

February 1962

Engineering Drawings on Microfilm

The TL Microwave System

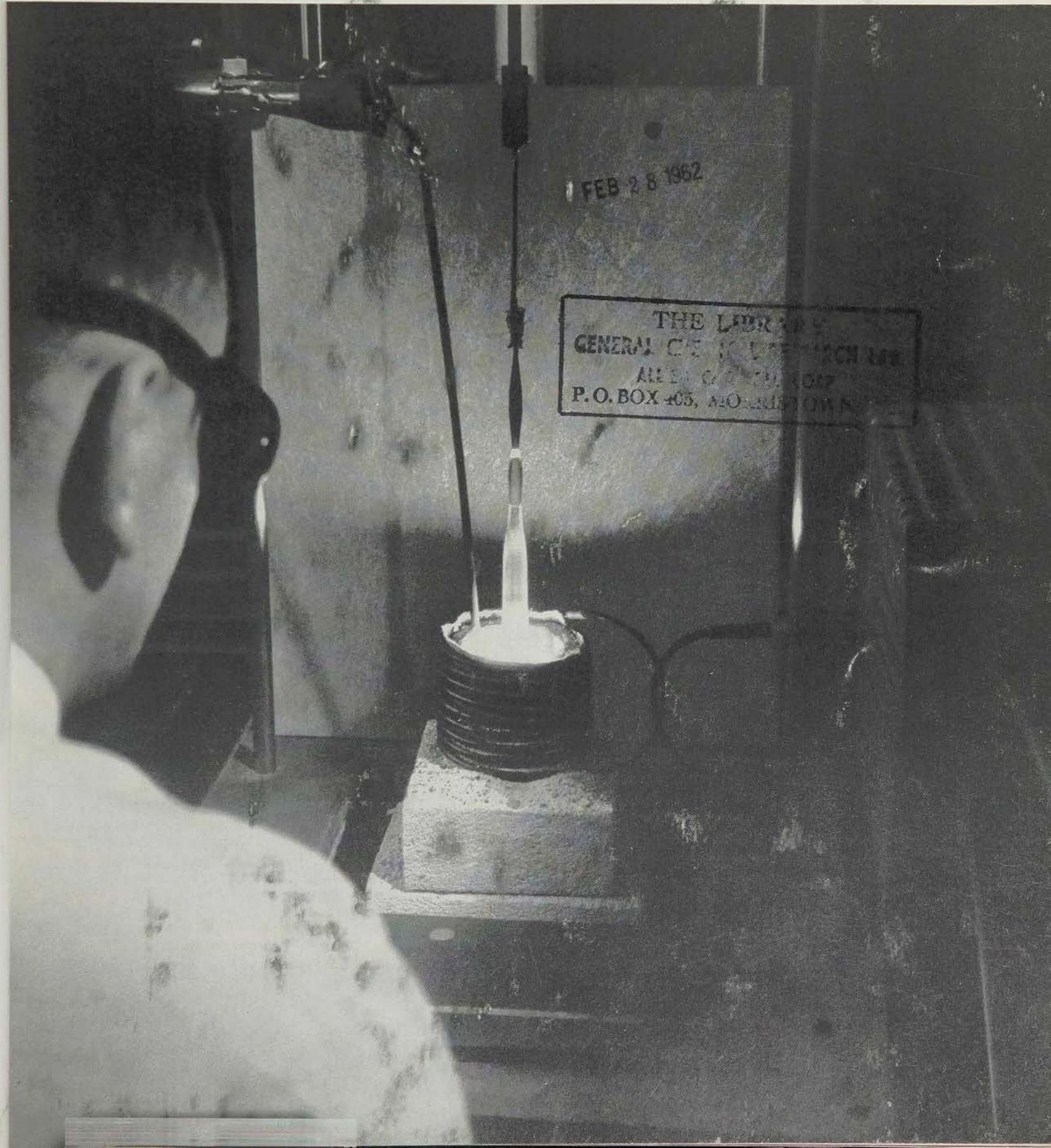
Machine Aids to Design

CAMA for Step-by-Step Intertoll

Bell System Cable-Laying Ship

Bell Laboratories

RECORD



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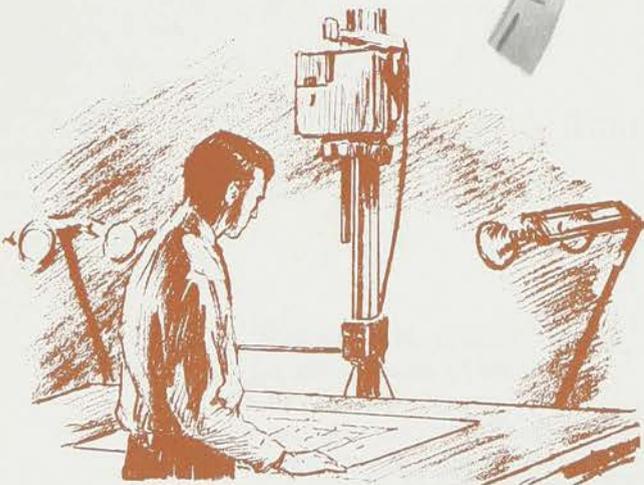
K. Nassau, Murray Hill, grows a crystal of calcium tungstate doped with neodymium, the material from which first continuously operating solid-state optical maser was constructed. (See page 63.)

Engineering Drawings



In July, 1961, equipment engineering organizations of the operating telephone companies and Western Electric began receiving microfilms of engineering drawings in place of blueprints. This marks a radical departure from past methods of distributing technical information, and introduces a new system which will substantially improve the efficiency of the engineer. When the transition is completed, it will result in annual savings to the Bell System estimated at several millions of dollars. The new approach to handling engineering drawings has come as a result of a continuing search for better ways of preparing and distributing technical information in the Bell Telephone System.

A brief comparison of the new system with the system being replaced quickly points up the reasons for making the change and reveals the attractive advantages. In Bell System equipment engineering organizations, now comprising well over 100 offices throughout the United States,

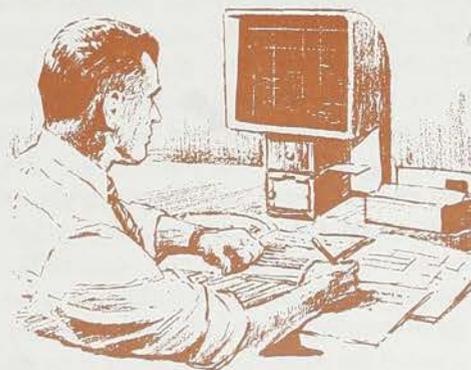


Microfilm

Bell System engineers, like engineers elsewhere, depend greatly on engineering drawings for communicating ideas and performing engineering work efficiently. A new system using unitized microfilms of these drawings promises to reduce both time and cost on engineering jobs.

W. J. Locke and C. E. Nelson

files of engineering drawings must be maintained. Much of the efficiency of the engineering work depends on the ready availability of these drawings. Since each engineering file must have on hand as many as 150,000 to 250,000 different drawings, the normal practice is to have only one copy of each drawing available, because spare copies would substantially increase the investment. It follows that frequently the one available copy will be in use by one engineer when another needs it. Often the copy must be marked up for changes and sent to the drafting room or elsewhere. A new copy is ordered, but until it arrives, the file cannot fill any requests for this drawing. The operating telephone companies cooperating in the initial trial of microfilm saved an average of about two hours per week per engineer by having a full complement of drawings available—an engineer could follow a job through to completion rather than be forced to lay it aside, perhaps midway, because he temporarily lacked a drawing.



Essentially what the new microfilm system does for the engineer is this: It provides a complete, inviolate reservoir of drawing information on microfilm, which can be drawn from without depletion, because the microfilm in the file can be used to make duplicate, nonreturnable microfilm copies on demand. The microfilm from the master drawing file never leaves the file room. It is ready to make copies for other engineers within seconds of the time they request it.

The key to the microfilm system is an apertured electric accounting machine (EAM) card into which the film image of a drawing has been mounted. Using EAM techniques, identification information is printed at the top of the card so that it can be read visually and handled with ease and dispatch in a filing system. The drawing file, now in microfilm form, is reduced to a fraction of its former size and lends itself to improved and more efficient service.

This is how the typical engineering file will operate. As in the past, an engineer requests a drawing from the file. The file clerk takes the microfilm card from the file, and with a card-to-card printer makes an exact duplicate on diazo film, which is mounted in a similar card. The non-returnable duplicate card is given to the engineer, and the card from the master file is returned, ready to serve the next request.

Non-returnable Duplicate Microfilm

The engineer now has a microfilmed drawing, which he can view in a reader as an enlarged image, to obtain the information he desires. If the engineer requires an enlarged print for marking or other purposes, his duplicate microfilm can be inserted in an enlarger-printer, and in seconds he has his print. The print will be somewhat smaller than the original tracing, but no more than reduced-size prints already in use in the Bell System.

The studies which led to the decision to convert to a microfilm system indicated that, in addition to the ready availability of information to engineers, other savings and improvements would accrue. While the convenience factor of having information easily and always available is important, the speed with which service can be given, the availability of completely up-to-date information and, in the long view, having information in a uniform size which lends itself to the application of automatic techniques for retrieval, transmission, indexing and handling, indicate future potential improvements.

The immediate advantages of conversion include substantial cost savings. First, microfilm is



At typical equipment engineering center, engineers work with volumes of paper prints of drawings.

cheaper than prints. The file operation becomes more efficient and personnel are used to better advantage. Floor space requirements are reduced by about 10 to 1. There are savings in office storage equipment, since the volume occupied by microfilm represents a reduction in the order of 20 to 1. With drawings readily available, the engineer is able to do his job more quickly. It has been estimated that an engineer, operating under the microfilm system can complete some engineering jobs from one to two or more weeks sooner. With schedules thus shortened, it should be possible for equipment to be completed, installed and producing revenue at an earlier date.

While the concept of using unitized microfilm is several years old, the tools and technology to use it have not been sufficiently advanced until very recently to make this concept work in a practical system. In fact, the background upon which microfilm has been built is very old. There are evidences that the Sumerians, who date to approximately 3000 B.C., had a method of making characters so small that they could not be read by the naked eye. The inference is that they must have had some means of reading these very small characters, and the natural conclusion is that some early work on optics had been conducted.

In modern history, microfilm began a little over 100 years ago, and the techniques of making extremely small images, as well as the development of adequate films and lenses, has advanced

rapidly. No broad attempt at commercialization was successful, however, until the late 1920's. Then, the first applications were in the field of office records, where the requirements for precision and fidelity are relatively broad. Only in the past approximately 20 years has any emphasis been directed toward recording large documents such

drawings, if adequate equipment and supplies could be made available.

Developmental and investigative work was continued in this direction, and with the cooperation of outside manufacturers, prototype and commercial equipment was provided, making it possible to begin field trials early in 1960. These trials of the microfilm system were set up to include Western Electric and one engineering office in each of three operating telephone companies. The response of engineers working with the microfilm was positive and favorable, confirming the results from microfilm programs installed earlier at Laboratories locations, and a demand began to grow throughout the System to make microfilm available as soon as possible. Responses to surveys made by AT&T in 1960 indicated that all the companies in the Bell System were interested in converting to the microfilm system. In September of the same year, AT&T examined the quality and capabilities of the microfilm then available, and decided that the quality was as good or better than that of drawings being furnished to the companies under existing standard procedures. The decision was made to move as quickly as possible toward furnishing equipment engineering offices with microfilm.

Based upon the expected availability of adequate commercial equipment and films, and the completion of systems planning, all parties agreed to work toward the introduction of microfilm beginning in July, 1961. The task of supplying the tremendous number of microfilms needed to replace the files of blueprints in the entire Bell System is of substantial proportions. From 20 to 30 million microfilms, mounted in cards, must to be produced and distributed to permit the 100-odd Bell System equipment engineering locations to operate with microfilms. To maintain these files, approximately five million microfilm cards annually will be required.

To produce this microfilm, the Western Electric Company has now set up the necessary duplicating equipment and facilities at their Hawthorne Works in Chicago. They have trained personnel and established internal routines for handling and distributing the microfilm cards. The investment in production equipment alone has been very substantial. Progress toward full microfilm production is being made very rapidly at Western Electric, and microfilm cards for distribution are currently being produced at a rate approaching a million each month.

Technical contributions of the Bell System and the cooperative efforts of a joint Bell Laboratories-Western Electric Reproduction Committee



After conversion of drawing file to microfilm, drawings are checked on individual readers, and desks are essentially cleared of paper prints.

as engineering drawings on microfilm. The application of microfilm to engineering drawings requires a more advanced technology, because higher quality is required to reproduce all information faithfully. Loss of any detail may be costly when the microfilmed information is to be used for engineering or manufacture.

The Bell System began giving serious thought to the possibility of using microfilm for engineering drawings some ten years ago. Inauguration of such a program required the same broad overall planning given to the introduction of any new technique or equipment into the Bell System. Plans were outlined and implemented for the design and operation of necessary equipment, for provision of supplies, and for adequate standards and procedures for use.

By 1956, the art had progressed to a point where the development work could be accelerated, and limited trials were begun. These feasibility trials indicated the practicability of using microfilm for the reading and reproduction of engineering

played a large part in proving the practicability of a microfilm system for engineering drawings and in producing the essential equipment. As recently as three years ago, most of the essential equipment and associated supplies were either not available or were unsatisfactory for the high quality level and large volume operations essential to the Bell System program. Now, with the joint systems planning activities of AT&T and Bell Laboratories, the design and development work of the Laboratories and the production efforts of the Western Electric Company, together with the full cooperation of a number of outside manufacturers in this field, the microfilm system is an operating entity with all components and processes operational. Development work is still continuing on improvements to the system.

The required equipment and supplies may be divided into two broad groups: 1. Those required to *produce* microfilm and, 2. Those required to *use* microfilm. In the first group are cameras, silver emulsion films, diazo films, processors, mounters, an automatic card-to-card printer, and electronic accounting machine (EAM) equipment. New features are being added to cameras, and other improvements are being made. New films have become available, and others with improved characteristics are in development. New processors and new, improved mounters for setting the film into the aperture of the card have been developed. Automatic card-to-card printers, which can make 2,000 microfilm copies per hour on diazo film, have been designed and produced to meet Bell System requirements, and are now in operation at the Western Electric Company in Hawthorne. EAM equipment has been modified to handle the microfilm cards.

New Equipment to Use Microfilm

The equipment and supplies needed to *use* microfilm include: Copy cards with diazo film mounted in the aperture, manual card-to-card printers for making duplicate microfilm, readers for viewing microfilm and enlarger-printers for making enlarged paper prints from microfilm.

At the time the microfilm program was first studied, no diazo films existed with appropriate characteristics. In fact, the ideal characteristics for such films were not even known or recognized. Existing diazo films were not satisfactory for copying purposes, largely because of their contrast, spectral sensitivity and transmission characteristics. New films with satisfactory characteristics have been developed, and further advances in the art are anticipated.

Of first importance to successful operation of

a microfilm system in an engineering file is a means to make duplicates of film easily and quickly. An efficient manual card-to-card printer was designed for this purpose and is used in the files by the file attendants to make microfilm duplicates as they are requested, in seconds.

To make microfilm attractive to an engineer, the system first of all must be as convenient to use as the one it supersedes. To accomplish this, a practical reader had to be provided which could be placed on the engineer's desk. This requirement was met by Bell Laboratories design of a new low-cost reader, which takes up only a square foot of desk space, provides high image quality, good illumination under normal office lighting conditions, and has low power requirements. The small size of the reader has been achieved by providing a scanning device. The low cost will encourage purchase in quantities that will ensure adequate coverage of engineering offices.

