytechnic Institute of Brooklyn. At the beginning of World War II he was engaged in a Laboratories project to which he was later assigned as a member of the Signal Corps. He attended the Bell Laboratories War Training School in 1944. From 1946 to 1950, Mr. Linehan was engaged in setting up the laboratory version of the Automatic Message Accounting Center in which he was responsible for maintenance and visitor demonstrations. Since then he has been active in the design and development of CAMA tandem crossbar equipment.

"Business Needs Basic Research"

Frederick R. Kappel Addresses New York Economic Club

Business needs to do more basic research to combat the competition posed by Soviet science, A.T.&T. President Frederick R. Kappel told The Economic Club of New York on January 21.

At the same time, he said "those who continually attack big business" should allow business the freedom to accept this new kind of risk.

"By all means, hold us in big business to our responsibilities," he said. "But give us, also, the freedom to build the strength that we need to meet them."

Mr. Kappel described basic research as "the search for new knowledge – the effort to increase our understanding of nature – the probing into the unknown." He contrasted it to the application of industrial and productive skills to existing knowledge.

Mr. Kappel displayed three devices growing out of basic research by Bell Laboratories scientists:

A waveguide of the kind used in long distance radio relay systems which carry both telephone conversations and TV programs.

Part of a pulse-code modulation system expected to be used to multiply talking paths over certain short routes more cheaply than by installing more cables.

A dataphone instrument that can transmit data at high speed over a regular telephone circuit.

"Perhaps in the past we telephone people have had more need for research than others," Kappel said. "However I question if this is any longer true. One reason why I question it is that today all industry in the free world faces a new kind of competition.

"Soviet science is moving with tremendous mass and terrific momentum. It has stepped out into space ahead of us and it would be sheer folly not to recognize its driving will to step ahead in every other way.

"This is not just a matter of missiles and satellites. It is much, much more. It is a matter of markets – of leadership in trade and commerce – of the power of free industry to strengthen the public welfare and to win and keep world-wide esteem.

"Of course, the cost of research is a business risk. But in any field of business, if we face new problems we must take new action. If we face new danger we must take new chances. And if the danger we face is to fall behind in knowledge, then it seems to me that taking the new risk becomes imperative.

"Really I think most of the hesitation about going into basic research is due to a worry that all the money may go down the drain. If you go at it the right way, however – and I'm coming to that directly – this ought not to happen."

Mr. Kappel then listed some of the principles that the Bell System regards as necessary in its basic research:

1. Get the best possible people.
2. Have a broad objective, but also give the brains full freedom.
3. Keep the researcher from becoming a developer. When one piece of research is done, the results must be given to others for development, and the researchers must turn to a new basic problem.
4. Basic research today needs adequate equipment.

Mr. Kappel invited "leaders in industry, and leaders also in government, to consider a single question. It is simple and short; merely this – What is our responsibility?

"For many years now big business has been under the necessity of justifying its existence. This is perfectly natural. Big business does affect the lives of everyone and it must continuously prove by its actions that everyone benefits. To me and I daresay to you, the evidence of the benefits is overwhelming:

" – in the capacity to take on big jobs that depend on big investment.

" – in the creation of new opportunities for small business.

" – in the sheer ability to produce in vast quantity at low price.

" – in the strength that armed ourselves and our allies in two world wars, and but for which this country today might be an overseas province of, let us say, the Third Reich.

"Our need to prove ourselves will never end, but I want to make this observation: It seems to me that at no time in this century has the man in the street had more reason or instinct to look hopefully and even prayerfully to big business than he has right now.

"He has a thunderclap awareness that it is big and mighty effort which has rocketed a living creature up out of the atmosphere and into the silence of space. His instinct and acknowledgement must be that the Soviets' kind of bigness can only be countered by another kind of bigness – and I mean our kind, which mixes bigness and freedom.

"So I think today we have the potential for a new degree of public awareness that the future depends very largely on big industry and on keeping it sound and strong.

"In our own case, as a public utility, to do the most effective research job we need the full understanding and support of the regulatory commissions. We are regulated in every state, and in some of them you would almost think the sole purpose of the regulation is to keep us from earning enough money to do a better job.

"In the postwar period as a whole this paucity of earning power has limited and circumscribed our effort. We have done a great deal, and I am only stating the fact when I say that this has opened up prospects for the future of communications that are beyond all calculation.

