

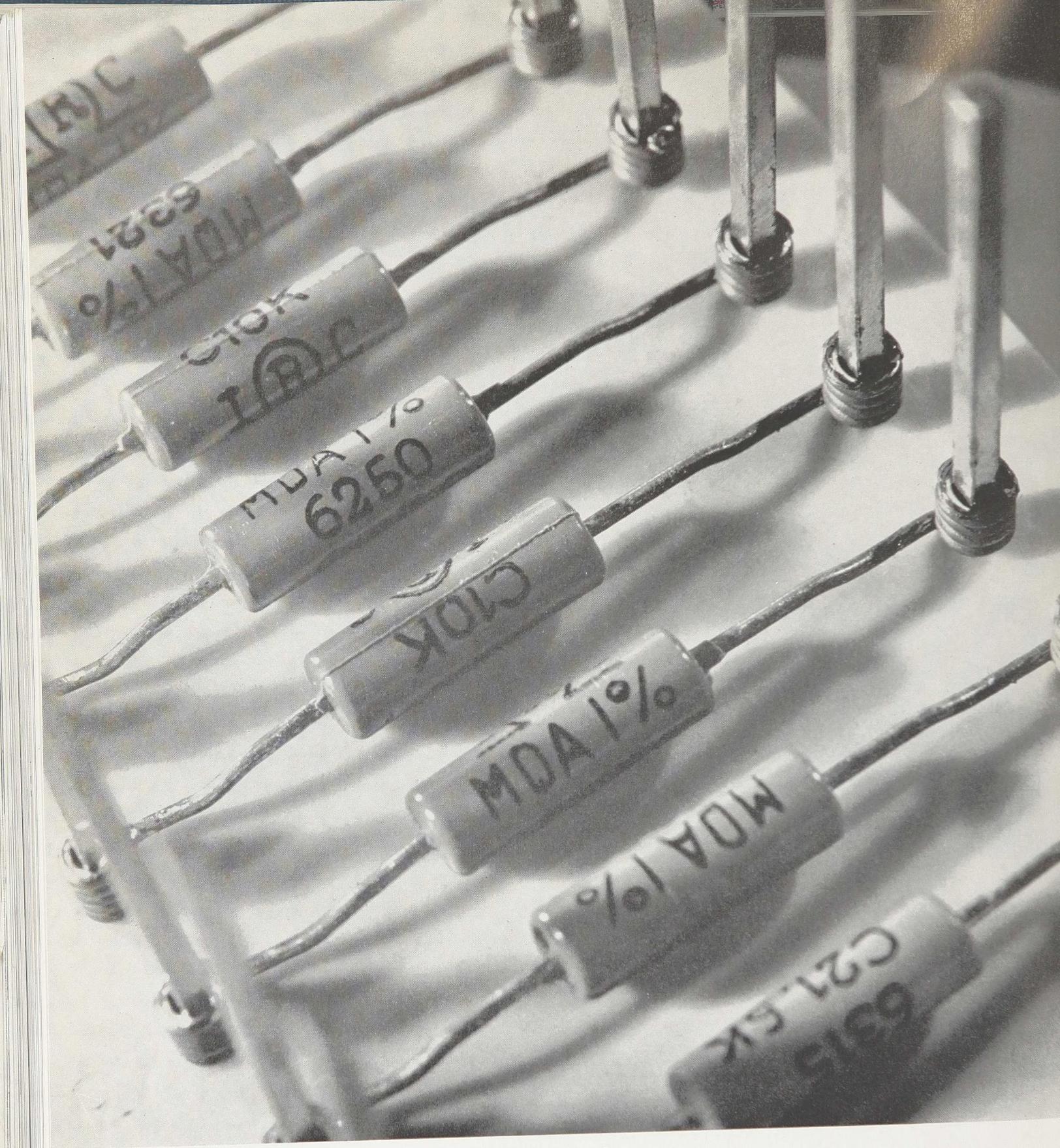
## Contents

PAGE

- 414 Solderless Wrapping of Pigtail Components *R. H. Van Horn*
- 419 Quality Assurance *E. G. D. Paterson*
- 425 No. 101 ESS: The Time-Division Switch Unit  
*R. M. Averill and R. C. Stone*
- 432 First Direct Submarine Cable Link Between United States  
and England Completed
- 434 New Technique for Foaming Polymers

Cover

*Inspection, statistics, and reports are the three principal factors involved with quality assurance, a procedure pioneered at Bell Telephone Laboratories. (See article on page 419.)*



*An enlarged view shows typical solderless wrapped connections of pigtail leads to test terminals.*

*The solderless wrapped connection has been in use for a number of years. Low cost and proven reliability are now opening up many new uses for this connection.*

# Solderless Wrapping Of Pigtail Components

R. H. Van Horn

THE VALUE of the solderless wrapped connection, introduced in Bell System central office equipment in the early 1950's, is now well-established. More than half a billion of these connections are made each year in the manufacture or during installation of switching, transmission, PBX, and other equipment. The savings resulting from the low cost of the connection itself, plus savings as a result of associated use of PVC-insulated wire (made possible by solderless wrapping), have been substantial. In addition, the proven reliability of solderless wrapped connections is now resulting in its use in many new applications.

The solderless wrapped connection originated when it was necessary to find an economical way to connect switchboard cable and surface (or point-to-point) wiring to the terminals of the wire-spring relay.\* The connection was first conceived as a wrap-and-solder technique but it was soon apparent that sufficiently tight connections

were being made without the final soldering. Gas-tight joints were formed at each intersection of the wire with the association terminal, thereby precluding deterioration from corrosive constituents of the surrounding atmosphere. This type of connection soon proved satisfactory for suitably designed terminals on other apparatus such as flat spring relays, switches, terminal strips, jacks, keys, lamp sockets, fuse mountings and the like. In these applications the wire was always soft-drawn copper in gauges ranging from 20 through 26. Critical, though not difficult, requirements controlled the manufacture of the associated apparatus terminals.

Some new uses for the solderless wrap came about recently when a number of military equipments required a highly reliable method for connecting the pigtail leads of resistors, capacitors, transistors, diodes, etc., to fixed terminals. Solderless wrap appeared to offer the required reliability if the various combinations of materials used in pigtail leads and the associated terminals were satisfactory. A number of materials were found

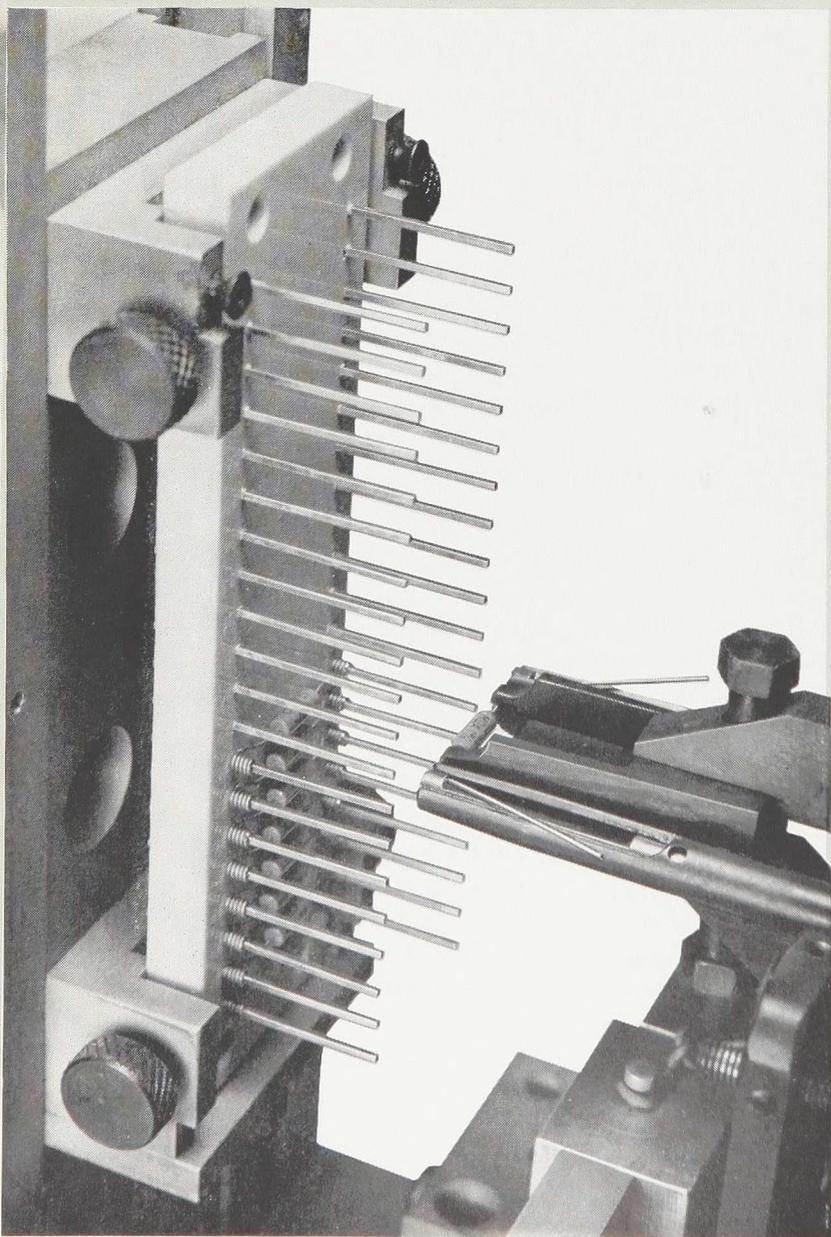
\* Reference—New General Purpose Relay—A. C. Keller, BSTJ, Vol. 31 pp. 1023-1067, November 1952.

to be satisfactory and requirements on the parameters of pigtail connections are now established. Many component pigtails are now being solderless wrapped in military equipment applications, some by automatic machines that take the component from a feeding mechanism, grip it by the pigtails, wrap the leads on the terminals, and retract the wrapping spindle, all in the space of a few seconds as shown in the photo. Pigtail components have been available for many years and manufacturers have largely standardized the length of the pigtail to approximately 1½ inches.