In addition to this small reader, a larger reader with an 18 x 24 inch screen has been designed around requirements formulated by the Laboratories. It is large enough for the entire area of the microfilm image to be viewed at one time. Although there are some instances in which this larger reader will be advantageous, it is expected that the smaller reader will be the real workhorse.

Substantial savings can result from using readers to as great an extent as possible. However, prints will have to be provided for certain uses. Accordingly, two types of enlarger-printers have been developed, one electrostatic and the other electrochemical. Both have been developed by outside companies in cooperation with Laboratories engineers, and are proving quite satisfactory. Other developments in this field are being followed closely.

It would be impossible to operate a system of the magnitude of this new microfilm program successfully without adequate standards. With the large quantities of film being produced and used throughout such wide areas, standards had to be established and rigidly applied. These standards begin with the production of the drawing itself. Although some new drafting standards have been established for the production of microfilm, for the most part the application of existing standards of drafting quality will produce good drawings for microfilm. Microfilm, however, has emphasized the necessity for following existing drafting standards very carefully. Standards books have been provided for internal use within the Bell System.

In addition to the drafting and systems standards, a number of quality standards are essential.

R. J. Kodatt, Western Electric equipment engineer takes data from image of microfilmed drawing on reader. Small file box holds equivalent of a shelf of paper prints.



Because at least two or three subsequent copy generations will be made from the original microfilm, it must have a very high quality. Resolution standards were established to control the sharpness of the image on the original film. Inspection methods and equipment are also provided for measuring these quality standards.

To assure that films have uniform printability and satisfactory readability, density standards were established. An archival quality test is also specified, to ensure that film will have long life.

In the many standards which have been established for use in the Bell System program, American Standards established through the American Standards Association (ASA) have been used wherever possible. Bell System personnel are active in the development of American Standards in this field, as in others. The Bell System has also cooperated very closely with the Department of Defense, to maintain as much correlation as possible with DOD standards, and has kept abreast of trends throughout industry.

Introducing microfilm into the equipment engineering areas of the Bell System is the first step in what may be an increasingly wide application. Studies are presently in progress to determine

the feasibility of its use in the Installation and Manufacturing Departments of Western Electric, and in the Transmission, Maintenance, Traffic, Station and Outside Plant Departments of the operating telephone companies. When these studies are finished, and following successful complete application in the equipment engineering areas, microfilm systems will be extended as the results indicate.

As mentioned previously, the new microfilm form reduces the photographic image of all drawings to the same size, with the film mounted in a card which can be handled in automatic accounting machines. This is basic to extension of the use of the microfilm medium into more sophisticated systems and applications. It is anticipated that as technical advances permit, microfilm images will be transmitted similarly to other data, and that automatic retrieval systems will become feasible.

The Bell System has found that microfilm is a new engineering tool of great potential, and further developmental effort will be directed toward full exploitation of this potential. The engineer will find that microfilm will be a great aid in his job of improving service, and of applying the fruits of research and development.



A new microwave radio system, TL, promises to become very important in short-haul circuits for telephone and television. Major advantages are simple installation, low system costs, and increased over-all economy.

U. S. Berger

The TL Microwave System

The growth and use of microwave radio for short-haul telephone and television circuits will depend almost completely on costs. The costs that a telephone company engineer must consider in laying out a new route, however, are many and varied. They include the cost of the equipment, of site preparation, and of installation, as well as the yearly maintenance costs for the expected life of the system. To provide a system which is satisfactory in all aspects, therefore, Bell Laboratories development engineers must strive for more than just economical *equipment* design as a development and engineering objective. The TL Microwave System furnishes this over-all economy for telephone and data service.

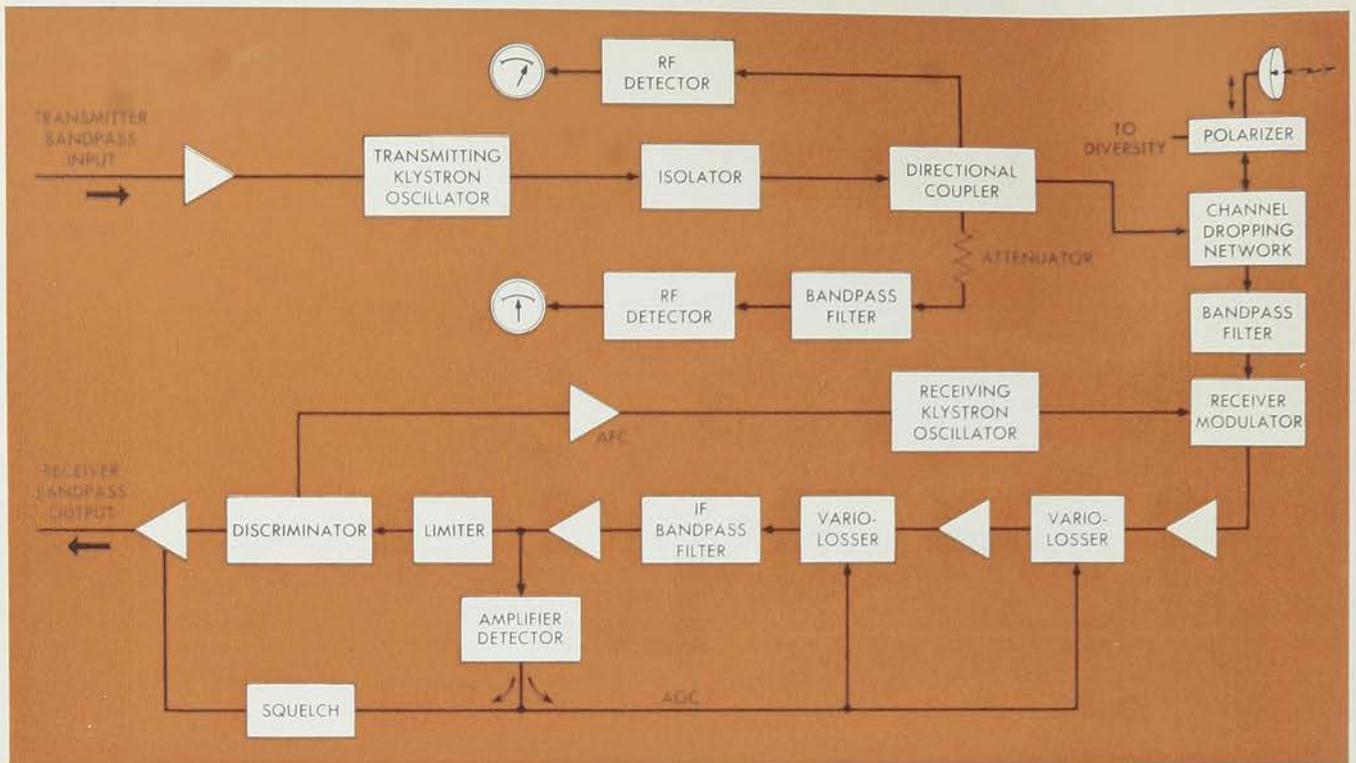
The major advantages of the TL System can perhaps be summed up in three areas: low system costs, simple installation, and reduced maintenance effort. These benefits all accrue from basic design features of the system, and are thus hard to separate. For example, since the system uses primarily solid-state devices, its power requirements are much lower than other systems operating in the same band. It can be operated with common lead-acid storage batteries for

standby emergency power, eliminating the need for an engine alternator. The storage batteries, held on charge from 115v commercial power, can operate the system from 12 to 24 hours after a power failure, depending on temperature conditions. The terminal and repeater equipment can be housed in compact outdoor cabinets which have been shop assembled and wired, without an elaborate building. Installation is thus reduced to setting a tower, attaching a cabinet and making external connections. The equipment can also be mounted on central office frames.

The solid state devices used should provide predictably longer life, reducing maintenance visits. When maintenance is required, the defective unit can simply be replaced by a spare, usually a plug-in unit, and returned to the factory for repair. Also, the klystrons which generate the needed microwave frequencies, the only non-solid state active elements in the system, are conservatively operated, increasing their life expectancy.

The expected reliability will be such that in many cases frequency diversity will be unnecessary, but diversity arrangements have been provided for the companies that wish the ultimate





Block diagram of TL microwave system is similar to that of TJ radio. Important differences include

gain control by temperature control of klystrons and use of transistors and ferrite transformers.

in reliability from outages caused by equipment failures and fading. TL also provides a simplified order-wire and alarm system for maintenance.

The TL Microwave System operates in the 10,700 to 11,700 mc common carrier band, and can be operated electrically and physically with TJ Microwave under most circumstances (RECORD, April, 1959). The basic TL concept is that proposed by the Radio Research Laboratory as an experimental "Short-Hop Microwave System" (RECORD, June, 1960) with departures where economic factors indicated a definite advantage.

The outdoor cabinet shown on page 48 holds all the radio, power and auxiliary equipment necessary to transmit and receive in one direction on a non-diversity basis, and can be used alone at terminal points in a short haul system. At a repeater point, a second cabinet is required for transmission toward the opposite terminal. Multiplex equipment used to translate several N or ON Systems to the radio frequency spectrum can be mounted inside the TL cabinet. The telephone channelizing equipment for the carrier system is located in the telephone company central office. Four six-volt storage batteries included within the cabinet provide the standby power referred to earlier. Standard automobile batteries will also operate the equipment, and provision is made for an external connection to a portable

engine-driven alternator for long-term power outages. The cabinet is attached to struts at the base of the two wood-pole antenna supports, requiring no further protection against the weather.

Conventional rack mounting arrangements have been provided where local conditions dictate that the radio equipment be mounted indoors. A single seven- or nine-foot rack includes essentially all of the equipment that is contained in the outdoor cabinet. The Western Electric Company has devised standardized shop-wired packages for the radio equipment to make very short delivery intervals possible.

The block schematic of TL Radio equipment shown above is quite conventional, and in many features is similar to the TJ System, also operating in the 11,000 mc band. A number of important differences do exist, however. For example, the TL transmitting and receiving oscillators use a new 11,000 mc klystron tube, coded the 457A. To maintain the desired frequency stability, a vapor-phase cooling system, shown at right, maintains the temperature within the klystron housing nearly constant over a wide range of ambient conditions. The klystrons are clamped to a small hollow boiler partially filled with a low-boiling (214 degrees F) fluorochemical liquid. When the tube and boiler reach this temperature, some of the liquid boils and the vapor

passes out into the cooling system. There it condenses and runs back into the boiler, keeping the temperature relatively constant. A rubber bag is used as an expansion chamber to permit volume changes without significant pressure changes. The diagram below the photo shows a typical temperature-frequency characteristic obtained from a laboratory model of the equipment. Because of the relatively constant temperature at the klystrons, automatic frequency control (AFC) provisions are unnecessary at the transmitter. AFC at the receiver, however, insures that the signal is centered in the intermediate frequency (IF) band.

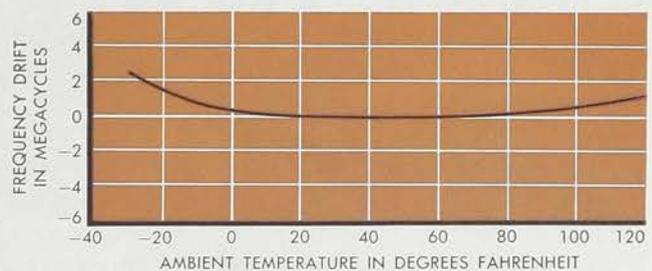
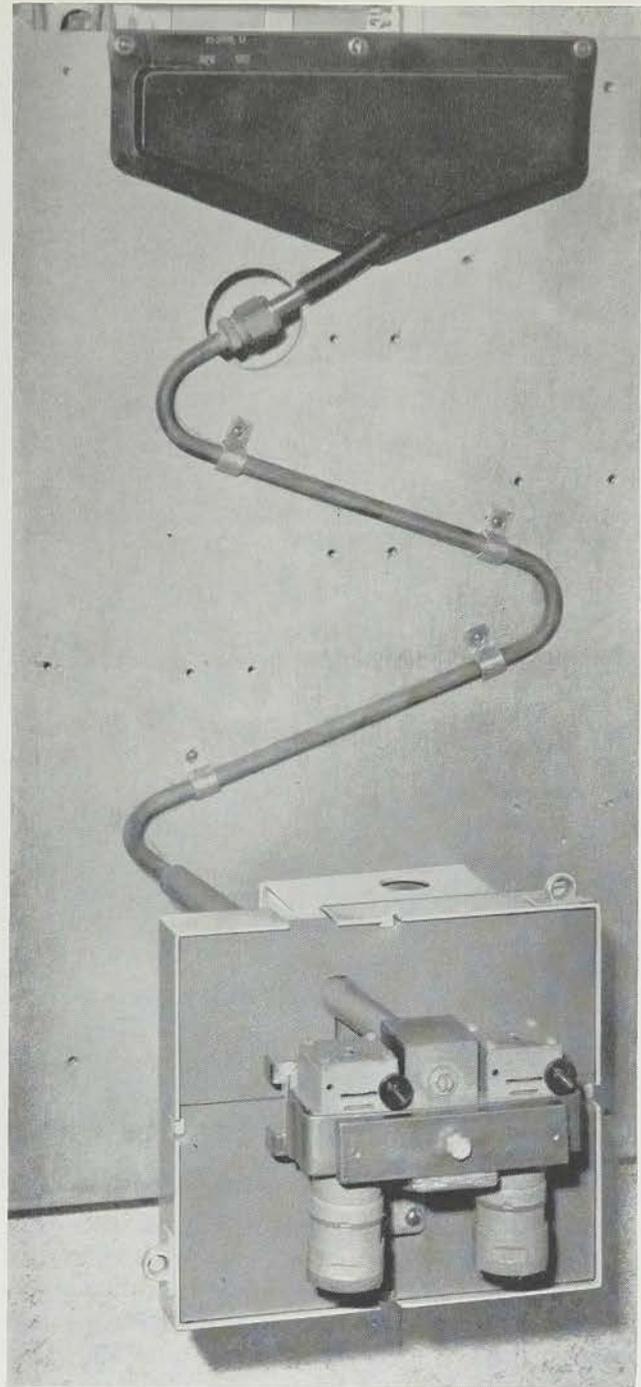
Solid-State Devices Used Throughout

As mentioned earlier, the entire TL System uses primarily solid-state devices and other recently developed devices and circuitry. The receiver, for example, incorporates a transistorized IF amplifier with wide-bandwidth ferrite transformers. These transformers provide the coupling between transistor stages, and with an impedance ratio of 4:1, give about 5 db gain per stage. A total of 27 transistors and 23 transformers provide the required 110 db of IF gain. Two diode variolossers, placed between sections of the amplifier, furnish automatic gain control. The amplifier has an essentially flat band from about 30 to 100 mc. A 60-80 mc band-pass filter selects the IF bandwidth desired. This band-pass filter is corrected for delay distortion to reduce intermodulation distortion between telephone channels to a minimum.

To provide automatic frequency control in the receiver, an error signal is derived from the discriminator and applied to the control winding of a magnetic amplifier through a dc amplifier. The magnetic amplifier output is detected, and dc is applied to the repeller of the receiving klystron oscillator to adjust the difference frequency between the incoming signal and the oscillator to 70 mc, the IF frequency.

Transmitting and receiving baseband amplifiers are used to obtain proper input and output levels of the carrier signal applied to the radio system. The operation of the system can be monitored using a control and meter panel included in each transmitter-receiver bay.

A simplified order-wire and alarm system makes monitoring the TL System convenient, while keeping the cost as low as possible. The order-wire and alarm circuit occupies the frequency spectrum from about 200 cps to 3000 cps, while the carrier systems use the spectrum above about 10 kilocycles.



As klystrons in lower part of photo heat up, low-boiling liquid in square boiler vaporizes and rises into heat exchanger tube. The constant temperature prevents frequency shift, as shown in graph.