"Nevertheless I think we would have done more, and be somewhat further into the future than we are today, if the conditions imposed on us had been less stringent.

"Finally, let me address a few remarks to those people both in and out of public office who for reasons best known to themselves seem dedicated to the effort to harass and attack big business, and to cut it down to some other size of their own choosing.

"I ask them to stop, look and listen. A few minutes ago I was saying that the cost of basic research is nothing for a big business to be scared of. However, I didn't say it was free. It is in fact big enough to require big resources.

"For one thing, the research group needs to be large enough for its members to spark each other, and to attract the topnotch people who want to work in a scientific community that draws others of equal caliber.

"So if basic research within industry is really going to grow, it is going to have to grow in big organizations. I don't mean there isn't room for it in smaller ones, especially when they are doing work for the government and the cost gets paid that way.

"But if industry as a whole is going to get up a full head of steam in acquiring new knowledge, the impetus has got to come from big business which has the means to pay for it.

"How can those who continually attack big business expect us to accept this new kind of risk if they keep us forever preoccupied with the effort to keep ourselves whole? This is simply not the way to get on with the vital tasks that we must get on with.

"So I say sincerely and urgently to those in public life: By all means, hold us in big business to our responsibilities. But give us, also, the freedom to build the strength that we need to meet them.

"The next generation – and the time may be shorter than that – will surely be decisive in the future of our country and the world. Let it never be said in years to come that we failed because this man had a pet theory, and that man was thinking of votes.

"I hope I have made myself plain. I have said to you tonight that we in the Bell System has found basic research essential to progress in one very important field. I have urged others in business to take note of the threat we all face and to accept whatever responsibility properly belongs with them in their fields. I have reminded members of government, finally, of their responsibility to allow us in business the freedom and the resources we need to do our job. For the stakes are high and they concern not any single group, but the welfare of the nation and of all free people."

C. J. Davisson, 1881-1958

Nobel Laureate, 1937

Dr. Clinton J. Davisson, 1937 Nobel Laureate in Physics, died at his home in Charlottesville, Va., on February 1. He was 76 years old.

Dr. Davisson, an internationally renowned scientist, won the Nobel Prize for his discovery at Bell Telephone Laboratories of electron diffraction and the wave properties of electrons, a cornerstone of the theory of wave mechanics upon which rests much of the physicist's present understanding of fundamental particles and the structure of atoms.

Dr. Davisson was born Oct. 22, 1881, at Bloomington, Ill., and was the son of Joseph Davisson, a craftsman, and Mary Calvert Davisson, a school teacher. Young Davisson attended the Bloomington public schools and on graduation was awarded a scholarship by the University of Chicago for his proficiency in mathematics and physics. He received a B.S. degree in physics from the University of Chicago in 1908, and the Ph.D. from Princeton in 1911.

From 1911 to 1917, he was an instructor in physics at the Carnegie Institute of Technology, and accepted wartime employment in 1917 with the Western Electric Company's engineering department, which subsequently became Bell Telephone Laboratories. He remained at Bell Laboratories until his retirement in 1946.

From 1919 to 1929, Dr. Davisson investigated thermionics, thermal radiation and electron scattering. In this work he collaborated first with Dr. C. H. Kunsman, and later with Dr. L. H. Germer.

That research led Davisson to demonstrate that under certain conditions electrons behave as beams of waves might be expected to behave. He showed that electrons may be diffracted by a nickel crystal just as if the electrons were made up of waves, as are light and X-rays. He thus demonstrated the concept originally propounded by Prince Louis-Victor de Broglie, France's Nobel Prize winner of 1929. In this year, de Broglie wrote to Dr. Davisson: "I know very well that if I have received the Nobel Prize, it is because your splendid research has provided confirmation of the ideas I had developed."

For this work, Davisson was awarded the Comstock Prize by the National Academy of Sciences in 1928. He and Dr. Germer received in 1931 Elliott Cresson Medals from the Franklin Institute, and in 1935 Davisson received the Hughes Medal of the Royal Society (London).