#### **Other Materials Used**

A number of materials other than copper are frequently used for these connections. The choice of material has largely been a matter of convenience to the component manufacturer. These are frequently gold-plated to facilitate the manufacture of components such as diodes or transistors. Various grades of brass, hard coppers, and nickel

*The automatic machine below wraps pigtail connections in a matter of seconds.*



are also used. These wires generally have similar elongation capabilities and more suitable physical properties than the annealed copper switchboard wire and mechanically strong connections can be made with fewer turns. Of special importance is the resistance to stress relaxation in the brass, iron alloy, and nickel wires. The limited length of the standard pigtail does not permit the full number of wire turns ordinarily used with copper switchboard wire. With the stronger wires this presents no problem. However, to provide comparable mechanical strengths with copper and brass pigtails in the completed connections, higher wrapping tensions are used during wrapping so that five turns of 24-gauge pigtail wire provide the same resistance to mechanical displacement of the connections as the conventional six turns of 24-gauge switchboard wire. The number of turns necessary varies somewhat with gauge size. Fewer turns are required as the diameter is increased. The number is never less than three in the case of 18-gauge wire, four with 20-gauge wire and may be as much as six with 25- or 26-gauge of wire.

In practically all cases the wire is wrapped onto terminals with a square cross-section 0.045" by 0.045". This cross-section offers the highest electrical stability of all those previously standardized for telephone applications. Since the components were being used on equipment packages especially designed for this technique, only one terminal cross-section was required so this optimum section was chosen. A limited range of other sizes and cross-sections was also expected to be satisfactory, but several experimental evaluations of their service life would have to be required for verification.

#### **Finish on Wire Important**

A good finish on the wire and on the terminal contributes significantly to the electrical stability of the connection. A soft gold finish was used originally on all terminals. This was a conservative choice in order to prove in, as early as possible, the use of wrapped connections with the expectation of the highest possible reliability. Hard golds showed a tendency to tarnish, presumably because of the hardeners used. Soft golds eliminated the tendency to tarnish and also provided higher stripping strength since the surface of the terminal was less hard and slick. Recent tests have shown good results in many cases with electro-tin finishes that are more economical than gold. With tin, the terminals must be spaced apart sufficiently to avoid trouble from whisker growth.

TYPICAL PHYSICAL CHARACTERISTICS OF WIRES APPROVED FOR  
SOLDERLESS WRAPPED CONNECTIONS\*

Material	Gauges	Tensile Strength (thousands of psi)	Yield Strength (thousands of psi)	Elongation in per cent	Relaxed Stress after 40 years (Per cent of initial)
99.9 + % Copper	18-26	34	15	15-25	43
Cobalt-nickel-iron alloy	20-26	77	29	14-28	93
Copper clad nickel iron wire	15-26	80	26	28	94
Brass As received on components	20-24	50	24	38	55
99.9 + % nickel	24	72	40	17	95
Copper clad iron wire	24	50	23	12	—

\*Unpublished data by G. R. Gohn and A. Fox

Gold also provides an excellent finish on the leads. Where gold is not otherwise needed, thin and uniform coatings of solder or tin have also been found satisfactory.

The reliability of a particular wire-and-terminal combination in solderless wrap is defined as the probability that less than a stated fraction, such as one in ten thousand, of an original population of connections will exceed a specified electrical resistance during the normal life of the connection. The evaluation of reliability in the laboratory depends on a reasonable and controlled simulation of the processes that will degrade the performance of the connection during its life.

The connection is held together by the hoop stress imparted to the wire during the wrapping operation. The wrapping tool stresses the wire in tension into its plastic range and, as the wire hooks over successive corners of the terminal, the tension is trapped and retained in the wire. As in all stressed metals, the stress trapped in the wire will relax during service life, and if the relaxation is great enough the connection could become loose. Vibration that may occur from time to

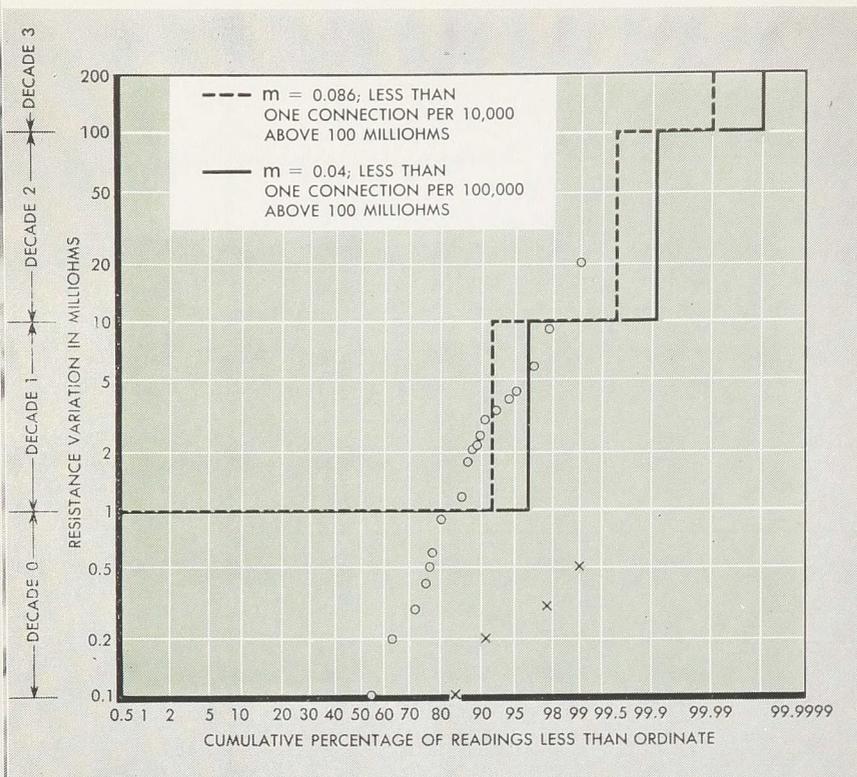
time could generate resistance variation in a loose connection that would modulate electric currents passing through it, causing noise.

#### Aging Simulated in Laboratory

The aging process is simulated in the laboratory by accelerating the stress relaxation with elevated temperature. For example, in copper approximately 40 years of service can be simulated by 150 days in an oven at a little over 100°C. Variation of resistance as the connection is mechanically plucked is a measure of the degree of looseness, if any, that may have developed.

To estimate the level of reliability from a reasonable-sized sample, assurance is needed that the statistics follow a repeatable pattern. For example, if one knows that the data from a given test always fall into a Gaussian or normal distribution, only enough samples to determine the average and variance within the required level of confidence need be tested to estimate the expected performance of large numbers of units.

In the case of solderless wrap, some early observations on large samples indicated that the



Stepped curves are theoretical cumulative probability curves for a Poisson distribution of the decade numbers of resistance variation. The plotted circles represent data from a set of connections judged unsatisfactory since they show higher resistance variation than permitted by the curves. The plotted crosses represent data from another set of connections judged satisfactory since their resistance variations fall below the curves.

The author (left) and E. J. Moskal measure the electrical stability of sample connections.



data were almost but not quite log-normal. That is, the logarithms of the measured resistance values were distributed almost normally. A better approximation was found, however, by fitting the characteristics of the logarithms (base 10) of the measured resistances in tenths of milliohms to a Poisson distribution forming what might be called a log-Poisson distribution.

This amounts to a process of assigning decade numbers to the measured resistance variations during vibration. Variations of less than one milliohm are assigned to decade "0"; those from one milliohm to less than ten are assigned to decade "1", etc. The mean decade number "m" for any wire-terminal combination is determined from measurements on a suitable sample, typically 80 connections. With this mean value and the Poisson equation, the per cent of the population with resistance variations expected to be 100 milliohms (decade "3") or higher can be estimated.