B. A. Rasmussen, Mountain States Telephone Co., checks the operation of TL repeater at Chink's Peak, Idaho, one of the first installations of TL.

The alarm system uses a continuously applied 2600 cps tone sent from the control terminal down the system and looped back at the distant end. As long as the system is functioning normally in all respects, the 2600 cps tone is steadily received at the control terminal. If ac power fails, a relay operates and interrupts the tone, sounding an alarm in the control terminal. This alerts an attendant, who then interrogates each station in sequence by sending out a series of tones, each unique to a particular station. A band-pass filter at each station, corresponding to the tone assigned to that station, is bridged from the incoming side to the outgoing side of the system, and returns the interrogating tone to the control station. The attendant listens at the output of the order-wire circuit to determine the presence or absence of the station-interrogating tone. If the system has

failed, interrogation can proceed only partially down the system and the attendant can determine where the trouble is within one repeater location.

Other warning signals can also be incorporated. For instance, if the station requires the use of high towers with aircraft warning lights, alarm indications of failure of the tower lights can also be interconnected to the alarm system, as prescribed by law.

A telephone talking circuit incorporated in the voice frequency range of the baseband spectrum provides radio order-wire facilities. Provisions have been made to talk either toward or away from the control points, or toward a spur on the through-signaling circuit, if one exists.

For those cases where maximum reliability against fading and equipment failure is required,

a diversity switch has been developed. In this switch, the logic is based upon the presence or absence of the 2600 cps tone in the baseband and on the strength of the received signal. This signal strength is determined by the magnitude of the AGC voltages in the two receivers. On a fade, the no-hit diversity switch instantaneously operates through the other receiver. In case of equipment failure, the switch operates in less than 35 milliseconds.

The power supply for the TL system operates from the 24-volt storage battery and delivers a highly regulated and filtered 20-volt dc for all the transistor circuits as shown below. A transistorized dc/dc converter provides 200 and 400 volt power for the klystron tubes. The converter also provides 6-volt dc, which applied to the klystron heaters, keeps low frequency noise at a minimum.

Antenna Arrangements

A number of antenna and tower arrangements can be used with the TL system. A five- or ten-foot parabolic antenna now used with the TJ System can be used as a direct radiator for TL when mounted on a low tower and fed from the radio equipment by two rectangular waveguide runs. A polarizer at the antenna distinguishes between the two modes of polarization. A unique drain system avoids the need for dry gas pressurizing, normally used with outdoor waveguides (RECORD, *January, 1961; July, 1961*). When taller antennas are required, a periscope antenna system is used to keep the over-all radio path loss as low as possible. The periscope uses either a five- or ten-foot parabolic antenna at the base of the tower, mounted to radiate directly upward. A metal reflector at the top of the tower, at an angle of 45 degrees, receives the signal from the ground antenna and reflects it horizontally toward the next station. The antenna and reflector, much like the elements of an optical system, must be accurately oriented to direct the

emerging beam toward the distant station. Depending upon the height of the tower, reflectors can be 6 x 8 feet, 8 x 12 feet, or 10 x 15 feet.

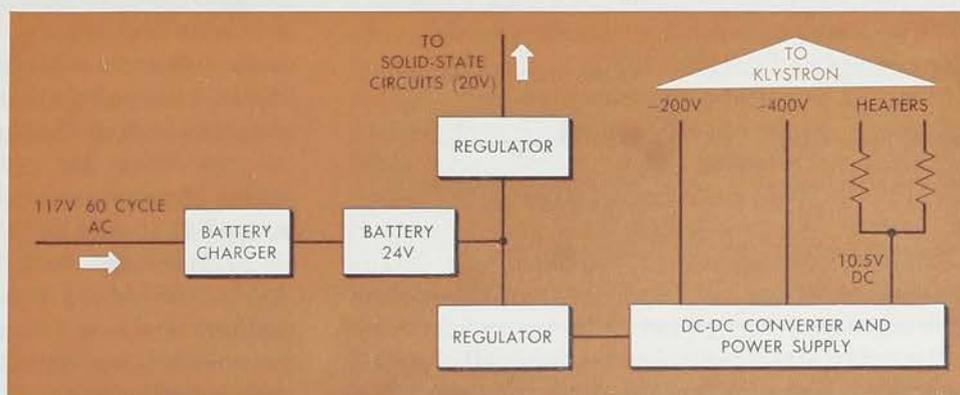
The simplest and most inexpensive type of antenna mounting is the woodpole "H" structure shown on page 44. This design is adequate for heights up to 60 feet, with either direct radiating antennas as shown, or with 6 x 8-foot reflectors. For those installations where a steel tower is preferred, or where heights greater than 60 feet are needed, a new series of lightweight, guyed and self-supporting towers has been developed. These towers, designated Type C, have been designed to withstand wind loads of 30 lb. per square foot, in heights from 60 to 105 feet. Where a very tall tower (up to 300 feet) or greater strength is desired, the Type B tower developed for TJ Radio Relay can be used.

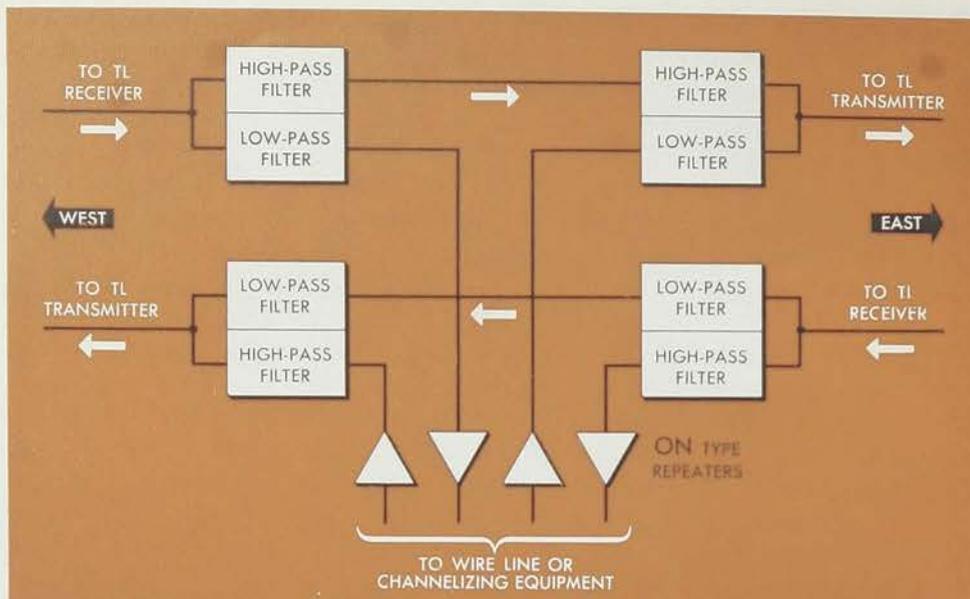
Many types of frequency division multiplex can be used as the channelizing equipment on TL Radio. Western Electric Type N, ON, and L have been provided as standard arrangements (RECORD, *February, 1959; November, 1960*). At least 48 channels of N and up to 96 channels of ON can be used, and performance tests on early models of the radio equipment indicate that more than 240 channels of L Multiplex (single-sideband suppressed carrier) meet system objectives for ten radio repeater hops.

The channelizing equipment is located in a central office, usually near other connecting equipment such as patch bays, and signaling and switching equipment. At the radio location, the various basic N or ON systems can be separated from the combined baseband signal and sent over separate cable facilities if required. A block diagram of a typical method of dropping and inserting signals in the baseband spectrum at a radio repeater site is shown on the next page.

Preliminary development work has substantiated that two 24-channel time-division T Carrier (Pulse Code Modulation) Systems can be

Power supply from 24-volt storage battery provides filtered 20-volt dc for all transistorized circuits plus 6-volt dc for the klystron heaters.





Channelizing equipment for TL is located in central office. Diagram shows method of dropping or inserting signals in baseband spectrum at site.

placed in the TL baseband frequency spectrum by frequency multiplex techniques. Means are provided for separating the two systems at a dropping point similar to that necessary for the frequency division multiplex systems, and for dropping and reinserting small groups of channels in the basic 24-channel group under certain conditions.

A few of the pertinent performance characteristics of TL Radio Relay are summarized in the table below:

PERFORMANCE CHARACTERISTICS OF TL RADIO RELAY

Frequency Range	10,700—11,700 mc
No. of Radio Channels	6 (each direction)
No. of Hops in Tandem	10 maximum per alarm section
Transmitter Power	0.1 watt (+ 20 dbm)
Receiver Noise Figure	less than 15 db at -35 dbm
Normal Receiver Input	-35 to -45 dbm
Normal Fading Margin	40 db
System Bandwidth, 1 Hop	200 cps to 6 mc
Carrier Frequency Noise (7.5 kc—5 mc)	62 db below full deviation (unweighted, 1 hop)
Order-wire Noise	45 dba at 0 db transmission level, 10 hops
Primary Power Input	170 watts per terminal
Antenna Gain (Typical)	42 db (5 ft antenna and 6 x 8 foot reflector)
Diversity Operation	Optional
Baseband Stability	± 0.2 db per repeater section

Repeater stations in most areas will normally be spaced 15 to 20 miles apart. In areas where

heavy rainfall is prevalent, repeater spacings may have to be reduced; conversely, in very arid regions, distances can be increased. On long spans, where maximum reliability and circuit continuity is desired, diversity operation fulfills this need as described previously.

The TL control panel itself contains many of the facilities for operating and maintaining the system. Two meters and a selector switch permit maintenance personnel to monitor numerous currents and voltages, as well as the frequency of the transmitter and the efficacy of the receiver AFC and AGC circuits. A new, transistorized portable field test set permits other, more detailed measurements on the system. Deviation, net loss, receiver gain, baseband amplifier gain adjustments, AFC alignment, and certain in-service tests can be made with this set.

Perhaps among the most valuable aspects of the TL equipment is its short delivery time. The equipment is so packaged that it can be shipped from the factory in complete operating condition, except for the storage batteries. A streamlined ordering and order processing scheme has been devised so that telephone company and Western Electric engineering operations are kept to a bare minimum. Installation effort has been reduced to a minimum by using a standardized arrangement of the equipment at the field site and by providing factory-prepared and terminated cables for interconnection. No soldering is required to install the radio equipment in the field.

TL is the first truly packaged microwave system to be offered to the operating telephone companies, a major forward step in providing fast, economical and flexible microwave service for every application.

Engineers designing large, complex systems spend many man-hours doing important yet non-creative work related to designing circuits and equipment or preparing maintenance information. These and many other tasks can now be done as well or better by computers.

C. W. Rosenthal

Machine Aids to Design

Engineering and science have initiated and fostered the automation of industry and commerce. Over the last century and a half, automation has produced automatic fabric mills, computer oriented accounting systems, machine assembly of electronic circuits, and countless other automatically controlled activities. Recently engineers have been automating the increasingly complex tasks they themselves ordinarily perform. This has been stimulated by the increase in size and complexity of the systems that engineers design. It is also a response to the competitive atmosphere which has stimulated invention of methods for producing the best designs and reducing development time and expense. This work is worthwhile since it reduces the number of repetitive tasks performed by engineers and thus tends to provide more satisfying work for creative people.

As discussed in this article, automation of design techniques (also called machine aids to design or machine aids) is the utilization of digital computers to perform engineering design tasks. Unfortunately, this definition is not very specific. The relatively short experience with this work and its increasing scope, however, make it dif-

ficult to provide a more precise description.

A Bell System development project usually contains five phases. A.T.&T., Bell Laboratories, Western Electric, operating telephone companies, and quite often military agencies contribute to each of the phases. This article will only consider the contributions of Bell Laboratories engineers. The first phase, systems engineering, relates functions and economics to available methods to produce a development plan. The second phase produces the designs for circuits, equipment, and logic needed to satisfy the system plan. In the third phase, engineers prepare layouts by selecting components and positioning them on equipment within the limitations of the electrical and mechanical design. This is the accommodation of the specific designs to one another. In the fourth phase, another group of engineers prepare the manufacturing information, including wiring information, materials lists, and drawings. In the last phase, the development group prepares maintenance information and aids, and often develops procedures to handle changes in the design data.

How can computers aid the development group in these different phases? To answer this ques-

tion completely, it is necessary to understand what a computer is and what it can do. The computer is a complex electronic machine constructed to solve problems by following a precise program of instructions that leads it step by step through the appropriate calculations. By changing the programs of instruction, engineers can change or modify the problems the computer solves. The computer simulates a system by repeatedly solving equations describing the system and using the results, or outputs, from a computation as the input conditions to the next computation.

For the first phase, programs have been written to control a general purpose digital computer to simulate the operation of a new system proposed by the systems engineers. Using the simulation results, the engineers select the parameters and organization to give the best results (RECORD, August, 1959). For example, a computer may provide data concerning the traffic capabilities of a proposed central office plan and the suitability of its links to other systems. In the past, this information has been provided by semi-automatic or manual methods.

Computers used in the second phase calculate the characteristics of electronic circuits, taking into account variations in component values, sup-

ply voltage and environmental situations. The selected operating parameters are then able to give the best circuit performance. Second phase programs have also been devised to aid in the design and analysis of logic networks. Individual programs have already been achieved to satisfy the tasks as described in the first two phases. However, this article is primarily concerned with the program's last three phases.

Integrated Computer Programs

In these last phases, the action of many separate programs is closely integrated and the programs automatically follow one another to perform a set of tasks. The Laboratories has developed and used three such integrated sets of programs. One set is the Bell Laboratories Automatic Design System (BLADES) (RECORD, February, 1961), a second the Development Information Processing System (DIPS), and a third the Machine Aided Manufacturing Information (MAMI) System. This article will not attempt to differentiate among specific features of these three systems.

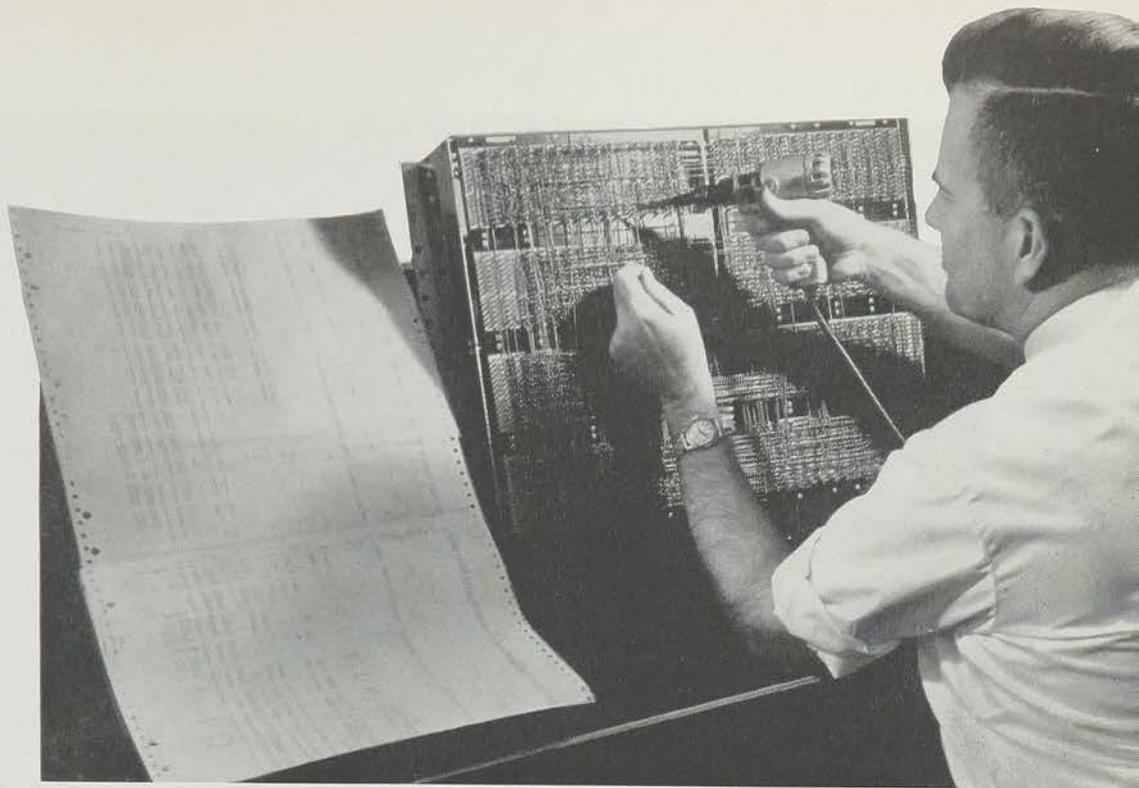
The necessary information, initially put into a set of machine aids computer programs, comes from information previously generated by logic and equipment designers at the second phase of development. It is important, first, that this design data should be readily convertible to computer language. For example, one frequently used design document is a logic diagram. This can be reduced to a tabulated set of equations by using special symbols and table formats. This information is then reproduced on a set of punched cards and used as the input data to the set of machine aids programs.