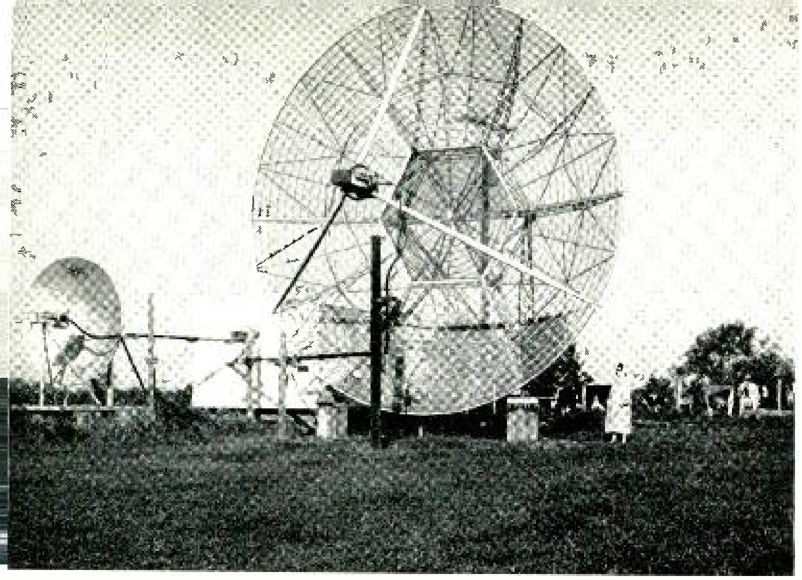
In 1937 Dr. Davisson shared the Nobel Prize in Physics with Professor G. P. Thompson of Britain who worked in the same field, although their techniques were vastly different.

In 1941, Dr. Davisson received the Alumni Medal of the University of Chicago. He held honorary degrees from Purdue, Princeton, the University of Lyon (France) and Colby College.

From 1930-37, Dr. Davisson devoted himself to the study of the theory of electron optics and to applications of this theory to engineering problems. He then investigated the scattering and reflection of very slow electrons by metals. During World War II, he worked on the theory of electron devices for the Armed Forces.

In 1946, Dr. Davisson retired from Bell Telephone Laboratories after 29 years of service. From 1947 to 1949, he was visiting professor of physics at the University of Virginia, Charlottesville, Va.

Dr. Davisson was a member of the editorial board of *The Physical Review* and a member of the National Research Council. He was a fellow of the American Association for the Advancement of Science, American Physical Society and the Optical Society of America, and an honorary life member of the New York Academy of Sciences. He was also a member of the National Academy of Sciences, American Philosophical Society, American Academy of Arts and Science, Franklin Institute, Sigma Xi, and Phi Beta Kappa.



Farm Housewife Helps Studies of Over-the-Horizon Transmission

On farm in Pharsalia, N. Y., Bell Laboratories microwave antennas and transmitting equipment are used in over-the-horizon radio research project.

Because of the need for studies of over-the-horizon microwave transmission, Mrs. Orton Newton, a farm housewife of Pharsalia, N. Y., is playing an important part in a Bell Laboratories radio-research project. She holds a restricted radiotelephone operator's permit and, almost daily, operates radio transmitters installed on an 1800-ft. hilltop on the Newton farm.

Mrs. Newton began assisting in the project about three years ago when Bell Laboratories researchers decided to learn more about the over-the-horizon method of microwave radio transmission. Dr. Wolfgang Kummer, of the Bell Laboratories Holmdel, N. J., location, says Mrs. Newton's work has been not only highly useful, but "essential in helping us fathom why over-the-horizon transmission works."

Each day, Dr. Kummer or one of his associates telephones Mrs. Newton and designates which transmitters are to be operated, and at what time. Adjoining Mrs. Newton's telephone is a special dial, exactly like that on a telephone. By dialing combinations of numbers, she activates the proper transmitters, beaming microwave radio signals to be received by a 60-foot antenna at the Holmdel radio-research center, 171 airline miles away.

The new system of radio transmission began when a Bell Laboratories engineer became intrigued with the phenomenon of microwave signals being received at points beyond the horizon from a transmitting antenna. The phenomenon had been studied here and abroad, but no practical use was seen until Kenneth Bullington of Bell Laboratories predicted it could be used for dependable communications. Bullington and his associates confirmed the prediction experimentally and over-the-horizon transmission was born. But many of the details of this transmission technique were not fully understood.