In telephone practice, only those terminal-wire combinations have been standardized where less than one connection in ten thousand is estimated to exceed 100 milliohms variation of resistance after exposure to the equivalent of 40 years of stress relaxation in the copper wire in the normal environments. For military applications, the same aging tests have been used but the judgment criterion for acceptance or rejection of a wire-terminal combination has been not more than one per hundred thousand connections at or above 100 milliohms resistance variation at the end of the simulated 40 years.

### New Uses for Solderless Wrapping

So far the solderless wrapping of pigtail components has found application primarily in non-telephone equipment. Its extended use places added requirements on the component manufacturer to provide leads suitable for this process. This should be no problem, however, as the material used for pigtail leads generally is superior to the usual soft copper wire common to the wrapping process.

About 70 combinations of wires and terminals have been approved for pigtail components. These include wires of copper, brass, iron alloy, copper-clad iron, and nickel from 20 to 26 gauge and carrying gold, tin and solder finishes. The associated terminals are most frequently brass, but bronzes, aluminum, and nickel-silver are approved in some cases. Where the need arises it should be possible to extend the use of wrapping of pigtail components to telephone applications where terminals appropriate to the characteristics of the pigtail wire can be provided.

# Quality Assurance

THE MEANINGS AND SIGNIFICANCE of the terms "Quality Assurance" and "Quality Control" are frequently subjects of widespread disagreement. In addition, there are no standard, or even commonly accepted, definitions for them and their purpose and practice vary widely in industry.

To appreciate the circumstances which ultimately led to these terms, it is helpful to review some early history of Bell Laboratories. Just preceding the formal incorporation of Bell Telephone Laboratories in 1925, a new technical function was conceived by management and steps were taken for its inauguration. Described as the art and science of "Inspection Engineering," its purpose was to apply "the pure sciences of mathematics, physics, chemistry and the like to problems of inspection in the same spirit and with similar research point-of-view as guide their application to development and design" (RECORD, August, 1926). At that time, the terms quality control and quality assurance were nonexistent; they were first used by Bell Laboratories to describe the purpose and techniques contemplated by the quoted passage. The concept of treating quality as a separate technical specialty was undoubtedly motivated by three factors: Bell Laboratories' business was entering an era of very rapidly increasing complexity; the integrated character of the Bell System encouraged and per-

mitted a unique approach to economically-optimized product quality; and incorporation of Bell Laboratories as a separate Development and Research entity provided both a favorable atmosphere and the proper organizational set-up for a more scientific approach to quality *per se*.

It is important to note the unusual factor in Bell Laboratories' original approach to quality was its "assurance" not its "control" aspect although the term, quality control, has received by far the greater publicity. The quality of the results of man-directed efforts has always been controlled in some degree. The whole field of industrial production is a process of control although, prior to Bell Laboratories' contributions in this area, the existing control techniques were lacking some of their present-day characteristics. The "assurance" of quality, on the other hand, implies a process of affirmation—that quality has, in fact, been adequately controlled. This assurance is based on sufficient knowledge and safeguard. "Assurance" also implies that the quality is good. In other words, to control quality one must play a direct part in limiting the underlying causes of quality variations; to "assure" quality one must satisfy himself that all the necessary controls exist and operate continuously and effectively on a continuing basis.

To appreciate fully the assurance aspect of

quality, the integrated set-up of the Bell System itself must be kept in mind. The System's ultimate product is service rather than hardware. It has essentially complete control over the hardware employed to provide the service. Thus, if we optimize the relationship between the quality and cost of hardware, we help directly to attain the same result for the service. Recognition of this fact, and the desire to capitalize on its possibilities, was undoubtedly one of the primary reasons for a Bell "System", when it was originally integrated. However, the System, although integrated, comprises a group of separate corporate entities with distinctively assigned functions and responsibilities: Research-Development, Product Supply, and Operation—all under the coordinating guidance of the American Telephone and Telegraph Company. In particular, one group of these corporations, the Operating Telephone Companies, are customers of another, the Western Electric Company, from which they purchase their hardware. The Operating Companies are also Public Utilities and, as such, are subject to regulation by Governmental Agencies. Therefore, they have both the need as customers and the obligation as Public Utilities to satisfy themselves as to the quality of the product which they purchase. They do not need to buy from Western; they do so only because it is to their economic advantage.

### **New approach to quality**

Certain circumstances existing during the incorporation of Bell Laboratories were particularly favorable for the new approach to quality. The Development and Research departments at that time were manned with the type of technical personnel needed to generate the specialized knowledge and provide the competence required to develop the new quality function and the specialists to prosecute it. Western Electric's Engineering Headquarters (Bell Laboratories' predecessor) already had responsibility for the investigation of engineering complaints (in other words, field reports of unsatisfactory quality). It was necessary only that this responsibility be turned over to Bell Laboratories to provide a source of performance information feedback valuable for both quality assurance and development purposes. Furthermore, Western had inspection forces—purposely organized to be independent and objective—to furnish Western's management with product quality information. While it retained these forces, Western made their services available to the Laboratories at no appreciable extra cost. Thus, qualified and independent agencies were immediately available to provide Bell

Laboratories with the inspection data necessary for quality analysis and evaluation. With this background, an organization—originally called the Inspection Engineering Department—was selectively recruited from the other technical areas of Bell Laboratories. Aided greatly by its Western Electric associates, this department gradually developed the techniques and procedures required to implement the new activity. From this organization came "Quality Control," developed by W. A. Shewhart and described in his now classic text "Economic Control of Quality of Manufactured Product." Because the range of interest, the methods employed, the responsibilities, and the underlying philosophy were in many respects broader than, and in other respects different from, those suggested by either "inspection" or "Quality Control," the function came to be known as "Quality Assurance" and the Department was so renamed in 1940.

### **Early methods of checking quality**

The direct and historical manner of checking the quality of one's purchases is to inspect them, and this is actually what the Companies themselves did in earlier years. However, inspection by each Operating Company is not only costly but at best inefficient, especially when such a wide variety and large volume of products are concerned—currently some 175,000 valued at over two billion dollars annually. Thus, as indicated previously, a primary purpose of the new organization was to attack this inspection problem in a scientific manner and develop procedures that would be efficient, economical, and adequate both from the standpoint of the Companies themselves and of the Commissions by which they are regulated. With an organization in Western already geared to provide objective inspection information to its management, it should be unnecessary to duplicate these activities if the results can be made to serve the customers' needs as well. One of the tasks of the new Laboratories organization was therefore to develop and introduce procedures by which one inspection could serve both supplier and customer, and to insure the continuing effectiveness and integrity of this dual process.

If we consider the really significant aspects of inspection—its scientific and engineering aspects—we find first that the basic purpose is to enable a decision-aiding evaluation as to product quality acceptability. Such an evaluation presupposes both a measuring process and a standard against which to compare the measurement. The measuring process itself, in fact, depends on the nature and magnitude of the standard. Thus, the first,

and perhaps the most economically important, function of Quality Assurance was to establish suitable product quality standards.

In deciding what is suitable, the integrated character of the Bell System becomes very significant. In this setting, we have the opportunity to truly optimize the quality versus cost relationship, taking into account not only the cost of manufacture, but the other intrinsic over-all costs of installation, operation, maintenance, life, and reliability—with full consideration given to the potential reactions on service. Restricted only by human capabilities in this respect, a standard of quality can be established so that money is wasted

by making the quality either better or poorer. It is obvious that such a standard represents the primary needs of the user and the fundamental intent of the design engineer.

In considering the manufacturing increment of the total cost of product, the design engineer bases his decisions on the assumption that the product will be made as specified. While this is a perfectly sound approach from the standpoint of design, experience shows that in many instances manufacturing costs can be reduced in the true over-all interest of the customer if occasional marginal deviations from the ideal design quality are permitted but properly limited. On the other hand,

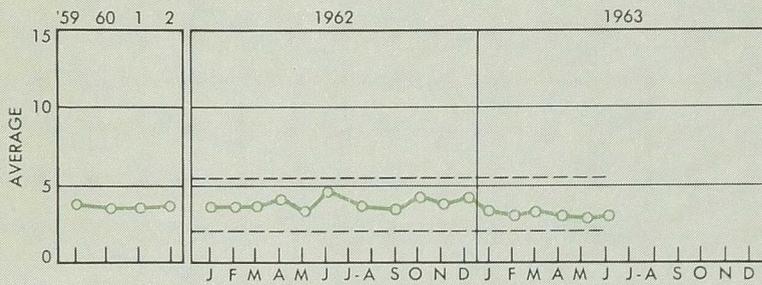
*Bell Laboratories' William L. French, Frank W. Horn, and Western Electric's R. L. Shire examine conductors insulated with expanded polypropylene that has been subjected to a cold wrap test.*



## CROSSTALK

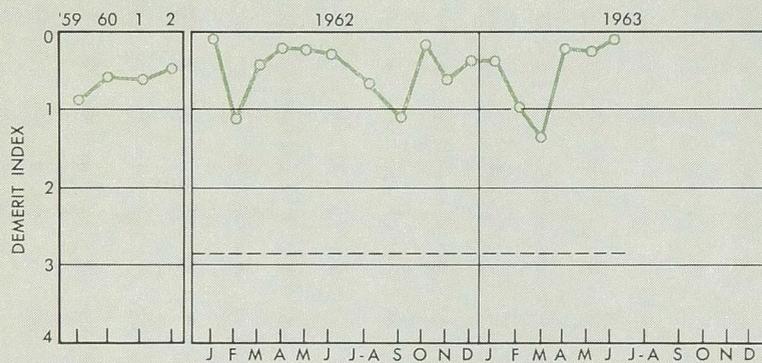
SIDE TO SIDE

ENGINEERING LIMIT: 35 CROSSTALK UNITS MAX.