The first computer programs check for possible input data errors. These errors may be due to the incorrect use of symbols, errors in transcription of an equation or the permutation of some characters. Errors found in the input data are listed by the computer and further processing is halted. The error list is then returned to the designers for correction. When all the data is finally correct, the check programs are followed automatically by additional programs. These programs lay out a good chassis arrangement of the elementary electronic circuit modules needed to produce the desired logical actions. These elementary circuit modules are designed so that in most cases, only a few different types need to be used in a large system such as a computer or a telephone exchange. Typically, the modules are small and many thousands are needed for a system. Incidentally, the use of these modules is characteristic of development projects at Bell Laboratories which thus



R. B. DePoy, Western Electric engineer, examines a D-unit drawer of a computer-designed computer.

A. Clayton uses a wire wrapping gun to connect wires, following instructions printed automatically on "wire running list".



far have used the machine aids techniques.

The first step toward a good chassis arrangement is to assign specific circuit modules to perform the necessary logic functions. The second step is to determine the placement of the modules on the chassis while keeping the total length of interconnecting wire to a minimum. This generally reduces the crosstalk and capacitive loading encountered by the electronic circuits.

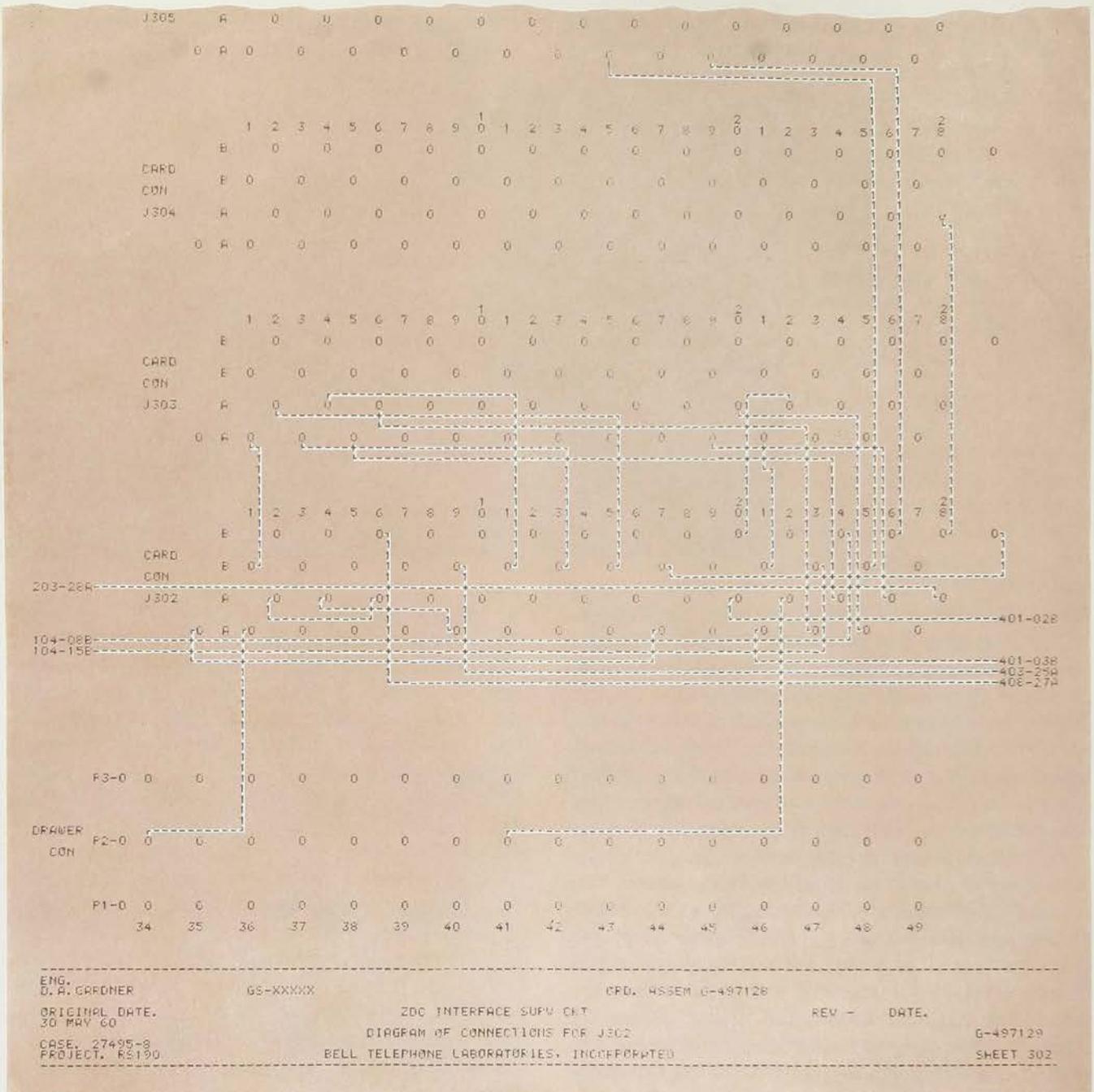
Following placement of circuit modules, programs select the wire routes to interconnect the circuits. Such routing is accomplished while adhering to limits based upon the lengths of wires, the proximity of adjacent wires, the length of the longest wire, the number of connections per terminal and the characteristics of an automatic machine which may be used later to perform the wiring. Signal and power supply wiring can have separate requirements and these can be individually considered by the computer when laying out the wires. The computer programs for circuit module placement and wiring often give better results than manual procedures. Men cannot successfully carry out manually the millions of calculations or trials that present computations methods employ.

It has proved desirable in certain instances to prepare manufacturing information in several forms to satisfy the differing needs of wiremen and logic design checkers. The computer programs record the document data on reels of magnetic tape which control the printers directly. Certain wiring diagrams can be prepared which provide figurative, non-literal layouts of the wires. A portion of such a wiring diagram is shown on page

54. Several forms of "wiring running" and electrical parts lists for ordering and inventory can also be prepared. By the end of the wiring operation all needed data have been generated, and magnetic tapes have recorded the information. The tapes are then filed for future use as manufacturing documents.

The filed magnetic tape information is also sorted and printed for use as maintenance information. The tapes are always available for automatic reference and correction should changes in the design occur. When any changes are necessary, only the change information is introduced. Change programs automatically use the new information to modify the design recorded on the tapes and to produce lists of the wires and components to be deleted and added. The speed, accuracy and ease of making changes can justify the entire machine aids procedure.

Experience with machine aids programs indicates that they can perform a broad range of tasks to aid the development engineer in his day-to-day work. Using computers to supplement the talents of men increases their productivity and accuracy and reduces the cost of design projects. Of prime importance, time is quite often saved. To date, machine aids have only been used on "large" projects which could absorb the very high cost of program development. This presently means that a system must use many chassis before machine-aided techniques are less expensive than normal manual methods. However, possible future acceptance of standardized design patterns may reduce the initial cost.



A wiring diagram printed by a computer, although nongraphic, indicates the actual wire connections.

Because of the useful application of machine aids programs, there is continued interest in improving and extending them to new tasks. The programs presently are intimately bound to specific electrical and mechanical designs. Standardization of designs will foster wider use of machine aid programs. However, the better alternative, though it is more difficult to achieve, is to generalize the programs to apply to several designs.

At present, the input data to machine aids programs describes the individual logic functions and their interconnection by the individual wires.

These are very detailed descriptions, and it would be very helpful if we had a language to describe larger collections of logic functions and a computer method to decompose them to their necessary details. Machine aids programs have been used in developing modularly constructed digital systems such as data processors for missile systems and new communication systems. Steps are also being taken to process No. 5 Crossbar data. It is possible that there will be other applications to both nondigital and nonmodular systems, to further expand the usefulness of machine aids.

To make direct distance dialing available to central offices handling a low volume of toll calls, Bell Laboratories engineers designed an inexpensive centralized automatic message accounting system.

A. S. Martins and R. G. Ruwell

CAMA for Step-by-Step Intertoll

Direct distance dialing (DDD) has been in effect in many areas of the United States for several years. Until recently, however, it has not been economical to provide this service in some of the more sparsely populated areas, particularly those served by step-by-step intertoll offices. Basically, the small volume of toll calls originating from these locations did not economically justify the installation of crossbar-type centralized automatic message accounting (CAMA).

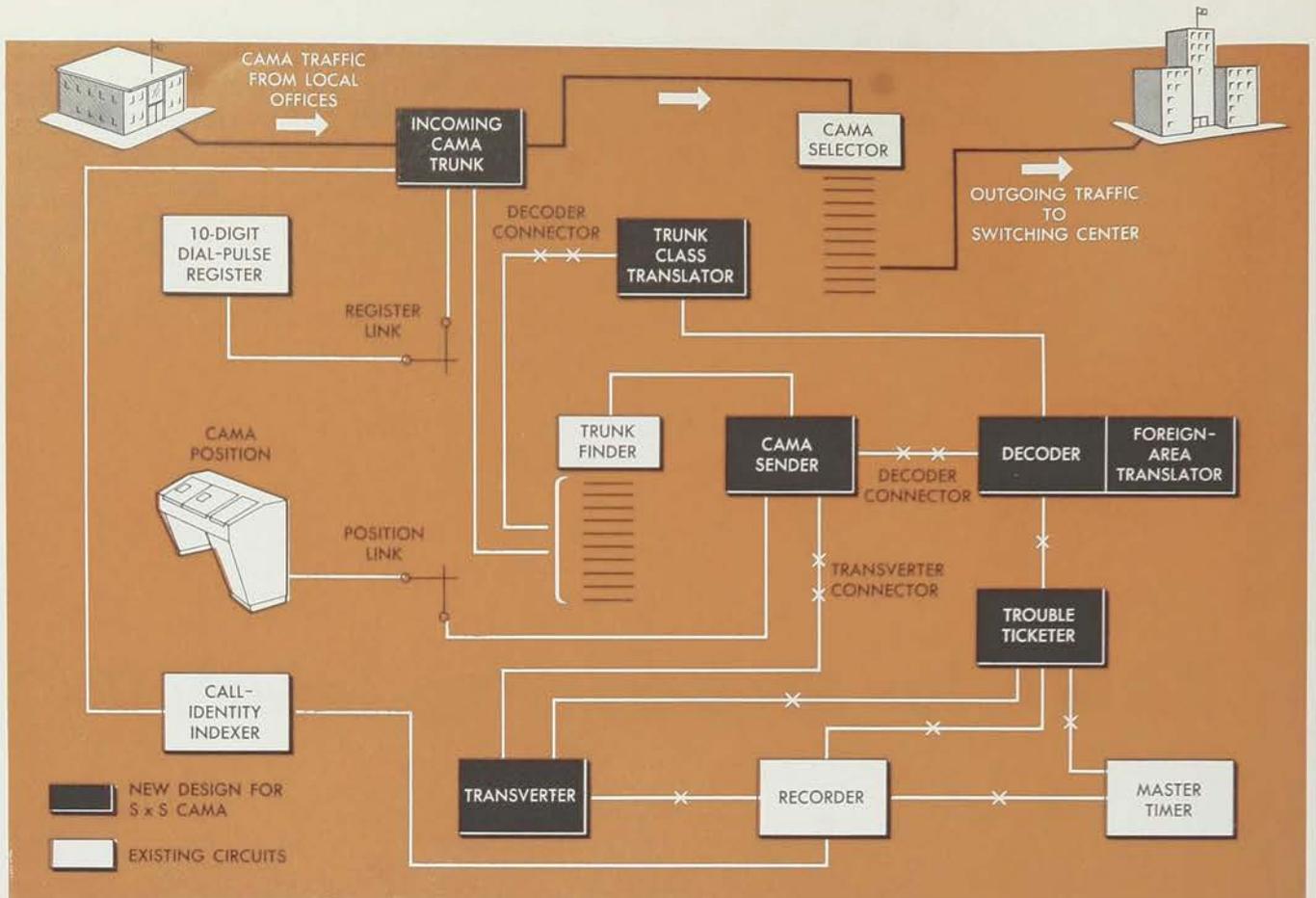
Nonetheless, it was felt that some arrangement was needed to permit DDD in areas where the high initial costs of toll crossbar, crossbar tandem, or No. 5 crossbar could not be justified. To meet this economic requirement, Laboratories engineers designed a CAMA system for step-by-step intertoll that has a low "getting started" cost, yet still furnishes a grade of service comparable to that in the rest of the Bell System.

This system is an example of the way limited common-control features can be added to step-by-

step switching systems without greatly increasing the cost and without excessive development effort. Many items, such as the 10-digit dial-pulse register, the CAMA operator position, and the register and position links were adapted from the other CAMA systems. However, the sender, transverter, decoder, incoming trunks, and maintenance equipment were newly designed.

The arrangement of the major circuits required for a CAMA installation in a step-by-step intertoll office is shown in the block diagram on page 56. Basically, this arrangement is similar to CAMA systems already in use. Because of the emphasis on economy, however, and because of the necessity of working with existing step-by-step intertoll circuits, the detailed circuitry and equipment arrangements used here are considerably different.

Calls from step-by-step originating local offices gain access to the CAMA equipment through dial-pulse incoming CAMA trunks. The digits are



Block diagram showing a typical installation of CAMA in a step-by-step intertoll central office.

stored in incoming dial-pulse registers. Calls from No. 5 crossbar originating offices are completed through multifrequency incoming CAMA trunks, and the multifrequency signals are detected by a receiver in the sender and stored there on memory relays. As in No. 5 crossbar CAMA (RECORD, October, 1958), the step-by-step system will accept calls originating from as many as 48 local offices in a maximum of three different numbering plan areas.

A calling customer's telephone number may be obtained verbally by a CAMA operator, or automatically if the originating office is arranged for automatic number identification (ANI). Where the calling customer's number is identified automatically and transmitted as multifrequency tones to the sender, the CAMA operator position and the position link are normally not used. Both dial-pulse and multifrequency incoming CAMA trunks function with either ANI or operator identification.

Incoming register links and dial-pulse registers are similar to those of the 4A CAMA system (RECORD, October, 1959). To ensure that a register will be connected in time to receive the pulses of the first digit following the directing code, the

link is arranged for "by-link" operation. In other words, the register temporarily uses contacts on the fast-acting link-control relays to connect the pulsing path from the trunk to the selected incoming register while the regular connection is set up through the slower-acting crossbar switch. The incoming register handles both seven-digit and ten-digit calls. It distinguishes between these two types of calls by examining the second digit for a zero or a one (which indicate area codes for ten-digit calls), and transmits the called number as multifrequency signals to the sender at the appropriate time.