In the usual line-of-sight radio transmission, signals travel in a straight line between the transmitter and the receiver — a distance limited for practical purposes to about 30 miles because of the curvature of the earth, except in mountainous regions. In beyond-the-horizon propagation, the transmitter and the receiver do not "see" each other because of that curvature. The antenna sends its signal into the atmosphere, and the receiving antenna picks up the weak energy scattered by the atmosphere.

The transmitting antenna may be thought of as a giant "searchlight" aimed at the sky. Although the source is not visible, the receiver antenna "sees" the light from the beam, though faintly because of the scattering of the energy by clouds, haze or rain. It was known that the atmosphere into which the "searchlight" signal was pointed contains scattering or reflecting surfaces created by changes in temperature, humidity and wind. However, this "scattered" radio signal could be made useful by using high powered transmitters, large antennas and sensitive receivers. To permit lengthy testing, the transmitters were installed on the Newton farm hilltop because it is on direct line with Bell Laboratories centers at Holmdel and Murray Hill, N. J., was an adequate distance from Holmdel and provided a clear sending path to the area.

Mrs. Newton's work has helped in a broader understanding of over-the-horizon microwave transmission, now a reality in the DEW line radar fence in the Arctic, the similar White Alice project in Alaska, and the Florida-to-Cuba microwave link opened by the Bell System in September, 1957.

BTL-WECo. Diffused Transistors Voice of "Explorer" Satellite

Transistors designed by the Laboratories are circling the earth and provided the "voice" of the Explorer satellite launched January 31 by an Army team at Cape Canaveral, Florida. Germanium transistors of the diffused-base type were used in the output stages of the two radio transmitters in the satellite's nose.

The transistors are Laboratories models manufactured experimentally by the Western Electric Co. at Laureldale, Pa. The diffused-base transistor (see RECORD, *December*, 1956, *page* 441) was developed by C. A. Lee and G. C. Dacey and was announced in January, 1956. Subsequent development work was led by J. M. Early.

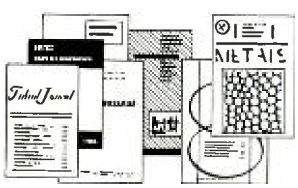
Instruments in the satellite collect information on cosmic radiation, the density of micrometeorites, or cosmic dust, and temperatures inside and outside the satellite. The information thus obtained is radioed back to earth in coded form by the two miniature transmitters. The radio signals were picked up at various points around the world and could be interpreted by all nations, since the key to the coded messages has been widely published.

According to press announcements the 30.8 pound satellite is traveling at a speed of 18,000 miles an hour. It circles the earth approximately every 115 minutes, in an elliptical path ranging from 230 to 1600 miles above the earth.

P. P. Cioffi Wins A. I. E. E. Prize

P. P. Cioffi of the Laboratories Device Development Department has been awarded the first prize in the Science and Electronics Division by the American Institute of Electrical Engineers. Mr. Cioffi was thus honored for his paper, "Rectilinearity of Electron Beam Focussing Fields from Transverse Component Determination," published in the A.I.E.E. *Transactions,* Part I, *Communication and Electronics,* **29**, pages 15-19, March, 1957.

The prize was given on February 3, during the 1958 Winter General Meeting. It is one of a group of prizes awarded annually for the best papers published during the preceding year in the various Divisions of the A.I.E.E.



Papers by Members of the Laboratories

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

Allen, F. G., *Emissivity at 0.65 Microns of Silicon and Germanium at High Temperatures,* J. Appl. Phys., Letter to the Editor, **28**, p. 1510, Dec., 1957.

Anderson, O. L., *Cooling Time of Strong Glass Fibers,* J. Appl. Phys., **29**, pp. 9-12, Jan., 1958.

Bashkow, T. R. and Desoer, C. A., *Digital Computers and Network Theory,* IRE WESCON Convention Record, **1**, Part 2, pp. 133-136, 1957.

Bashkow, T. R., *The A Matrix, New Network Description,* IRE Transaction on Circuit Theory, **CT-4**, No. 3, pp. 117-119, Sept., 1957.

Bozorth, R. M., see Matthias, B. T.

Brady, G. W., *Structures of Sodium Metaphosphate Gases,* J. Chem. Phys., **28**, pp. 48-50, Jan., 1958.