## PROTECTOR BLOCKS

ROUND TYPES  
32 AND 33



SAMPLE NUMBER PER MO.	654	665	691	688	787	690	497	780	815	800	825	770	800	750
OUTPUT 1000'S PER MO.	3303	3672	4002	4019	4413	4141	3209	4312	3924	4796	5378	4447	4607	5269

*The charts above show two methods of reporting the quality of telephone products.*

the design specifications may permit, for an individual unit of product, tolerances for quality characteristics—such as cross-talk in loading coils or conductor resistance in cables—that would not be suitable for the average quality of the product. In such cases, the design intent represents an average product that is better than that specified for the individual unit. Thus, the quality standards must call for quality that is in some instances slightly poorer, in others better, than actually specified by design. Since the establishment of proper quality standards involves some immeasurable factors that prevent it from being an exact science, a large degree of engineering judgment is required. This judgment is made with assistance from the areas of design, manufacture, and use, with the aid of feed-back sources that ade-

quate quality assurance must provide.

The measurement part of inspection raises several questions: what measurements are to be made, how many, and by whom? The Bell Laboratories goes into meticulous detail in designing products for the Bell System. By this method, quality is built from the ground up—not partially characterized by “end requirements” alone. In these circumstances, a complete picture of quality involves the measurement of all specified characteristics, from raw material to finished product, as well as a verification of those unspecified attributes that are governed by specific manufacturing processes. Fortunately, several factors aid in discharging this necessary but burdensome responsibility. The quality of product that is “quality controlled” during manufacture can be adequately ascertained by measuring small samples of the finished product. Western Electric was a partner in the development of “quality control” and pioneered its application. Other quality assurance safeguards (notably Field trials, the Engineering Complaint activity, Quality Survey, and Quality Rating Techniques) insure the continuing adequacy of the “quality control”.

### **Economical way to quality**

With a Western Electric organization at hand to perform the inspections, there remains only the need for Bell Laboratories to specify, in the form of Inspection Specifications, the “what” and “how many” measurements needed for quality assurance purposes. This it does in a manner that is both economical and effective. If the “consumer acceptance” type of inspection employed by much of industry was in use in the Bell System, not only would quality assurance costs be increased by 50 to 100 times, but the over-all effectiveness of the operation would actually diminish.

While the Inspection Documents specify what, when, and how many inspections are to be made, the inspection results data required and the criteria which indicate conformance with quality requirements, they cover only in general terms what may be done with nonconforming lots of product, of which there will be a small number. Western may ship such nonconforming products to the Companies only with Bell Laboratories' (Quality Assurance) approval. The Inspection Documents therefore indicate the general circumstances under which Bell Laboratories will consider the acceptance of such product. The Laboratories decisions in this respect are based on consideration of all of the service implications of acceptance or rejection, after consultation with others, including the customer if necessary.

Because Quality Assurance did, in fact, begin with the art of inspection and because "Inspection Engineering" was the term used to describe its purpose, it is logical to trace the development of Quality Assurance from this point. But it is also to be noted that in developing the over-all quality assurance function, inspection has acquired a broader significance and treatment than usually accorded the inspection process. The probabilistic and "risk" aspects of inspection results have been explored and put to use; the control chart has been invented and its potential advantages implemented, quality standards are established and quality evaluation techniques are applied so that the inspection results can be translated and combined to provide management a shorthand report in the form of over-all "quality rates".

Similarly, the methods of handling Engineering Complaints have been improved, to better serve the assurance function in particular and the Laboratories in general. Thus Quality Assurance—as an organization free of direct responsibility for design, manufacture, or use—is given the authority to determine and assign technical responsibility for the complaint condition. On this basis corrective measures can be taken and monetary adjustments made between Operating Telephone Companies and Western Electric. This requires the quality engineer to investigate the complaint condition in detail and determine its technical cause, extent, and source—incorrect or inadequate design requirements, faulty material, improper processing, inadequate inspection, misuse in service, etc. Field Engineers are now assigned to each Operating Company territory to facilitate complaint handling and to provide on-the-spot assistance to Bell Laboratories and the Companies. While the 6000 complaints received annually represent only one complaint per third of a million dollars product delivered—or one per four million dollars of installed plant—their value as a feedback to quality and design is obvious.

Another important activity pioneered and carried on by Laboratories Quality Assurance—and one, incidentally, that has not yet diffused as widely into outside industry as have many of the others—is the Quality Survey. This is a basic Bell System philosophy that effective assurance of quality involves adequate control of the complete underlying system of contributing causes. As a contribution to this goal, the Quality Survey comprises, in relation to a particular product, a critical study of the design-manufacturing structure, namely, the intent of the design requirements and the processes employed to meet this intent. The controls and readings of quality as-

urance are examined to see if the antecedents of ultimate quality appear to be properly coordinated and controlled. Where shortcomings are disclosed, they are referred to and corrected by the organization responsible. In a search of this magnitude and depth, Quality Assurance obviously requires—and obtains—the unlimited counsel of both Bell Laboratories and Western Electric experts.

One of the factors that emphasizes the character of Laboratories Quality Assurance is found in the nature of its personnel. This function presupposes the same basic engineering approach, the same qualifications, and the same purpose that underlies the other technical areas of the Laboratories. Not only was the original organization recruited from the other professional divisions of the Laboratories, but there has been a free interchange ever since. It was a carefully considered decision that placed the Quality Assurance function in the Research and Development unit of the Bell System.

Since the birth in 1925 of a separate engineering activity concerned with the economic achievement of satisfactory quality, recognition of its potentialities as an important contributor to industry has spread throughout the world. In 1946, the American Society for Quality Control was formed in the United States (with George D. Edwards, then the Director of Laboratories Quality Assurance, as its first president). Other foreign counterpart societies followed. Expansion of the quality function has been particularly rapid during the past decade. Since the original RECORD article, volumes have been written to keep pace with technical developments. As in other areas of science and technology, the more we learn, the better we are able to recognize our shortcomings. Much remains to be done to improve these techniques. Perhaps in no other phase of activity, for example, are better methods more needed than those related to the setting of quality standards—the primary goals to which the other detailed aspects of quality assurance are pointed. Much is known about the relation between quality and the cost of production; but too little is known about the economics of quality variations and their service implications. Both better information and better tools are needed to rationalize this information—even though we are probably more favored in this respect in our Bell System environment than is most of industry. With 40 years of effort and experience Bell Laboratories is still facing the original challenge to improve the science of quality. The application of the "research point of view" to an "art and science" is a never-ending process.

# Miniature Gas Laser

## Emits Single Frequency

A miniature helium-neon gas laser that emits only a single frequency of visible red light has been devised at Bell Telephone Laboratories. The length of its discharge tube is only two inches, its diameter is 0.04 inches and it operates continuously at room temperatures on direct current. The frequency of oscillation is very stable and the power of the emitted coherent light is comparatively high for the laser's small size.

Several miniature lasers have been built and used as single frequency oscillators at different frequencies.

Also, Eugene I. Gordon and Alan D. White who developed the lasers, used one of them as a swept-frequency local oscillator in an optical heterodyning experiment. By varying the spacing between the end mirrors of the laser cavity, they made the laser oscillate at any one frequency within a 1500 megacycle range centered at 473,000 kilo megacycles. To tune the laser over this frequency range, one of the end mirrors need be moved less than 12 millionths of an inch. This can be accomplished smoothly and precisely with a piezoelectric transducer attached to one mirror.

Previous gas lasers, because of their large size, can oscillate at many optical frequencies simultaneously; and they are difficult to stabilize against frequency fluctuations. The new lasers, because of their short length, oscillate at only one frequency. Also, they are much less susceptible to vibration, thus considerably simplifying the problem of achieving frequency stability.

The combination of stability plus single frequency oscillation is very useful in that the laser can act as a very precise measuring instrument. If one of the mirrors is connected to a positioning device, very slight changes in position will cause the laser to shift frequency. Displacements considerably less than one millionth of an inch can be detected and, with an oscilloscope, readily measured.