The trunk finder (between trunks and senders) is similar to that used in the step-by-step AMA system (RECORD, March, 1957). Each sender works with a trunk finder. The sender receives both calling and called numbers in the form of multifrequency tones. It outputpulses a maximum of 15 digits. First, it outputpulses one or two dial-pulse digits to reach an outgoing trunk, and then it either continues with dial pulses or it shifts over to multifrequency pulses for the remaining digits. The sender controls the action of the decoder, transverter, and CAMA position circuits. Although

one decoder (used primarily for translating the called code into routing information for the sender) could probably handle all the traffic in the largest installation, two decoders are always provided to insure continuity of service. As many as three foreign-area translators may be furnished on an optional basis as part of each decoder. These translators provide six-digit translation and direct routing to points in as many as three numbering-plan areas adjacent to the home area.

A trunk class translator, also optional, supplies the decoder with such information as area of call origin, recorder number, rate class, and type of calling-number identification required. The decoder uses the area of origin and the called number information to determine the routing of a call and to select the proper foreign-area translator to operate the correct route relay. In addition to furnishing the sender with all the information required for the proper routing of the call, the decoder also informs the sender whether the particular destination called can be reached by way of an alternate route. With this feature, if the sender finds the preferred route busy, it calls in the decoder again to obtain the alternate route.

The transverter is similar to the No. 5 crossbar CAMA transverter. It has been simplified somewhat in that it no longer provides for compressed-area codes or operation with a billing indexer. In step-by-step CAMA, the transverter takes over the billing indexer function of matching the called and calling office codes to determine whether the customer gave the operator the called rather than the calling number. The transverter also translates the calling office code into an office index—in this case, a two-digit index.

The switchboard for step-by-step CAMA may be either the cordless type designed specifically for CAMA operation or, in small offices, it may be the existing toll or dial service A (DSA) board modified to handle both CAMA and regular toll or DSA traffic. The call-identity indexer, the master timer, the recorder, and perforator are similar to those used in other CAMA systems.

Several factors account for the low initial cost of the system. One of the costly items eliminated by the step-by-step CAMA design is the billing indexer. In certain CAMA systems, this unit combines originating and terminating rate class information to determine the cost of message-unit calls. Because this CAMA system will be installed primarily in step-by-step areas where message rate service and message units are practically never used, it is economical to eliminate the billing indexer by simply not providing for the

handling of message-unit billing. In the few instances where step-by-step CAMA will be installed in areas having message-unit traffic, message-unit detail records can be made on the CAMA tape. Detailed recording also eliminates the costly line number matching equipment required for line-observing. In this system, all DDD calls are detail-recorded. This means that each customer receives a complete record of all extra-charge calls made during the previous month. With this arrangement, customer inquiries should be relatively few.

Another saving was made by using a step-by-step type trunk finder instead of a sender link. The cost of sender-link frames would be prohibitively high in smaller step-by-step CAMA installations. The reduction in cost is also appreciable in the larger installations.

Because step-by-step CAMA will be installed in areas originating relatively few toll calls, more central offices can be included in a recorder group than in other CAMA systems. (A recorder group is one or more AMA recorders whose tapes are processed together.) Accordingly, the number of central-office indices per recorder group was increased from 10 to 30. This regrouping should eliminate one or two CAMA recorders in approximately 80 recording locations.

Special equipment layouts also contribute important savings. Many unorthodox combinations of units on a frame reduce the number of frames required for smaller installations. In the very small central offices, with less than 70 CAMA trunks, two arrangements are available to minimize the amount of CAMA recording equipment. With one arrangement, two call-identity indexers are combined with two regular recorders. There is no emergency recorder. Half of the trunks are normally served by one call-identity indexer and half by the other; however, all the trunks are multiplied to both call-identity indexers. In case of trouble, all the trunks can be transferred manually to a single call-identity indexer. The second arrangement uses only a single call-identity indexer which is served by a single CAMA regular recorder. In the event of trouble, maintenance personnel can substitute an emergency recorder. The first arrangement provides better service protection if a call-identity indexer fails since at least half the CAMA trunks will still be in service.

To get an idea of how these units work, suppose a customer in a step-by-step originating office not equipped for ANI places a call through the CAMA equipment. First, he dials an access code. This code activates the local-office switch train which connects his line to the outgoing trunk to the CAMA office. At the CAMA end, the

dial-pulse incoming CAMA trunk is attached to an incoming register during the interdigital time following the access code. The customer follows the access code with the called number. Just before the customer completes dialing, the register signals the trunk to attach an idle sender through the trunk finder. When the sender is attached, it tells the register to transmit the called number by multifrequency tones and then to release so that it will be free to register other dial-pulse calls.

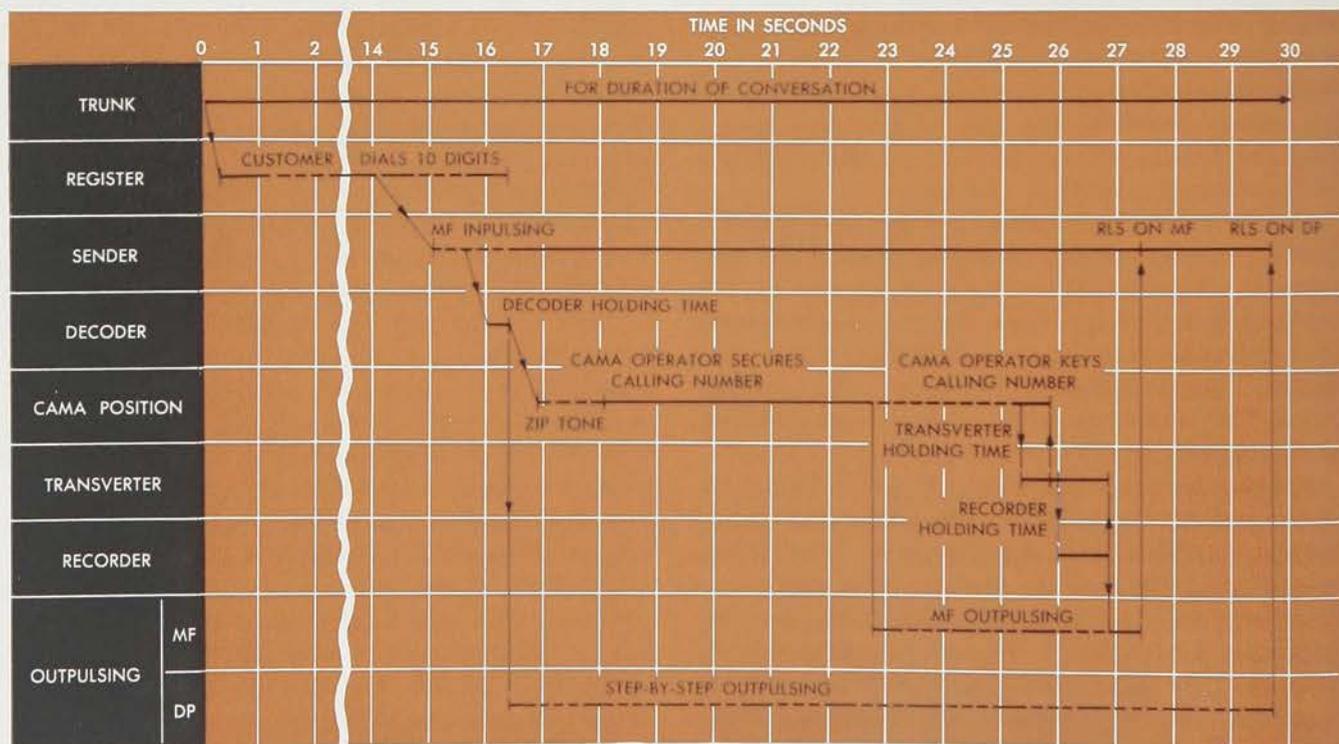
After the sixth digit is stored in the sender, a decoder is summoned. By checking the second digit for a zero or one, the decoder determines whether the call is seven-digit or ten-digit. It uses this information, as well as the information from the trunk class translator (if provided), to route the call. The decoder then tells the sender whether any digits of the called number should be deleted, how many additional digits to prefix for routing purposes, the type of outpulsing required, whether the calling number should be operator-identified or automatically identified, and whether an alternate route is available. If the calling number should be operator-identified, the decoder releases and the sender puts in a bid for a CAMA operator position.

If the call is to a step-by-step office, where there is no danger of timeout of the equipment

due to delay in obtaining the calling number, out-pulsing also starts at this time as shown below. When the position is attached, the operator is given an alerting tone signal, and a talking connection is established between the operator and the calling customer. The operator requests the calling number and keys it into the sender. If the call is to a common-control office, where there is danger of timeout of the registering equipment, outpulsing, and thus seizure of an outgoing trunk, is delayed until the operator keys the first digit.

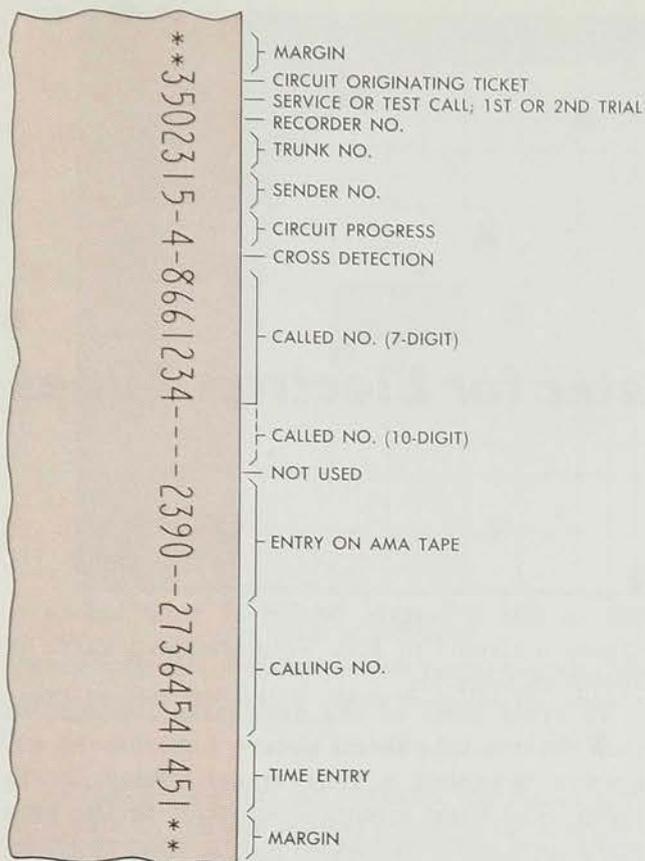
After the calling number is keyed into the sender, a connection is made to a transverter, and the sender transmits all the necessary details for making an initial CAMA-type entry. The transverter now compares the calling and called office codes, and if they match, the CAMA operator is recalled to rectify the error. If they do not match, the position is released to serve other calls. At the same time, the office code is translated into a two-digit office index. The transverter then connects to a perforator to record the initial charge data on the AMA tape which will be used later at the accounting center in preparing a customer's bill.

In the meantime, the sender is outpulsing the received digits, except the last or units digit. When the initial data has been recorded, the trans-



Time chart of a typical customer dial call as it progresses through step-by-step intertoll office.

The CAMA operator secures the calling number from customer and key-pulses it into CAMA sender.



Typical trouble ticket used in maintenance of CAMA equipment for step-by-step intertoll offices.

verter then releases, and the sender outpulses the units digit. This digit is held up deliberately to avoid ringing the called customer's telephone until a satisfactory initial entry has been made. Just before releasing, the sender causes the trunk circuit to switch through for transmission. When the calling party answers, the trunk circuit causes the "answer" time entry to be made in the AMA tape through the call-identity indexer and the "disconnect" time entry is made when disconnection occurs, so that the exact amount is charged for the call.

If the call comes from an originating office equipped with ANI, the sender, instead of calling for a CAMA position, transmits a signal to the ANI office to tell it to identify the calling line and pass the information to the CAMA office. The calling customer's number is then registered in the sender by multifrequency signals from the ANI office, and the call proceeds as before. If the ANI equipment is unable to identify the calling line—either because the calling party has multiparty service or because of trouble in the identifying equipment—a special information signal is transmitted to the sender which tells it to call in a CAMA operator to identify the number as before.

On a call from a No. 5 crossbar office, the called number is transmitted to the sender by multifrequency signals without the aid of a dial-pulse register. In all other respects the operation is the same as for a call from a step-by-step office.

Calls which have already had the charge information recorded at an originating common control office with local automatic message accounting (LAMA) may be handled on a non-CAMA basis by way of a multifrequency incoming trunk. In this case, the system uses senders and decoders to route through the intertoll equipment, but no charge record is made at the CAMA office.

In keeping with the economy desired, the maintenance equipment has been kept as simple as possible. A No. 1A ticketer is used for recording troubles in the transverter, decoder, recorder and master timer. A typical trouble ticket, shown on the left contains 42 printed characters. The first digit following the two asterisks indicates the particular circuit originating the ticket. A maintenance man uses this indication to select one of four charts which enables him to interpret the remaining digits on the ticket. In this manner, he obtains information regarding the progress of the call, the identification of connecting circuits, time-out conditions, crosses, false grounds, and the time at which the failure occurred.

A manually-operated test circuit and a portable test set are used to check the operation of the various CAMA circuits. The portable test set may be used with the test circuit at the test frame or it may be connected at any of a number of multiple jack appearances at the CAMA equipment frames. This permits the maintenance man to observe the operation of the circuit while the test is in progress. This is particularly advantageous when clearing troubles on faulty circuits. The test set can originate dial-pulse and multifrequency calls. A numerical indicator tube ("nixie" lamp) mounted on the set checks the digits outpulsed by the register or sender circuits.

Although CAMA for step-by-step intertoll offices was developed primarily for toll centers originating small volumes of toll traffic, it proves to be economical in many centers where the toll traffic is quite heavy. However, the greater flexibility and the automatic maintenance equipment of the crossbar-type CAMA systems will probably make them more desirable where the toll traffic exceeds 500 messages per busy hour. Cities of the size of Elmira, N. Y.; Nashua, N. H.; Pensacola, Fla.; and Santa Fe, N. M. are potential candidates for step-by-step CAMA. The first installation of step-by-step CAMA was put into service at Steubenville, O., in September, 1961.

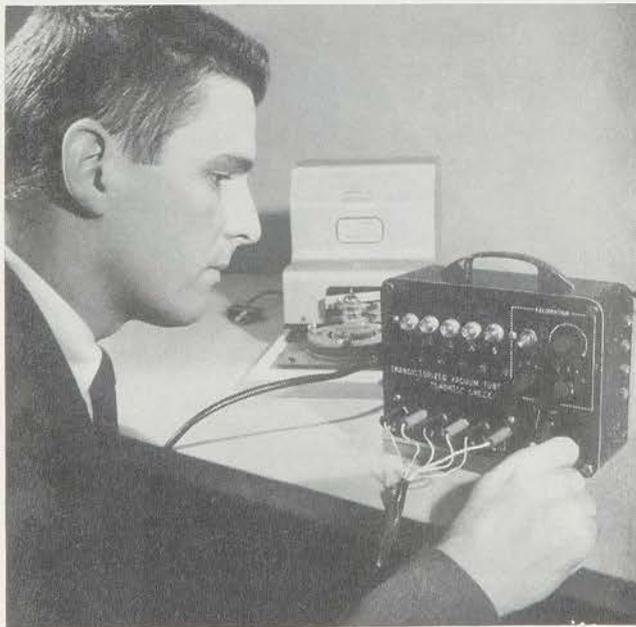
The use of transistors in a new shorts tester for electron tubes results in a unit which is more compact, lighter, and easier to calibrate than previous testers.