Buehler, E., see Feher, G.

Caroline, J., *Current-Carrying Capacity of Printed Wiring,* Electronic Design, **6**, pp. 22-25, Jan. 22, 1958.

Desoer, C. A., see Bashkow, T. R.

Feher, G., Gordon, J. P., Gere, E. A., Buehler, E. and Thurmond, C. D., *Spontaneous Emission of Radiation from an Electron Spin System,* Phys. Rev., **109**, p. 221, Jan. 1, 1958.

Garn, P. D., see Sharpe, L. H.

Gere, E. A., see Feher, G.

Gordon, J. P., see Feher, G.

Hare, W. F. J. and Welsh, H. L., *Pressure-Induced Infrared Absorption of Hydrogen and Hydrogen-Foreign Gas Mixtures in the Range 1500-5000 Atmospheres,* Canadian J. Phys., **36**, pp. 88-103, Jan., 1958.

Kramer, H. P., *Perturbation of Differential Operators,* Pacific J. Math., **7**, No. 3, pp. 1405-1435, Fall, 1957.

Matthias, B. T. and Bozorth, R. M., *The Ferromagnetism of* $ZrAn_2$, Phys. Rev., Letter to the Editor, **109**, pp. 604-605, Jan. 15, 1958.

Morton, J. A., *The Technological Impact of Transistor Electronics,* Signal, **12**, No. 5, pp. 40-51, Jan., 158.

Munson, W. A., *The Loudness of Sounds,* "Handbook of Noise Control" (McGraw-Hill, New York), Chapter 5, pp. 5.1-5.22, 1957.

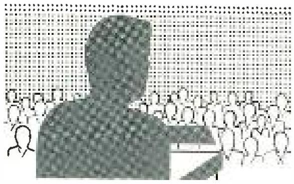
Rigrod, W. W., *Space-Charge Waves Along Magnetically Focused Electron Beams,* Proc. IRE, Letter to the Editor, **46**, pp. 358-359, Jan., 1958.

Sharpe, L. H. and Garn, P. D., *Electrolytic Regeneration of Cupric Chloride Etching Solutions,* Proc. of Joint BTL-WE Co. Symposium on Printed Circuits, Oct. 29-30, 1957, Jan., 1958.

Thurmond, C. D., see Feher, G.

Welsh, H. L., see Hare, W. F. J.

Wood, D. L., *Infrared Absorption Bands in a-Quartz,* J. Chem. Phys., Letter to the Editor, **27**, p. 1438, Dec., 1957.



Talks by Members of the Laboratories

Following is a list of speakers, titles, and places of presentation of recent talks given by members of the Laboratories.

American Physical Society Meeting, New York City

Anderson, P. W., *Coherent Excited States in the Theory of Superconductivity.*

Dillon, J. F., Jr., *Domain Structure and Optical Properties of Transparent Ferrimagnetic Crystals.*

Haynes, J. R., *Fine Structure of Intrinsic Recombination Radiation in Silicon.*

Jaccarino, V., *High Frequency NMR in Antiferromagnetics.*

Kaminsky, G., see Lee, C. A.

Lee, C. A., and Kaminsky, G., *Temperature Dependence of Noise in Transistor Structures.*

Remeika, J. P., see Sherwood, R. C.

Sherwood, R. C., Remeika, J. P., and Williams, H. J., *Observation of Magnetic Domains in Some Ferrospinels and Compounds Related to Magnetoplumbite Utilizing the Faraday Effect.*

Stadler, H. L., *Switching Time of $BaTiO_3$ Crystals at High Voltage.*

Wertheim, G. K., *On the Nature of Radiation Damage in Silicon.*

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

Other Talks

Arlt, H. G., *Standardization of Materials,* Pittsburgh Section of Standards Engineers Society, Mellon Institute, Pittsburgh, Pa.

Bennett, W. R., *Introduction to Noise and Stochastic Processes,* Central Pennsylvania Section, Society for Industrial and Applied Mathematics, State College, Pa.

Benés, V. E., *On Exponential Holding-Time, III – Continuous Time Treatment of a Trunk Group Serving a Renewal Process; On Exponential Holding-Time, IV – The Character of Overflow Traffic,* Am. Math. Soc., Cincinnati, Ohio.