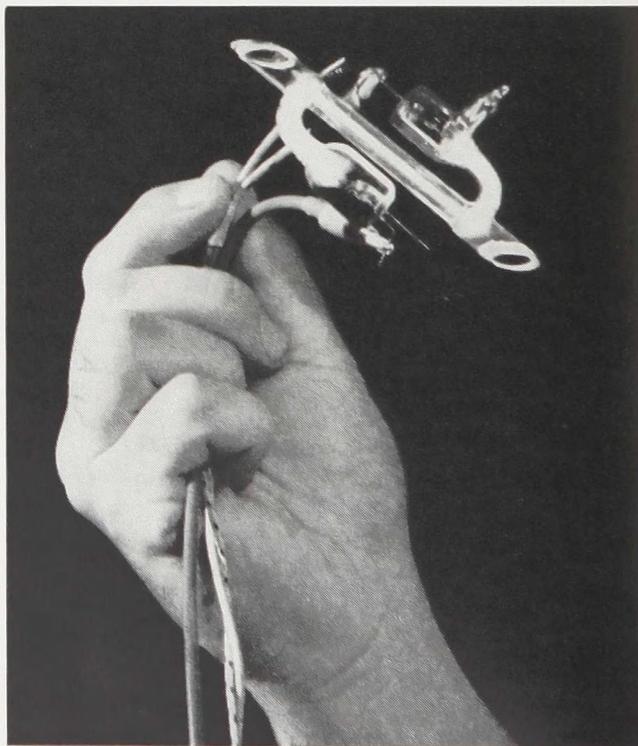
The miniature lasers grew out of studies by Gordon and White into the basic excitation mech-

anisms that give rise to laser action at 6328 Å in helium-neon discharges.

To increase laser gain so that very short lasers could be made to oscillate, the helium 4 gas used in earlier lasers was replaced with the lighter helium 3 isotope, and the diameter of the laser discharge tube was reduced from 7 mm to 1 mm. (Helium 3 is a non-radioactive gas produced as a by-product in atomic piles.)

A more detailed explanation of how these modifications allow the laser length to be reduced is given in a paper, "Single Frequency Gas Lasers at 6328 Å," by Messrs. Gordon and White.

*Miniature gas laser developed by Bell Telephone Laboratories operates continuously at room temperatures. When placed in an appropriate optical cavity, it oscillates at only one frequency of visible red light.*



*A new technique of switching, called time-division, is used in the No. 101 ESS. It provides a high call-carrying capacity with a relatively simple switching network.*

# No. 101 ESS: The Time-Division Switch Unit

R. M. Averill and R. C. Stone

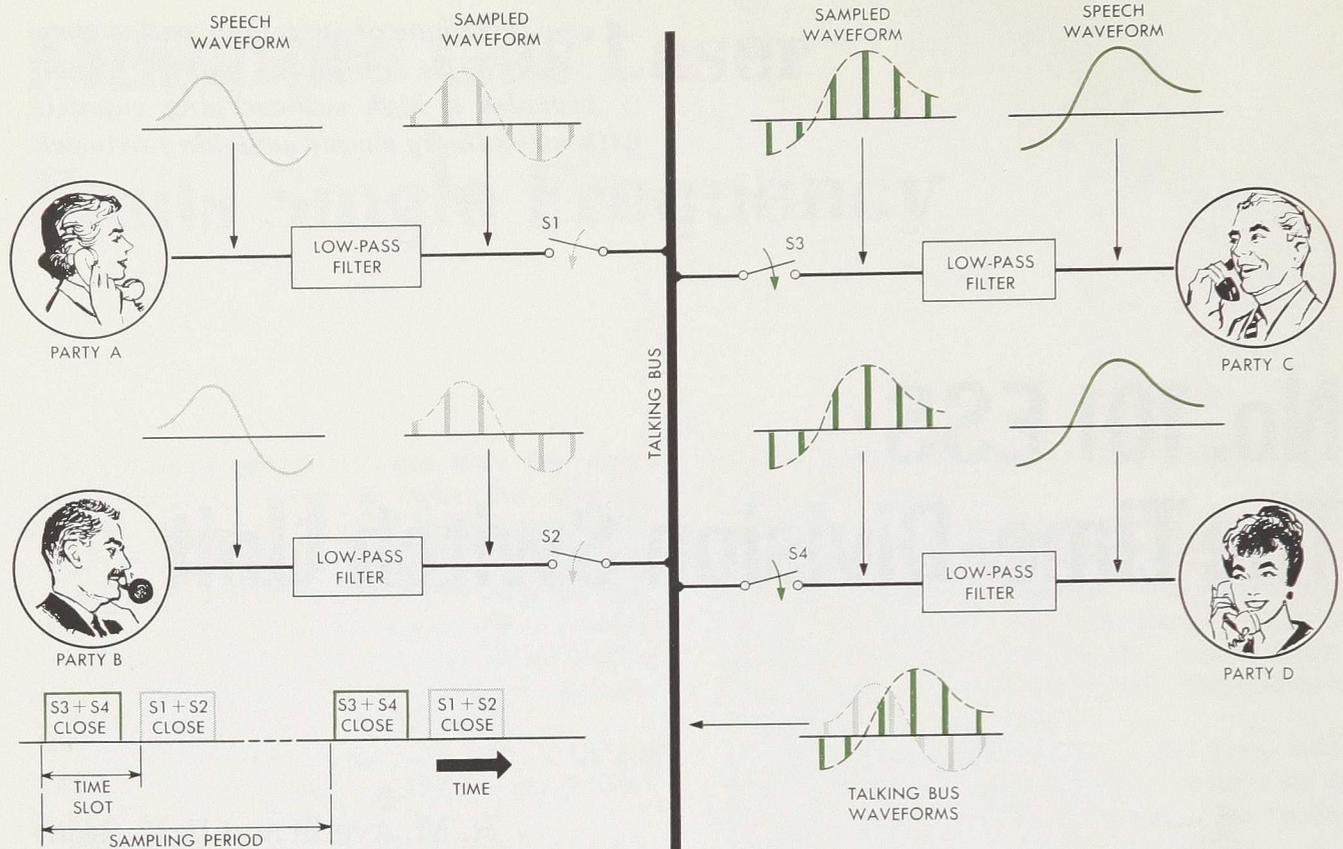
**I**N ELECTROMECHANICAL SWITCHING SYSTEMS the talking energy of separate conversations is carried over separate paths. Because each conversation is assigned a unique path, this technique has been called space-division switching. High-speed electronic circuits have led to a new kind of switching. Its principle is that the energy of each telephone conversation in a system can be stored for a short period after which it can be transmitted in a still shorter period. Thus several conversations can be interleaved in time on a common path. This technique is called time-division switching.

The No. 101 Electronic Switching System (RECORD, November 1963), is a time-division switching system for PBX and Centrex service. Each customer has an individual switch unit with a capacity of up to 200 lines. The operation of up to 32 switch units is directed by one centrally located control unit. Actual switching connections, however, are made by the time-division switching network in each switch unit.

Time-division switching is essentially a sampling process. A series of short pulses that are samples of the complete electrical wave from the

transmitting telephone, and not the wave itself, are interleaved in discrete intervals of time and transmitted over a common switching path. A high-speed time-division switch associated with each line circuit makes the connection to the common path. When two customers are talking, the switches do not establish a permanent connection to the path, but open and close very rapidly to connect the two telephones for very short periods of time (see the drawing on page 426). Each time the pair of switches closes, the stored talking energy represented by the wave samples is transmitted between the two telephone circuits. The process is analogous to the effect of a movie. Each frame on the film is actually a still "sample" of motion. The eye smoothes over the interval between the stills so that we see the picture move.

In a time-division switching system, low-pass filters smooth the pulse samples so that the signal reaching the listener is a reproduction of the signal at the talker's telephone. If certain basic requirements are met, the transfer of energy is essentially lossless. If the sampling rate is at least twice the cut-off frequency of the low-pass filter,



When two telephones are to be connected together in the time-division switching unit, they are actually joined in a single time slot. Samples of the

amplitude of the speech wave are taken at various points and transmitted. The complete wave is then reconstructed at the called end of the connection.

the device will characteristically "save" all the energy generated by the talking telephone between samples. For example, if the highest transmitted frequency is 3500 cycles per second (the telephone band is 200 to 3500 cycles) the sampling rate is usually set at 8 kc or higher. In the No. 101 ESS, it is fixed at about 12.5 kc.

common path called a talking bus. (There are two buses in each switch unit.)