Transistorized Shorts Tester for Electron Tubes

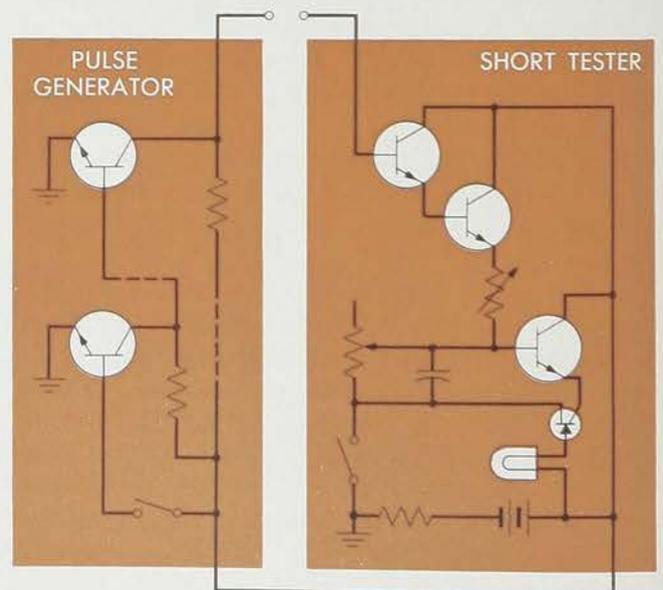
Because transistors are consistently replacing electron tubes, it may seem somewhat anomalous for Bell Laboratories engineers to have designed a transistorized shorts tester for electron tubes. Thus, although much of today's electronic equipment cannot be adapted for transistors, the semiconductor proves to be far superior to the tube for detecting those momentary shorts in electron tubes that have plagued certain circuits for years. Studies performed on various types of electronic equipment revealed that inter-electrode shorts are characterized by a resistance time function. That is, a short of a particular magnitude of resistance

has to last a certain period of time before it causes a circuit to fail. This standard curve is shown on page 61.

To avoid some of the drawbacks inherent in such electron-tube shorts testers, Laboratories engineers developed a fully transistorized shorts tester. The basic circuit is superior to the generally used electron-tube circuit in many respects. The new test set is more stable and considerably easier to calibrate because of its single low-voltage supply. A test set consists of five sections; each section is capable of detecting a short thereby providing a simultaneous test of a multi-element tube.

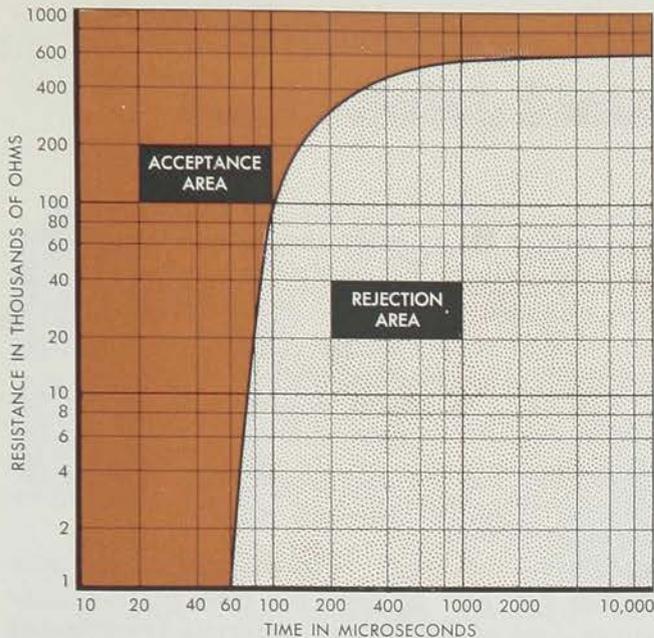


The new shorts tester demonstrated above by author Allan Proske is about one-twentieth the size of electron-tube testers and weighs only five pounds.



To calibrate shorts tester, a pulse generator is connected with a calibrating resistor and an oscilloscope is placed across the output of the generator.

New Military Switching System Goes Into Operation



Curve indicates resistance-time requirements that must be met in testing electron-tubes for shorts.

To test for a short, an operator inserts an electron tube in the test jig and connects the elements of the tube to the set. The tube is then mechanically shocked to test for intermittent shorts. The resistance between the elements of the electron tube under test determines the input current to the test set. When the magnitude and duration of this resistance equals or exceeds that shown in the standard curve, a lamp lights to indicate a short. The lamp remains lit until the operator de-energizes the circuit by opening a switch.

To calibrate the transistorized test set, an operator uses a built-in pulse generator. This generator is connected in series with a calibrating resistor, and an oscilloscope is placed across the output of the generator. Each time the operator closes the generator switch, a pulse appears on the oscilloscope. One battery supplies the power for both the pulse generator and the test set. Therefore, whenever the lamp indicating a short lights up, its current drain causes a decrease in the terminal voltage of the battery. This decrease is observed on the oscilloscope as a step in the output pulse. Several values of resistance are inserted in turn and the time required to light the lamp (that is, from the beginning of the pulse to the step) is recorded. By adjusting the variable resistors and capacitors in the test set, the operator records values of resistance and time and matches them to the standard curve.

A. F. PROSKE
Reliability Engineering Center

The Long Lines Department of AT&T late last year established a new automatic dial switching system, designed by Bell Laboratories, for the U.S. Army Signal Corps. Known as SCAN (Switched Circuit Automatic Network), the system is designed to satisfy the present basic military requirements for a rapid, automatic, user-to-user service that is capable of transmitting ordinary speech, encrypted speech, data, and facsimile communication. The new system

News of the Bell System will provide service to more than 500 station lines in 154 locations throughout the United States.

The stations at all of these locations are now operative.

The system utilizes four Bell System No. 5 crossbar switching equipment units of the same basic design as those used in the regular commercial network. The SCAN units are unique in that they provide separate electrical paths for speech in each direction, from user to user, as contrasted to the more conventional No. 5 crossbar four-wire switching arrangement that provides a single path for speech in both directions. A touch tone or rotary dial telephone may be provided at any user location. Facilities also permit user designation of calls to be expedited.

The switching units are located at Santa Rosa, California; Hillsboro, Missouri; Rockdale, Georgia; and Frederick, Maryland. These locations are outside critical target areas. In addition, they will permit maximum utilization of express and by-pass communication network facilities between the several units.

SCAN replaces a network of manually operated switchboards established in November, 1956 for Signal Corps encrypted speech and data communications. It also accommodates certain ordinary speech communications previously carried over a number of point-to-point private line facilities.

This is the first installation of a network using four-wire No. 5 crossbar equipment. It is expected to be the forerunner for other military and civilian applications.

New Infrared Spectroscopic Technique

Total Internal Reflection Indicates Characteristics of Molecular Layers

The use of total internal reflection to obtain spectroscopic information about compounds deposited on the surface of a transparent body has been applied to long-chain oriented molecules by L. H. Sharpe of the Chemical Research Laboratory. In this technique, first discussed by N. J. Harrick of Philips Laboratories, Irvington-on-Hudson, N. Y., and by J. Fahrenfort, Shell Laboratories, Amsterdam, a beam of infrared radiation is projected into one end of a transparent parallelepiped which has been coated with a layer of the substance being investigated. After one or more total internal reflections from the surface, the radiation emerges, carrying with it spectroscopic information, to be directed into an infrared spectrometer. The original work used polyethylene and water as coating agents, and only broad absorptions were observed, with no spectral detail.

Mr. Sharpe has extended the technique, which may be termed "frustrated total internal reflection infrared spectroscopy," to observe the infrared spectrum of layers as thin as only one molecule. In addition, he has observed shifts in these spectra resulting from orientation of the molecules, and the appearance of new bands indicating reaction (or chemisorption) at the surface of the reflector cell.

In a letter to the Proceedings of the Chemical Society, December, 1961, Mr. Sharpe described a specific cell made of germanium, in the shape of a parallelepiped as shown in the figure below. The beam of radiation strikes one end face perpendicularly and is reflected internally until it emerges at the opposite end. There it is refocused

and redirected to enter the monochromator-photometer unit of the spectrophotometer properly. An identical cell, without any coating, is placed in an identical position in a reference beam; the technique is thus compensative.

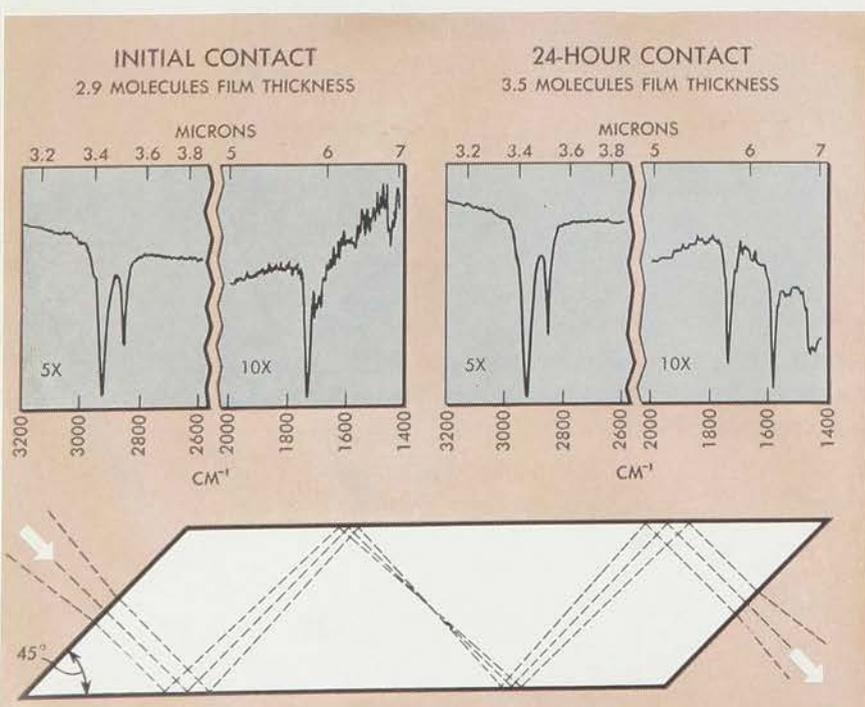
The ratio of length to thickness of the cell determines the number of internal reflections before the beam emerges. In the cell described by Mr. Sharpe, the ratio is 10:1; the number of reflections is thus ten.

Silicon and other infrared-transparent materials can also be used for cells in this technique. One of the coating materials investigated was the monoethyl ester of hexadecane dicarboxylic acid, placed on the cell in successive series of monomolecular layers, each approximately 25 Angstroms thick.

New Compound Detected

After this material was in contact with the germanium for a number of hours, a new absorption peak appeared on the spectrum. This peak indicated that a chemical reaction had taken place between the coating and the germanium surface; the new compound was producing the new spectral data. Details of the reaction and the nature of the new compound have not yet been worked out; however, the compound was probably the germanium salt of the acid.

With certain modifications, the new technique will have definite applications in the study of all types of adsorption phenomena, in the study of the fundamentals of adhesion, the conformation of polymers at surfaces, and in many other problems in surface chemistry in addition to its obvious application in analytical infrared spectroscopy. Mr. Sharpe also believes that the technique can be made at least 10 times more sensitive than it is in its present form.



Infrared radiation is directed into one end of germanium parallelepiped coated with substance being investigated. Emerging beam carries information as shown in charts. After 24 hours, second peak indicates the presence of a new compound.

Continuous Operation Achieved In Solid-State Optical Maser

Bell Telephone Laboratories scientists recently announced that they have achieved continuous operation in a solid-state optical maser. The active medium in the device is a single crystal rod of calcium tungstate containing trivalent neodymium ($\text{CaWO}_4:\text{Nd}^{3+}$). This medium radiates in the infrared portion of the frequency spectrum at 10,650 Angstroms.

This development was reported at a meeting of the American Physical Society, held in Los Angeles in December, in a paper by L. F. Johnson of the Solid-State Electronics Research Laboratory, G. D. Boyd of

the Electronics and Radio Research Laboratory, and K. Nassau and R. R. Soden both of the Crystal Chemistry Research Department.

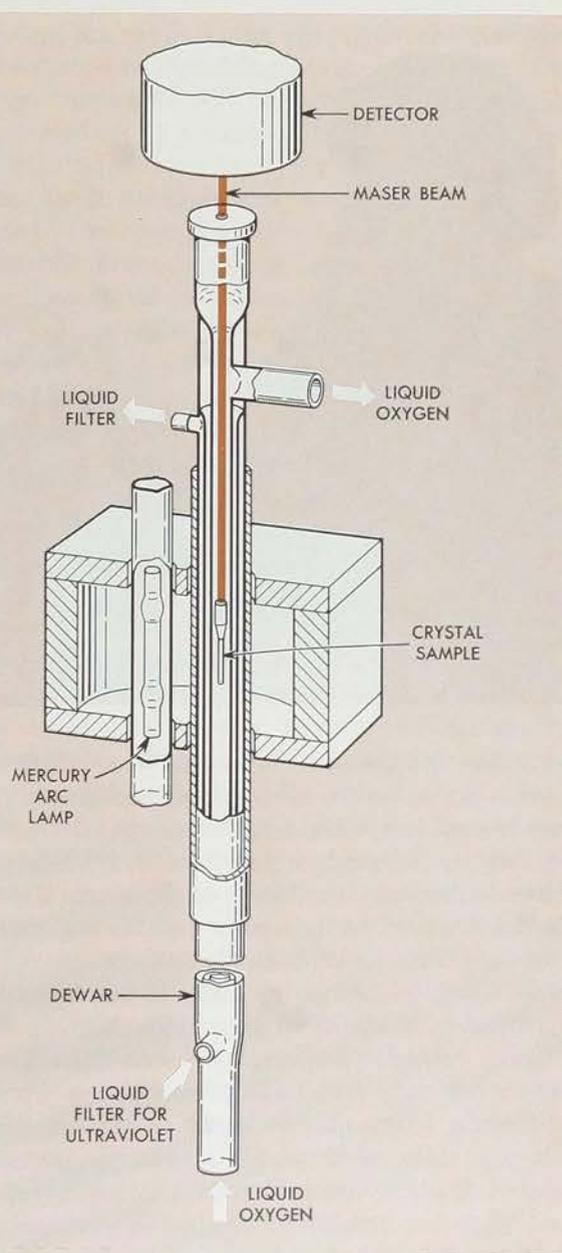
Continuous operation of a solid-state optical maser marks the advent of a series of masers with a potential for generating power sufficient to be practical for a variety of applications in communications and physical research. At present, the power output of the neodymium-containing crystals is in the milliwatt range. Substantially higher powers, however, are anticipated.

In a solid-state maser, electromagnetic oscillations at a visible or infrared frequency are generated through the process of stimulated emission. The crystal rod, whose ends are highly polished to a slight convex curvature and silvered, is excited by the "pumping" light from a bright lamp. The result is a coherent optical wave which travels up and down the rod, some of it escaping from the partially reflective ends. Until now, the power requirements of the pumping light have been so severe that they could only be met by use of a flash lamp, permitting the solid-state optical maser to oscillate for only a few milliseconds.

The new Bell Laboratories development removes the restriction of a short, intense pumping light, and optical maser oscillations are maintained indefinitely. The experiments open up the possibility of combining prolonged operation, hitherto possible only with the gaseous optical maser, with high output power, attainable more easily in solids.

The continuous maser resulted from the discovery by Mr. Johnson of a strong infrared fluorescence in certain crystals containing neodymium. Mr. Nassau grew a number of crystals of calcium

tungstate containing neodymium of high optical quality. Pulsed optical maser action with these crystals was reported at a symposium on optical masers held at Bell Laboratories last October. This preliminary work indicated that calcium tungstate containing neodymium is particularly favorable for continuous operation because of its low power threshold—the point at which optical maser action commences.