Bogert, B. P., *Multi-Channel Systems I,* Audio Engineering Society, RCA Institute, N. Y. C.

Calbick, C. J., *Electron Microscopy,* Rochester Section, Am. Chem. Soc., Dryden Theater, Rochester, N. Y.

David, E. E., Jr., *Speech, Hearing and Communication,* Georgia Institute of Technology, Atlanta, Ga.

Douglass, D. C. and McCall, D. W., *Self-Diffusion in Paraffin Hydrocarbons,* Meeting in Miniature of the North Jersey Section of the Am. Chem. Soc., Seton Hall, South Orange, N. J.

Feldman, D., *Engineering and Research,* Jersey City Community Center, Jersey City, N. J.

Fox, A. G., *MASER and MAVAR Amplifiers,* A.I.E.E.-I.R.E. Section Meeting, Mellon Institute, Pittsburgh, Pa.

Garrett, C. G. B., *Semiconductor Physics and Free Radical Chemistry,* Polytechnic Institute of Brooklyn.

Githens, J. A., *Leprechaun – A Solid-State Digital Computer,* Pittsburgh Chapter, Armed Forces Communication and Electronics Association, Pittsburgh, Pa.

Guttman, N., *Frequency Division of Speech in Real Time as a Means of Counteracting High-Frequency Hearing Loss,* Audiology Study Group of New York, Hunter College, N. Y. C.

Harvey, F. K., *The Physics of Hearing and Music,* Pittsburgh Section, A.I.E.E., Pittsburgh, Pa.

Hebel, L. C., Jr., *Nuclear Spin Relaxation in Superconductors,* Franklin Institute, Philadelphia, Pa.

Herman, R. J., *Principles for Substituting Spare Units at Remote Locations to Maintain a Given Level of Reliability,* 4th National Symposium on Reliability and Quality Control, Washington, D. C.

Herring, C., *Phonon-Drag Thermoelectric Effects,* Physics Colloquium, Pennsylvania State University, University Park, Pa.; Physics and Metallurgy Colloquium, Northwestern University, Evanston, Ill.; and Department of Physics, University of Illinois, Urbana, Ill.

Herring, C., *Thermomagnetic Effects in Semiconductors,* National Carbon Research Laboratories, Cleveland, Ohio.

Jaycox, E. K., *Quantitative Spectrochemical Methods of Broad Applicability,* Meeting of Baltimore-Washington Spectroscopy, Society, Loyola College, Baltimore, Md.

Kellogg, L. H., *NIKE – A Guided Missile System for AA Defense,* Presbyterian Church, Basking Ridge, N. J.

Kooharian, A., *On Uniformity in Singular Perturbation Theory,* Seminar on Differential Equations, Princeton University, Princeton, N. J.

Kramer, H. P., *Best Finite Linear Approximation to a Second Order Stochastic Process,* Am. Math. Soc., Columbus, Ohio.

Lloyd, S. P., *A Sampling Theorem for Stationary (Wide Sense) Stochastic Processes,* Am. Math. Soc., Cincinnati, Ohio.

Mathews, M. V., *Digital Computers as Research Tools in Speech and TV Experiments,* Arnold Auditorium, Murray Hill, N. J.

McAfee, K. B., *Electron Capture Cross-sections in Molecules,* Phys. Colloquium, Newark College of Engineering, Newark, N. J.

McCall, D. W., see Douglass, D. C.

Miranker, W. L., *Singular Perturbations of Partial Differential Equations,* Seminar on Differential Equations, Princeton University, Princeton, N. J.

Moll, J. J., *Breakdown in Silicon,* Stanford University, Palo Alto, Calif.

Ryder, R. M., *Aging Affects in Transistors,* 4th National Symposium on Reliability and Quality Control, Washington, D. C.

Sherman, R. E., *Engineering as a Career,* Richmond School, Danvers, Mass., and Andover Junior High School, Andover, Mass.

Smith, K. D., *Present and Future Status of Earth Satellites,* Sigma Delta Epsilon Womens Science Fraternity, N. Y. C.

Thomas, D. E., *The Design of* RF *and Video Transistor Amplifiers,* School of Electrical Engineering, Cornell University, Ithaca, N. Y.

Townsend, M. A., *Some Problems of Digital Communication,* Johns Hopkins University, Baltimore, Md.