### The Switching Network

Since the original speech can be reconstructed from short samples, many simultaneous conversations can be transmitted on one path. Sampling is done in rotation over all connected telephones and the times in which the various pairs of switches are closed are displaced from each other so that the signals from each conversation are separated in time. The period of time given to each connection is called a "time slot"; the period between closures is called the "sampling period." The number of slots a system can support or, to put it another way, the capacity of the common path, is equal to the sampling period divided by the period of the time slot. A time slot in the No. 101 ESS is 3.2 microseconds. The switches are closed for 2 microseconds in this period and the remaining time is used as a guard interval between closures. Therefore, 25 conversations can take place over a single

A switching network (see the drawing on page 429), has three major parts: the switch-store, the line number translators, and time-division switches. There are two networks in each switch unit. The switch store is the heart of the switching network. Its contents and cycle time determine the sequence in which the time-division switches close, and its contents can be altered only by a message from the control unit. The store has no "intelligence" as to the state of a call, it merely maintains the time division connection until ordered by the control unit to break it. The magnetic core memory of the switch store has a capacity of 25 words, or time slots, each 21 bits wide. (Because each memory word is associated uniquely with one time slot, the terms are often used interchangeably.) The memory stores and reads out together the addresses of each pair of telephones to be connected together.

The switch store continuously cycles through all time slots in sequence and delivers the contents

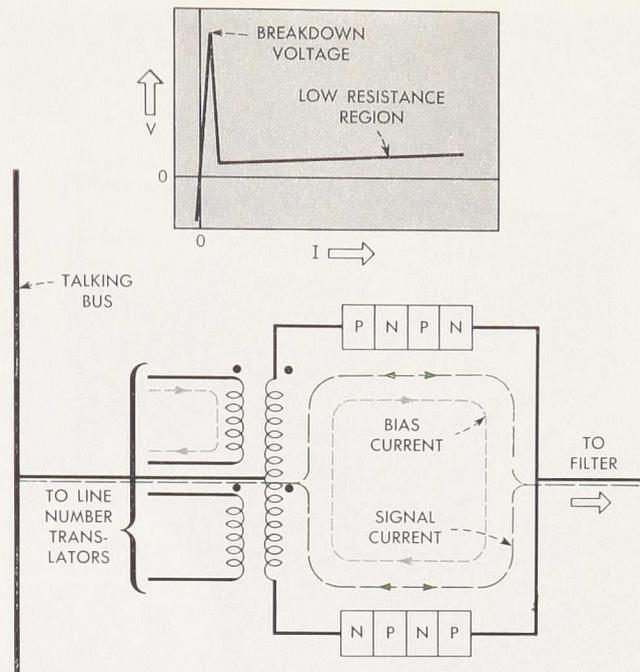
of each time slot to the line number translators. If the time slot is empty, the translators take no action. If the time slot contains a valid address, the translators close the two time-division switches designated by the address.

A continuous exchange of information over high-speed data links between the control unit and a switch unit marks the progress of a call through the No. 101 ESS. The switch unit tells the control unit when there are changes in the supervisory states of telephones (i.e. on-hook or off-hook) or attendant keys, and, in return, receives orders from the control unit to write addresses into, or erase them from, time slot memories. The switch unit also transmits dialed digits over digit trunks to the control unit.

A line scanner—basically an electronic rotary switch—in the switch unit continuously examines every line and refers its supervisory state to a scanner memory. This memory stores an indication of the state of the line—off-hook, or on-hook—at each scan. At every scan, the scanner compares the immediate and the previous states of the line. If the two states match, no action is taken. If they do not match, the memory is updated and the address of the line circuit and its immediate state is coded for transmission over the data link to the control unit.

When a customer lifts his telephone to place a call, the message to the control unit is the first step the system takes after it detects the off-hook condition. The control unit knows that the line has been idle and that the change in state is, therefore, an indication that the customer wishes to place a call. The control unit then seizes an idle digit receiver and digit trunk circuit, and sends a connection message to the switch unit. This message consists of the addresses of the line originating the call and the digit trunk circuit that has been seized, and a time slot number. The switch unit shifts the message into a data distributor (shift register), logic circuits translate the time-slot number, and the time-slot memory records a time-division connection between the originating line and the selected digit trunk. Dial tone is sent from the digit receiver to the customer over the time-division connection. On the average, there is only one-tenth of a second between the change in state of the line circuit and the arrival of dial tone.

The No. 101 ESS, which is basically a multifrequency signaling system, will accept dial signals from either TOUCH-TONE\* pushbutton telephones or standard rotary dial telephones. TOUCH-TONE\* signals (RECORD, *July-August 1963*) are translated directly into digits by the digit re-

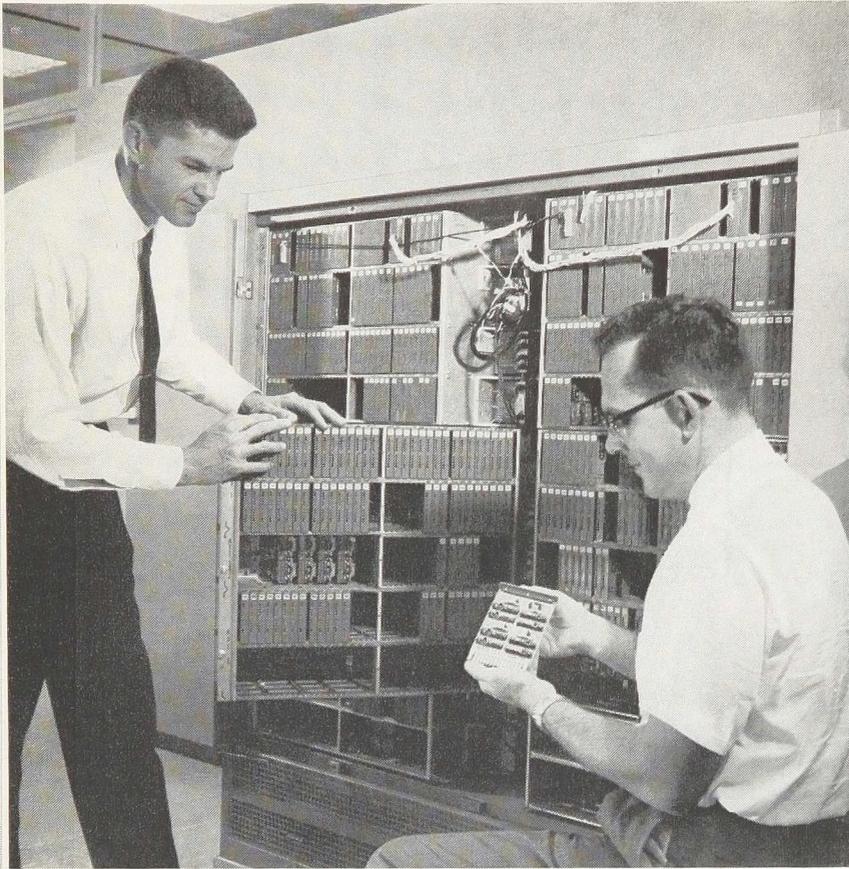


The time-division switching gate. When the diodes are in a low-resistance state due to circulating bias current, bilateral signal current may flow between the talking bus and the filter (green lines). Graph at top of the drawing shows breakdown characteristics.

ceiver circuits in the control unit. Rotary dial pulses are converted in the digit trunk to bursts of a multifrequency signal that does not correspond to any TOUCH-TONE\* dial signal. The digit circuits in the control unit recognize this special tone and count pulses to determine what digit is dialed.

As the customer dials, the digits are stored in a temporary digit memory in the control unit. When he completes dialing, the control unit examines the digits to see what type of call they indicate—extension-to-extension, trunk, or special service. Let us assume, for this example, that the customer is placing an extension-to-extension call. The control unit checks the called line and, if it is idle, sends a ringing message to the switch unit. The switch unit immediately makes a time-division connection between the called customer and the ring generator control supply and between the calling customer and ring-back, or audible signal. Thus the calling customer immediately hears ringing and knows that a connection is being made. Only one time slot is used for both connections and the two are alternated each cycle. The result is half the normal rate of sampling for both ring and ring-back signals. Since these are low-frequency signals, transmission does not suffer.

\* Reg. U.S. Pat. Off.



*F. Tendick (standing) and R. Weise study a plug-in module typical of the No. 101 ESS switch unit circuit equipment.*

Ringling is the conventional 20-cycle ring. It is applied through a per line electronic switch controlled by the ring generator control supply, a DC voltage from the switching network. One second after immediate ringling, the control unit sends another message to specify the standard interrupted ring cycle which consists of one second on and three seconds off. The calling customer is connected to the new ring cycle, and ringling continues until the called customer answers. When he lifts his telephone from its cradle to answer, the scanner detects the off-hook condition and informs the control unit. The control unit, knowing that the off-hook is in answer to a call being processed, returns a talking connection message to the switch unit which connects the calling and called customers in a time slot of the time-division switching memory. When the customers hang up, the scanner detects the change in state of their lines, and the control unit orders the switch unit to erase their addresses from the time-division memory.