The recent experiment used an optical system consisting of a special housing for the maser rod. (See drawing on page 63.) This is an elliptical cylinder whose walls are highly polished and aluminized. A high-power d.c. lamp at one focus of the cavity serves to concentrate the pumping light on the maser crystal placed at the other focus.

The apparatus also contains a way to remove heat from the crystal and an optical filter that excludes unwanted ultraviolet light. This part of the light from the pumping lamp is not only useless, but tends to degrade the maser crystal.

Maser action is obtained when power fed to the d.c. lamp exceeds 900 watts. In the experiment, continuous oscillation, with no detectable decrease

in amplitude, was observed for five minutes and there is every reason to believe that it could have been continued for substantially longer.

In addition to calcium tungstate, other crystals containing neodymium show substantial promise for continuous operation. One such crystal is strontium molybdate. Strontium molybdate containing trivalent neodymium has been used to construct an optical maser that oscillates for an indefinite time with a duty cycle of 30 per cent. In other words, the device "mases" 30 per cent of the time when it is pumped by a lamp powered at sixty cycles. This oscillation wavelength is 10,634 angstroms. Physical measurements suggest that this material ought to be operable continuously.



Experimental

Telephone

Is Field Tested

The Magnetic Drum Dialer combines features of a six-button keyset with number recorder and dial.

A new telephone on which 50 frequently called numbers can be recorded and automatically dialed has been developed by Bell Telephone Laboratories. Called the Integrated Magnetic Drum Dialer, the new device was produced in Western Electric's Model Shop in Indianapolis and is now undergoing field tests in Buffalo, New York.

The new telephone combines in one housing the features of a standard six-button key set with a number recorder and dialing mechanism. The customer can record up to 50 telephone numbers on a magnetic drum. Each space on the drum can accommodate up to 14 digits, thus providing for Direct Distance and Inward Dialing services.

The names and numbers of each recorded party may be written on a built-in directory for easy

reference. In addition to automatic calling, the customer may dial numbers manually.

The new dialing feature is similar in operation to a tape recorder in its "recording" and "play-back" functions. The customer "records" by dialing a number into the magnetic drum rather than by speaking into a microphone. The "play-back" occurs when he turns a selector knob to index a number to be called from the directory. He then lifts the receiver and presses the automatic "call" bar. The dialing operation is completed automatically.

As with tape recordings, the repertory is permanent until the customer wishes to change it. He may revise it simply by recording a new number in place of the old.

Bell System Launches Cable-Laying Ship

The *C.S. Long Lines*, the largest cable-laying ship in the world, was launched recently in Hamburg, Germany. Built by the Long Lines Department of AT&T to help expand the present network of submarine cables, the ship will have cable gear for uninterrupted high-speed laying of the new systems using armorless cable and rigid repeaters. She will be equipped to repair both this type of system and the armored cable with flexible repeaters used in older submarine cable systems.

New concepts of cable and repeater handling on the ship were developed by Bell Laboratories with the assistance of Gibbs & Cox, naval architects and design agents for the ship. A new type of stern cable engine is a basic component of the system. It is designed to hold the armorless cable without damage and will accommodate the repeater sections of the cable without slowing down.

The cable is squeezed between the engine's flexible tracks which permit it and the repeaters to remain in a straight line during the gripping process. The track mechanism changes shape to conform to the increased size of the repeater without disturbing the normal gripping action. A chute supports the cable and repeaters as they move over the stern; its contours are designed to protect the cable from excessive bending under any condition of cable lead.

Cable-handling machinery at the bow, like that

used on other cable-laying ships, has drums 12 feet in diameter to control the cable.

New features of the bow machinery include a linear machine to provide back tension. Also, new "fleeting and traversing arrangements" (cable-laying terms for procedures that keep the cable moving smoothly across the drums) were devised to permit passage of the rigid repeaters at slow speed. Large-diameter conventional sheaves are fitted at the bow for repair operations.

To complete the main cable-laying system, facilities are provided to connect all the cable storage tanks with the cable engines and with the bow and stern overboarding devices. Repeaters are located in storage areas on the deck above the tanks. Large slots in the deck permit free but controlled, passage of the cable from the tanks to the repeaters.

During the cable-laying operation, the repeater will be placed in launching position before it is to be overboarded. It will be picked up by the cable and carried along a supporting trough to the engine with no change in laying speed. The design of the cable storage and associated devices is planned to protect the cable from damage and to restrain it from forming leaks during the repeater launching operations.

The unique task of the ship requires a reliable, well-coordinated system of internal and external communications, navigation aids, and testing facilities. One room is equipped solely for the maintenance of electronic gear, another for the centralized control of cable-laying operations. Because the ship will be at sea for long periods in various climates, all accommodations and critical spaces are air-conditioned.

The ship's hull, of welded construction except for some riveted shell seams, is strengthened against ice damage. Twelve water-tight transverse bulkheads greatly reduce the danger of foundering or capsizing. Fire-resistant construction was used throughout the ship.

For efficiency and good control the *Long Lines* is powered by a steam turbine electric propulsion system with twin screws and twin rudders. A bow thruster provides power for swinging the bow without assistance from the rudders.

Over-all length of the ship is 512 feet; beam, 70 feet. She can carry 1800 nautical miles of armorless cable. Her sustained speed at sea is 15 knots and she will draw 26½ feet of water.

The *C.S. Long Lines* will be ready for cable-laying service in the late summer of 1962. Her first assignments are expected to be putting down a submarine cable in the Caribbean and installing a new transatlantic cable.



news in brief

Nike-Zeus Destroys Simulated ICBM

An Army NIKE-ZEUS missile has successfully intercepted a simulated intercontinental ballistic missile traveling at a speed of 14,000 miles per hour. An Army spokesman said that success of the test with the "ghost target" proved that "NIKE-ZEUS can do its job" in defending this country against missile attacks. The test was the fifth complete success in a row for the anti-missile missile in firings from Point Mugu, California.

Bell Laboratories project engineers said data from the test showed that the ZEUS missile got within killing distance of its target. The Laboratories is responsible for the design and development of NIKE-ZEUS under a prime contract held by the Western Electric Company from the Army Ordnance Missile Command.

Firing tests against electronically-simulated ICBM's provide electronic means of further evaluating the missile system's capabilities prior to engagements with actual ICBM-type targets. In forthcoming tests, the NIKE-ZEUS test complex on Kwajalein Island will engage target nose cones launched down-range by ICBM boosters fired from Vandenberg Air Force Base, California.

For the test, the simulated target, with characteristics of an ICBM warhead flashing earthward from space, was programmed into the ZEUS system's target intercept computer. In a real engagement, radars of the system would supply target information to the electronic brain.

NIKE-ZEUS system ground guidance equipment controlled the engagement and guided the ZEUS missile to intercept.

The firing was another in the

series of development tests being conducted at White Sands, Point Mugu, and Kwajalein under the management of the Army Ordnance Missile Command at Redstone Arsenal, Alabama.

Holmdel Prepares For Project Telstar

Modifications to improve the message capacity and sensitivity of the Project Telstar receiving antenna system, are being made at the Crawford Hill space station at Holmdel. Telstar I, the Bell System's active communications satellite developed at the Laboratories and scheduled for launching next spring, will relay a broadband signal capable of carrying hundreds of voice or data channels.

Among the modifications to the receiving system is a new solid-state maser which will reduce noise in signals received from the satellite while amplifying them about 1000 times. Holmdel will receive only—not transmit—for the Telstar experiment. Transmission will originate at the Bell System's major ground station near Andover, Maine. The Telstar satellite will intercept and amplify the transmitted signals and relay them to the Holmdel receiving system.

Tracking and pointing accuracy of the antenna will be improved by modifying an existing radar to enable it to receive and follow a beacon signal sent from the satellite. To boresight the antennas, a precise theodolite is being installed on Crawford Hill. It will permit scientists to use exact astronomical measurements to align their antennas to the critical tolerances necessary for communicating with Telstar. Radio signals from the stars themselves

will be used to help with the alignments.

Another modification involves installing equipment to receive television pictures transmitted from Maine to Crawford Hill. As an alternative to voice and data channels the Telstar frequency can carry one television program. For this part of the experiment, facilities will be available to retransmit the television pictures which are received at Holmdel over the Telstar circuit back to Maine over regular TV circuits. This will allow engineers in Maine to see the results of tests actually in progress.

Work has already started on the modifications and will be completed early this year. Crawford Hill was Bell Laboratories "telephone terminal to outer space" during the Echo satellite test conducted during 1960-61 in cooperation with the National Aeronautics and Space Administration.

Deutsch, Krauss Receive AAAS Essay Award

Morton Deutsch and Robert M. Krauss were recently awarded the American Association for the Advancement of Science annual Socio-Psychological Prize of \$1,000 for a meritorious essay in that field. The award is considered the outstanding one presented in the socio-psychological field in this country.

The prize-winning essay by the two members of the Communications Research Social Science Laboratory was entitled "Experimental Studies of Interpersonal Bargaining." It discusses research done at the Laboratories by Messrs. Deutsch and Krauss which employs an experimental game where people are faced with bargaining problems and must find some mutual agreement.

Mr. Deutsch is in charge of studies in interpersonal processes in the Laboratories social science research program. Mr. Krauss has been working with Mr. Deutsch on experimental studies of bargaining since he joined the Laboratories in 1958.

**L. F. Wingert, Elected
A.T.&T. Vice-President;
H. T. Killingsworth to
Defense Activities**

Lowell F. Wingert, vice president-operations of the Pacific Telephone and Telegraph Company since 1960, was elected vice president of A.T.&T., and is in charge of the Long Lines Department. Henry T. Killingsworth, vice president in charge of Long Lines since 1949, moves to the general headquarters staff to coordinate Bell System defense activities and services. The changes were effective January 1, 1962.

Mr. Wingert joined the Tri-State Telephone and Telegraph Company (now Northwestern Bell) at Winona, Minnesota, in 1934. After serving in the commercial department at Winona he moved to Minneapolis where he worked in the commercial and traffic departments. He joined Long Lines' traffic department in 1944. He was also an engineer in the O. & E. department of A.T.&T. In 1950 he returned to Northwestern Bell as general traffic engineer. In August, 1951, he was named general traffic manager of the Mountain States company. A year later he was elected vice president of that com-



H. T. Killingsworth

pany in charge of personnel; and in 1958 was named vice president-revenue requirements. In March, 1960, Mr. Wingert returned to New York as assistant vice president of A.T.&T. He was elected vice president, operations, of the Pacific Company in August, 1960.

A native of Georgia, Mr. Killingsworth joined Long Lines in Atlanta after graduating from Auburn University in 1919. He joined the Long Lines engineering department in New York in 1925. Two years later he was named division plant engineer in Cleveland, then division plant superintendent in Denver. He returned to New York in 1940 as general plant supervisor. He was appointed general plant superintendent in Atlanta in 1945, and the next year was named area plant manager, Atlanta. Mr. Killingsworth returned to New York in 1948 when he was appointed general manager of Long Lines. He was elected A.T.&T. vice president in charge of Long Lines in November, 1949.

**World's Telephones
Increase by 8 Million
In 1960**

Bell telephone users can call 138,239,700 telephones, 97.6 per cent of all the telephones in the world. This includes the 244 tele-

phones in Muscat and Oman, all three of the telephones in the British Virgin Islands and 60 per cent of the estimated 4,276,000 telephones in Russia.

According to the 1961 edition of *The World's Telephones*, released by A.T.&T., there were 141,700,000 telephones at the beginning of 1961, a gain of 8,100,000 in 1960. All figures in the report are as of January 1, 1961, since it takes a year to collect and compile the data. At that time the United States had 74,342,000 telephones, more than 40 per 100 persons. Today there are some 77,500,000 telephones in this country. Russia had about two telephones for every 100 persons.

The report shows the number of telephones in the world almost doubled since 1951. The United States, with 52 per cent of the world's telephones, accounted for 47 per cent of the entire gain of the past decade. The United Kingdom was second in the number of telephones with 8,270,000 or 16 per 100 persons. West Germany ranked third with 5,994,051, or 11 per 100 persons. Canada had 32 telephones per 100 persons, for a total of 5,728,167.

While Canadians ranked fourth in the total number of telephones, they apparently use their phones more than anyone else. In 1960, Canadians averaged more than 538 telephone conversations per person. In the United States, the average was 520. Sweden, with 37 telephones per 100 persons, ranked third with 349 conversations, per person.

Two-thirds of the world's telephones are privately operated, according to the report, but the majority of countries have government-operated telephone systems. In Europe, for example, only 17 per cent of the telephones are privately operated. In Africa, the figure is 1.6 per cent. In North America, more than 98 per cent of the telephones are operated by private enterprise companies.



L. F. Wingert

PATENTS

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

- Abbott, H. H.—*Selective Signaling Device*—3,012,226
- Andrews, F. T., Jr.—*Magnetic Core Shift Register Circuits*—3,013,252
- Ashkin, A., Gordon, J. P. and White, L. D.—*Molecular Beam Maser*—3,013,218
- Busch, A. J., Cahill, H. D. and Myers, O.—*Message Transmission with Privacy*—3,012,099
- Cahill, H. D., see Busch, A. J.
- Christensen, H. and Noll, W. S.—*Process of Selective Etching with Resist Preparation*—3,012,920
- DeGrasse, R. W.—*Gyromagnetic Microwave Filter Devices*—3,013,229
- Dransfeld, K., Kompfner, R. and Tien, P. K.—*Elastic Wave Parametric Amplifier*—3,012,204
- Goordman, R. V.—*Broadband Amplifier Using Vacuum Tubes and Transistors*—3,015,071
- Gordon, J. P., see Ashkin, A.
- Ilgenfritz, L. M.—*System for Detecting and Recording Temperature Differentials*—3,011,853
- Klahn, R.—*Digital-to-Analog Converter*—3,012,240
- Kompfner, R., see Dransfeld, K.
- Mason, W. P.—*Microwave Ultrasonic Delay Line*—3,012,211
- Mitchell, D.—*Telephone Privacy System*—3,012,100
- Myers, O., see Busch, A. J.
- Noll, W. S., see Christensen, H.
- Ostendorf, B., Jr. and Sellers, G. A., Jr.—*Station Selector and Control Apparatus*—3,014,982
- Raisbeck, G.—*Smoothing of Rectangular Waves*—3,014,985
- Robertson, D. D.—*Signal Translating System*—3,013,222
- Schulz-DuBois, E. O. and Scovil, H. E. D.—*Thermal Maser*—3,015,072
- Scovil, H. E. D., see Schulz-DuBois, E. O.
- Sellers, G. A., Jr., see Ostendorf, B., Jr.
- Tien, P. K.—*Traveling Wave Parametric Amplifier*—3,012,203
- Tien, P. K., see Dransfeld, K.
- White, L. D., see Ashkin, A.
- Zarouni, A.—*Automatic Data Reader*—3,014,652

PAPERS

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

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- Boyd, G. D., Gould, R. W., and Field, L. M., *Interaction of a Modulated Electron Beam with a Plasma*, Proc. IRE, 49, pp. 1906, December, 1961.
- Dillon, J. F., Jr., and Walker, L. R., *Ferrimagnetic Resonance in Rare Earth Doped Yttrium Iron Garnet. II. Terbium Substitution*, Phys. Rev., 124, pp. 1401-13, Dec. 1, 1961.
- Ellis, W. C., see Greiner, E. S.
- Field, L. M., see Boyd, G. D.
- Fox, A., see Gohn, G. R.
- Frisch, H. L., Sonnenblick, E., Vyssotsky, V. A., and Hammersley, J. M., *Critical Persolation Probabilities (Site Problem)*, Phys. Rev., 124, pp. 1021, Nov., 15, 1961.
- Geller, S., Williams, H. J., and Sherwood, R. C., *Substitution of Fe^{3+} Ion in Sc_2O_3 and In_2O_3* , J. Chem. Phys., 35, pp. 1908-09, Nov. 1961.
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- Gohn, G. R., and Fox, A., *A Fatigue Test for Printed Wiring Boards and Through Connections*, ASTM Materials Research and Standards, 9, Sept. 1, 1961.
- Goldstein, H. L., see Ollom, J. G.
- Gould, R. W., see Boyd, G. D.
- Greiner, E. S., Gutowski, J. A., and Ellis, W. C., *Preparation of Silicon Ribbons*, J. Appl. Phys., 32, pp. 2489-90, Nov., 1961.
- Gutowski, J. A., see Greiner, E. S.
- Haszko, S. E., see Wernick, J. H.
- Hammersley, J. M., see Frisch, H. L.
- Hartman, C. D., see Germer, L. H.
- Hawkins, W. L., and Winslow, F. H., *Stabilization of Plastic Insulating Materials for Wire and Cable*, J. Plastic Inst., 29, pp. 82-9, June, 1961.
- Johnson, L. F., and Nassau, K., *Infrared Fluorescence and Stimulated Emission of Nd^{3+} in $CaWO_4$* , Proc. IRE 49, pp. 1704-06, Nov., 1961.
- Keller, A. C., *Relays and Switches*, IRE Anniversary Issue, May, 1962.
- Kirby, Mrs. D. B., and Rosenthal, C. W., *Computer Program for Preparing Wiring Diagrams*, AIEE Trans., 80, pp. 509-13, Nov., 1961.
- Klauder, J. R., see Kunzler, J. E.
- Kunzler, J. E., and Klauder, J. R., *The Observation of Four Types of Hall Constant Anisotropy in Copper and their Role in the Determination of the Fermi Surface*, Philo. Mag., 6, pp. 1045-51, Aug., 1961.
- LeCraw, R. C., see Pincus, P.
- Liehr, A. D., see Ballhausen, C. J.

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- MacRae, A. U., see Germer L. H.
- Matsuoka, S., *Hypothesis of Voids in Semicrystalline Polymers*, J. Appl. Phys., 32, pp. 2334, 1961.
- Nassau, K., see Johnson, L. F.
- Nassau, K., *Application of the Czochralski Method of Divalent Metal Fluorides*, J. Appl. Phys., 32, pp. 1820-21, Oct., 1961.
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- Preziosi, S., see Van Uitert, L. G.
- Romanow, W. J., see Wernick, J. H.
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- Swanekamp, F. W., see Van Uitert, L. G.
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- Vyssotsky, V. A., see Frisch, H. L.
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- White, S. R., see Weissmann, G. F.
- Williams, H. J., see Geller, S.
- Winslow, F. H., see Hawkins, W. L.
- Wolff, P. A., *Localized Moments in Metals*, Phys. Rev., 124, pp. 1030-35, Nov. 15, 1961.
- York, R. K., see MacPherson, D. H.

TALKS

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

SIXTY SECOND MEETING OF THE ACOUSTICAL SOCIETY OF AMERICA, Cincinnati, Ohio

- David, E. E., Jr., see Flanagan, J. L.
- Fitch, A. H., *Synthesis of Dispersive Delay Characteristics By Thickness Tapering in Ultrasonic Strip Delay Lines*.
- Flanagan, J. L., *An Electrical Analog for the Middle Ear and Basilar Membrane*.
- Flanagan, J. L., David, E. E., Jr., and Watson, B. J., *Effects of Masking upon Lateralization of Cophasic and Antiphasic Clicks*.
- May, J. E., Jr., *Guided-Wave Dispersive Delay Sines*.
- Schroeder, M. R., see Sessler, G. M.
- Sessler, G. M., and Schroeder, M. R., *Sound Velocity in Slight-*

ly Ionized Gases.

- Sessler, G. M., and West, T. E., *Condenser Earphone with Solid Dielectric*.
- Sikorski, M. E., *The Esaki Diode Pressure Transducer*.
- Watson, B. J., see Flanagan, J. L.
- West, T. J., see Sessler, G. M.

OTHER TALKS

- Alexander, E. J., Young, L. H., McAlexander, J. C., and Salhany, R. J., *A Permanent Magnet Twistor Memory Element of Improved Characteristics*, Conf. Magnetism and Magnetic Materials, Phoenix, Arizona.
- Allen, F. G., *Mossbauer Scattering from Surfaces*, Phys. Colloq., Univ. Ill., Urbana, Ill.
- Allen, F. G., see Gobeli, G. W.
- Allen, F. G., and Gobeli, G. W.,

Work Function and Photo Threshold for Atomically Clean Silicon, Am. Phys. Soc., Chicago, Ill.

- Ansley, W. G., see Smith, K. D.
- Balacek, F., *Ruggedizing of Wire Spring Relay*, E. of M. Staff Conf., Indianapolis, Ind.
- Bauer, E. O., and Fox, P. E., *The Influence of Extruder Geometry in the Production of Homogeneous Cellular Plastic Insulation*, Tenth Annual Wire and Cable Symp., Asbury Park, N. J.
- Benes, V. E., *An Application of Schauder's Theorem*, Dartmouth College, Hanover, New Hampshire.
- Benes, V. E., *On Rearrangeable Three-Stage Connecting Networks*, Intern. Fed. of Information Proc. Cong., Munich, Germany.
- Benes, V. E., *Some Combinatory*

TALKS (CONTINUED)

- Properties of Connecting Networks*, Third Intern. Teletraffic Cong., Paris, France.
- Black, H. S., *Satellite Communications*, Engrs. Club, Philadelphia, Pa.
- Black, H. S., *Global Communications Via Satellites*, Men's Club, Comm. Cong. Church, Short Hills, N. J.
- Black, H. S., *New Developments in Communications Research*, Western Electric Company's Grad. Engg. Training Center, Chicago, Ill.
- Bond, W. L., see Garrett, C. G. B.
- Boxer, A. S., and McCarter, R. S., *A Coaxial Ferrite Phase Shifter for High Power Applications*, Conf. Magnetism and Magnetic Materials, Phoenix, Ariz.
- Bozorth, R. M., *Magnetism of Dilute Solutions of Iron-Group Elements in Platinum Metals*, Intern. Conf. on Magnetism and Crystallography, Kyoto, Japan.
- Bozorth, R. M., *Some New Magnetic Materials*, Tohoku University, Sendai, Japan.
- Brady, G. W., *Studies in the Critical State*, Bryn Mawr College, Bryn Mawr, Pa.
- Brattain, W. H., *Brattain on Semiconductors*, Ohio Sci. Educa. Assoc., Ohio State Univ., Columbus, Ohio.
- Cave, J. H., *Echo I First Birthday—and The New Active Relay Communication Satellite Program*, Commerce—Kiwanis—Rotary & Lions Clubs Annual Meeting, Mountainside, N. J.
- Cave, J. H., *Bell System Satellite Space Communication Program*, U. S. Navy VRR, Company 4-1, Princeton, N. J.; Congdon Lodge, Free and Accepted Masons, Bernardsville, N. J.
- Ciccolella, D. F., see Smith, K. D.
- Courtney-Pratt, J. S., *New Techniques in High Speed Photography*, Phys. Colloq., Polytech. Inst. Brooklyn, Brooklyn, N. Y.
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W. J. Locke was born in Castlewood, South Dakota, and received his BS in EE degree in 1925 from South Dakota State College. He joined the Sales Inspection Department of Western Electric Company in 1926, and soon after became resident inspector at the General Electric Company plant in Ft. Wayne, Indiana.

After varied assignments in the Apparatus & Supplies Pricing Department at Western Electric headquarters, he came to Bell Laboratories in 1941. During the war he supervised a team at Whippany turning out spare parts and maintenance drawings for radar equipment.

In 1946, Mr. Locke was assigned to the General Methods Department, where he helped with the equipment investment unwinding operations. A few years later, he joined the Design Engineering Department where he engaged in method studies and standards work relating to the production and handling of specifications and drawings. Since 1956 he has been devoting full time to the development of microfilm, a program for engineering drawings.

Mr. Locke has been active with the Standards Engineers Society and is a member of the AIEE and American Ordnance Association. He is the co-author of "Engineering Drawings on Microfilm" in this issue.

C. E. Nelson, a native of Brigham City, Utah, received a B.Sc. from Brigham Young University in 1928 and a Master's degree from New York University in 1930. He first joined Bell Laboratories in 1928, in the Commercial Relations Department. During World War II, he served as commanding officer of the Frankford Ordnance Depot, then with the Allied Council in Berlin in charge of optical and precision instrument industries, as well as in negotiations on postwar problems in this industry with the Russians, British, and French. After the war, Mr. Nelson returned to the Laboratories, assigned to AT&T as liaison on rate prob-

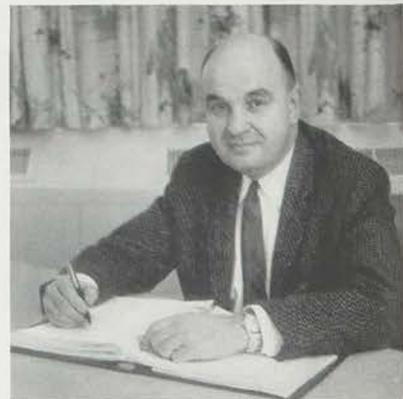


C. E. Nelson

lems, where he remained until 1950, when he returned to the Laboratories in the design engineering area. He has been responsible for research and development associated with the microfilm program described in this issue, as chairman of the Bell Laboratories reproduction committee and vice chairman of the Bell Laboratories-Western Electric reproduction committee. Mr. Nelson is president of the National Microfilm Association, a member of American Standards Association committees, the Standards Engineering Society, and the Society of Reproduction Engineers, a consultant to C.I.A. on micro-

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U. S. Berger, a native of Dayton, Ohio, attended Ohio State University and graduated with the degree of B.S. in E.E. in 1937. He joined Bell Laboratories upon graduation, and engaged in research on voice operated devices. Early in World War II, he transferred to the Specialty Products Department, where he was concerned with circuit development of radio receivers for the Navy, Air Force, and Coast Guard. After World War II, Mr. Berger was responsible for the development of mobile telephone equipment, microwave radio relay equipment, and several military communication systems. In 1955 he became a subdepartment head in charge of the TD-2 Microwave Radio Relay System and a short while later of the L3 Coaxial Cable System. In 1956 he transferred to the newly formed Merrimack Valley Branch Laboratory and in September, 1957 he became the assistant director at that location. In April, 1961 he was appointed director of the radio transmission laboratory. His current responsibilities cover TD-2, TH, TJ and TL Microwave Systems, and the T1 Carrier (PCM) Exchange Area System. Mr. Berger is a member of Tau Beta Pi, a Senior Member



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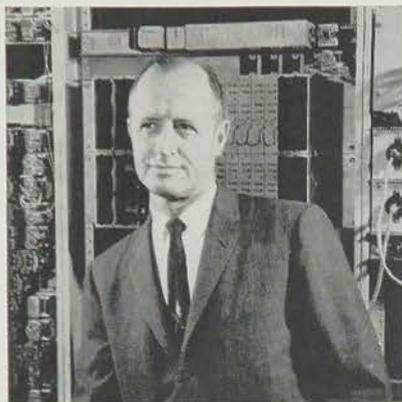
AUTHORS (CONTINUED)

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Charles W. Rosenthal, a native of New York City, received his B.E.E. degree from City College of New York in 1950 and the M.S. in Engineering Sciences and Applied Physics from Harvard University in 1951. He is presently a candidate for the Ph.D. in Electrical Engineering at Columbia University. Mr. Rosenthal joined Bell Telephone Laboratories in 1951 and his earliest work was analysis, system design and logic design on military systems for communications, and display and for ballistic missile control. In 1956 he joined the department developing a data processing system for the mechanization of Bell System revenue accounting. Since 1958 he has been concerned with machine aids to design and the development of computer programs to test for and locate faults in the computer. He is a member of Eta Kappa Nu, Tau Beta Pi, the Association for Computing Machinery, and the IRE.



C. W. Rosenthal



A. S. Martins

A. S. Martins, a native of Queens, New York, and now a resident of New Hyde Park, Long Island, joined the Laboratories in 1928 and completed the Laboratories' student engineering course in 1932. In 1936, he joined the step-by-step systems laboratory testing group. During World War II, Mr. Martins took part in the development of electrical gun directors and in the construction and testing of the early models of a submarine radar system. Since the war he has been concerned primarily with the design of switching circuits for step-by-step systems. He is now in charge of a group responsible for the design of step-by-step common-control circuits. Mr. Martins received the B.E.E. degree from Brooklyn Polytechnic Institute in 1943. He is co-author of "CAMA for Step-by-Step Intertoll" in this issue.

R. G. Ruwell was born in Philadelphia, Pennsylvania and received a B.S. degree in Electrical Engineering in 1927 and an E.E. degree in 1940 from the University of Pennsylvania. During his senior year at Pennsylvania, he was

awarded the Moore Honor Scholarship. In 1929, Mr. Ruwell joined the Bell of Pennsylvania in the Executive Operations Department to work on long-range planning. During World War II, he served as a Lieutenant Commander in the Naval Reserve, taught at the M.I.T. Radar School, and was connected with guided-missile research in the Bureau of Ordnance. He also served as technical observer for the U.S. Naval Mission in Europe. In 1946, he returned to Bell of Pennsylvania, and in 1951 was recalled to active duty to serve as Assistant Project Officer on the Terrier missile. In 1953, Mr. Ruwell transferred to the Laboratories, where he has been concerned with systems engineering of AMA, CAMA, micro-image information and electronic data processing. At present, he is responsible for systems engineering of arrangements for customer dialing of coin toll calls. Mr. Ruwell, co-author of "CAMA for Step-by-Step Intertoll," is a member of Tau Beta Pi and Sigma Xi, a Commander in the Naval Reserve, and is serving on the Transfers Committee of the New York Section of A.I.E.E.



R. G. Ruwell



FROM BELL TELEPHONE LABORATORIES...

The fundamental capabilities of pulse transmission are under study at Bell Laboratories. At a transmission rate of 200 million bits per second, for example, PCM could simultaneously transmit 3000 telephone conversations on a single circuit.

AN INTRIGUING DEVELOPMENT IN TELEPHONE TRANSMISSION

Bell Laboratories engineers have applied a method of transmitting telephone conversations which uses a series of ON-OFF pulses rather than the continuous electrical signals generally used since the time of Alexander Graham Bell's first famous message.

The method is called Pulse Code Modulation. With PCM the telephone caller's voice is sampled every 1/8000th second. Each sample is then encoded into a series of ON or OFF pulses, and these pulse groups are sent over the regular telephone line. Spaced periodically along the line are repeaters which clean up and amplify the pulses. At the receiving end the pulse groups are decoded and the caller's voice is reconstructed.

Since the pulses are of very short duration, it is possible to interlace many different voice messages and send them all over one line. For example, in a PCM system now operating between Newark and Passaic, N. J., a single pair of wires carries as many as 24 one-way voice signals.

Other systems for carrying more than one voice signal over a single telephone line have been developed and are in widespread use. PCM, however, provides special advantages, for example, in cable circuits connecting telephone offices in a congested metropolitan area.

PCM in its present practical form for cable circuits has been made feasible by Bell Laboratories' invention and development of the transistor, the key element necessary for a small economical system.

Currently, PCM systems carrying much larger bundles of communication channels are under study at Bell Laboratories. The goal as always is the improvement of Bell System communication services.



BELL TELEPHONE LABORATORIES

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