Two p-n-p-n diodes form the time-division switch (see the drawing on page 427). These devices have both a high-resistance state, in which the time-division switch is open, and a low-resist-

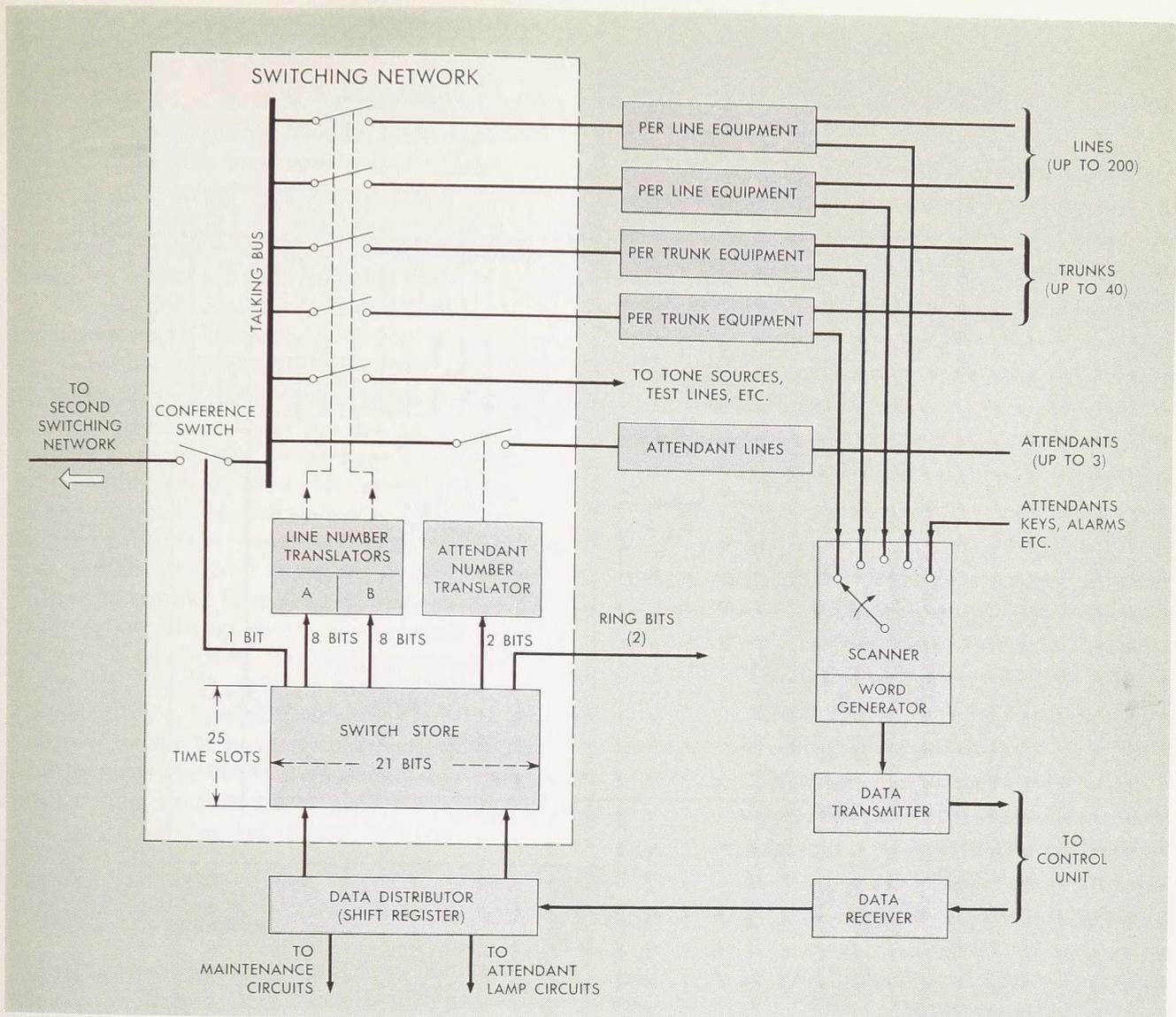
ance state, in which the switch is closed. Normally, the diodes are in the high-resistance state. At a critical breakdown voltage they switch into the low-resistance state which is maintained by circulating bias current. During this time, bilateral signal current can flow between the talking bus and the filter. Bias current and the initial breakdown voltage surge are supplied by either line number translator through one of two primary transformer windings.

Two line number translators designated A and B, (see the drawing on the opposite page) are associated with each switch store. Each closes one time-division switch in response to an 8-bit binary address from the store. When the 21-bit memory word is read out of the store, the A translator operates on the first 8 bits (the calling party address) and the B translator operates on the next 8 bits (the called party address). The remaining 5 bits in the word are used for attendant connections, conference connections, and ringing. The line number translators are high-speed devices which may be called upon to operate on a new address as often as once every 3.2 microseconds.

A simplified drawing on page 430 shows the operation of the line number translator. Upon receiving the 8-bit address from the switch store, it splits it into two 4-bit addresses and then translates each 4-bit number to a 1-out-of-16 code. The 16 outputs from one translator control 16 vertical switches; the 16 outputs from the other control 16 horizontal switches. Thus, each 8-bit address causes the closing of one horizontal and one vertical switch which sets up a current path through the primary winding of the time-division gate at the intersection of the vertical switch column and the horizontal switch row. This causes the p-n-p-n diodes to break down. A timing circuit then generates a 2-microsecond pulse of bias current which holds the time-division switch closed. At the end of this time, the vertical and horizontal switches open, removing bias current from the gate.

The attendant number translator is a scaled-down image of the line number translator. Two bits of each memory word delivered to this translator determine if an attendant is to be connected to the talking bus. If a time slot contains the addresses of two lines and an attendant, all are connected in a time-division connection.

Any switch unit can have up to three attendant consoles associated with it. An attendant can originate calls from the Universal attendant console (RECORD, June 1963) in much the same way they are originated from an extension telephone. To go off-hook, the attendant merely operates a loop key on the console. The scanner considers this a



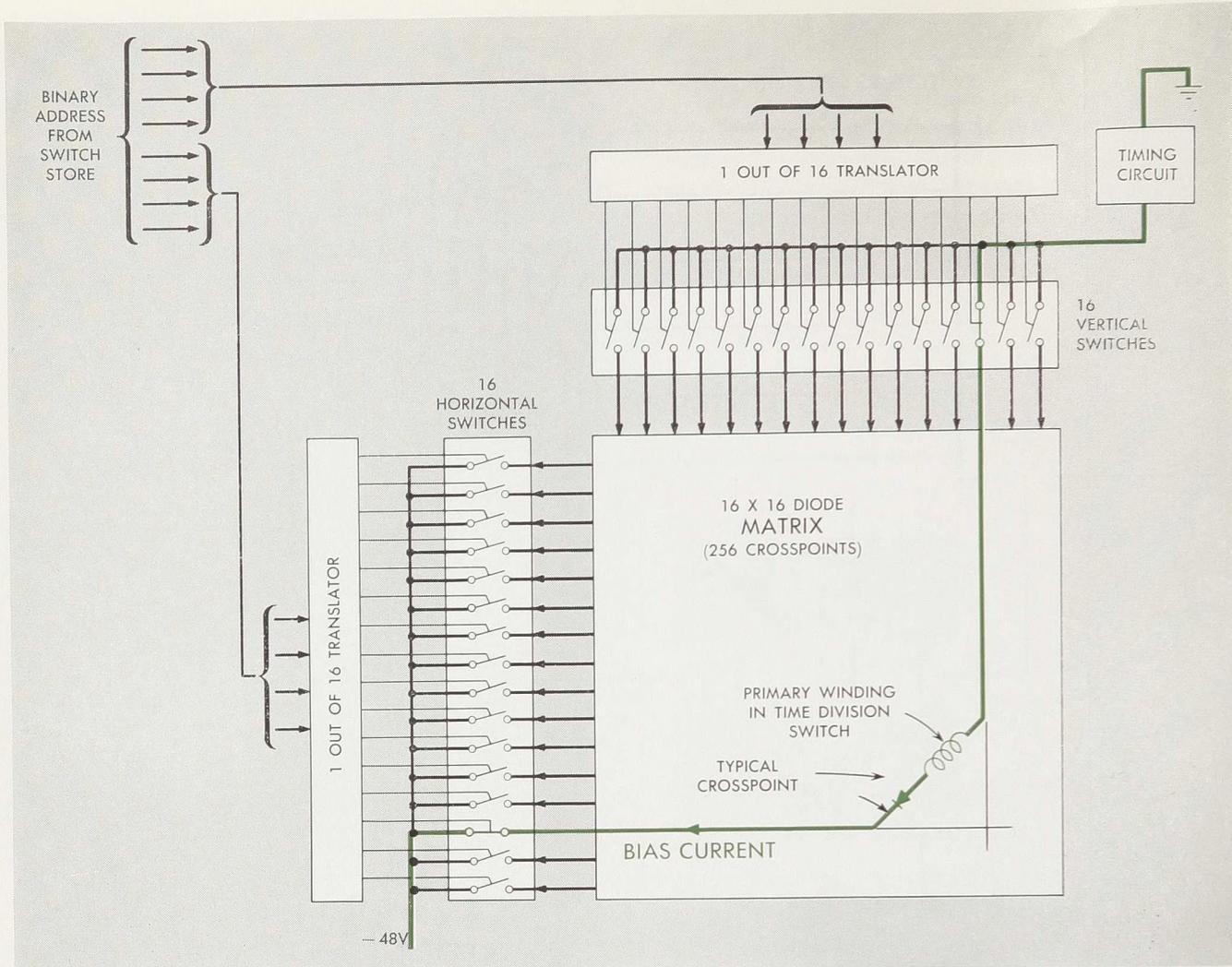
The time-division switching unit of the No. 101 ESS. The scanning equipment keeps a continuous check on all lines associated with the switch unit.

Thus it knows which lines are on-hook and which are off-hook at any given moment and can inform the control unit of a change.

change of state, and informs the control unit which seizes the loop and returns a message to illuminate a lamp in the loop key. The attendant then operates a start key which causes a digit trunk and digit receiver to be seized, and a time-slot message is sent to the switch unit to connect the attendant to a digit trunk. The call is completed in the same way as the extension-to-extension call described above. To disconnect, the attendant operates a release key.

Four-way conference calls are set up by using both switching networks together. The two switch-stores are run synchronously, and if corresponding time slots in the stores contain a conference bit, the two talking buses are connected together in that time slot. All four parties in that time slot can converse in conference fashion.

As it is in all Bell System equipment, reliability was a touchstone in the design of the No. 101 ESS. Redundancy was one of the basic techniques used to achieve high reliability in the system. The switch unit circuits are designed as two identical parts; each half of each circuit will provide service even if its counterpart is not functioning. For example, there are two switching networks, each with its own switch store and line number translators. Similarly, there are two scanners. Although only one is connected to the data link at any instant, both keep their memories up to date so that if one fails the other may be immediately cut into service with little or no destruction of information. Also, each line is served by two time-division switches which gives the line access to either talking bus. Thus, if one switching network is out of



*Simplified diagram of the line number translator. The outputs from each 1-out-of-16 translators control the horizontal and vertical switches. Clo-*

*sure of one horizontal and one vertical switch causes the time-division switch at the crosspoint to close. Each switch unit has two translators.*

service, all customers connected to the unit are served by the second network. In this event the unit's traffic capacity is reduced to 25 simultaneous calls and conference calls cannot be handled.

### **Maintenance Program**

To make efficient use of this redundancy, the control unit runs a continual maintenance program on the system. It checks the various parts of the switch unit and, when it finds a part that is not functioning properly, it takes that part out of service and cuts the duplicate part into service until repairs can be made. Some parts, as the ringing generator, have scan points which indicate a malfunction. Others are checked by a maintenance routine initiated by the control unit.

The maintenance routine actually consists of sending test calls through the system. There are two test lines which are controlled by the switch-

ing networks in the same fashion as other lines and trunks. One test line is a tone source, the other an amplifier that drives a scan point. The control unit uses various parts of the redundant switch unit to set up "conversations" between these test lines. By examining the scan point message which is transmitted in response, the control unit can determine if there is a malfunction in any part. A test call is sent through the system about once every 4 seconds. If a fault is uncovered, the control unit tells the switch unit maintenance circuits to take the faulty part out of service. If a scanner is malfunctioning, it is removed from the outgoing data link and the standby scanner is connected. The maintenance circuits, as well as the messages to transfer between parts, are highly redundant so that improper transfers due to errors will not occur.

If malfunctioning equipment is taken out of

service by the control unit, troubleshooting must be done at the switch unit. The control unit assists in the troubleshooting by sending a repeating test message to exercise the malfunctioning part of the switch unit. The aim of troubleshooting is to trace the malfunction to a faulty circuit package and replace the package. General purpose circuit packages were used as much as possible in the switch unit so that the number of different packages which must be kept on hand as spares is held to a minimum. A compact, portable test set has also been developed to isolate the one package that may be the cause of the trouble.

On one type of failure, the switch unit will act without a message from the control unit. If the AC power, or any DC power supply, momentarily drops below the required voltage the scanner and switch store are stopped immediately so that they do not operate falsely and lose the stored information in their magnetic memories. When the power returns to normal, they are returned to operation. If the failure is very short, i.e., less than a second, the action of cutting the scanner and store out and in again would probably not be noticed by any customers in a talking connection. If the power failure lasts for 30 seconds or more, six preselected extensions are directly connected to six central office trunks so that some emergency service is maintained during the power failure.

### **Installation**

The switch unit is very easily installed. In size it is roughly equal to three five-drawer file cabinets standing side-by-side. Four plug-in cables are wired to the customer's cross-connection box to put the switch unit into operation and a 20-ampere 115-volt wall outlet is adequate to power it. The modular plug-in packages make a relatively simple task of expanding the number of lines up to the maximum capacity of the switch unit. Since all the common equipment in the switch unit (stores, line translators, scanner) is provided for any number of lines at initial installation, only the per line equipment must be added. This equipment is contained on one plug-in package only 4 inches by 6 inches. No wiring must be done except for the new tip and ring pair at the cross-connection box.

Three No. 101 ESS switch units have been part of a field trial in New Brunswick, New Jersey this year. Two of the units serve New Jersey Bell Telephone Company business customers, the third serves a group of lines at the Holmdel Laboratory. Preliminary results of this trial indicate that time-division switching can provide a high quality of telephone service.

## ***New Laser Emits Photons And Generates Phonons In Crystal***

Bell Telephone Laboratories scientists have discovered a new optical maser material—magnesium fluoride doped with nickel ions—which in addition to emitting coherent infrared light, also generates vibrations, called phonons, in the crystal lattice.

This material is unique in that it "lases" at a wavelength that is determined partly by vibrations of the crystal lattice near the nickel ions and partly by electronic states of the nickel ions. In previous lasers, the wavelength of the emitted laser light is determined solely by electronic transitions.

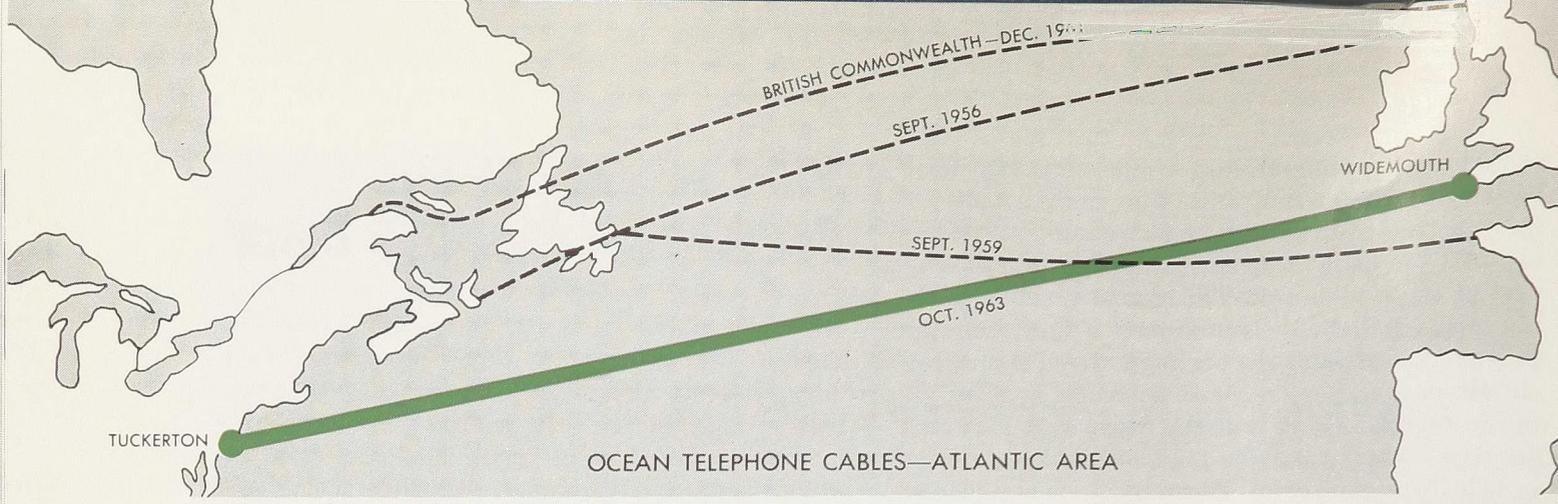
L. F. Johnson, R. E. Dietz, and H. J. Guggenheim of Bell Laboratories reported the discovery in the October issue of *Physical Review Letters*.

In the new laser, nickel ions are excited to high states of energy by optical pumping in the usual way and they then relax back to the upper laser level. From this level, which is an electronic state of nickel in the magnesium fluoride lattice, the ions fall to the lower laser level, emitting the photon associated with laser action. At this lower level the nickel ions are in the ground state and, therefore, unexcited; but the lattice, on the other hand, is vibrationally excited.

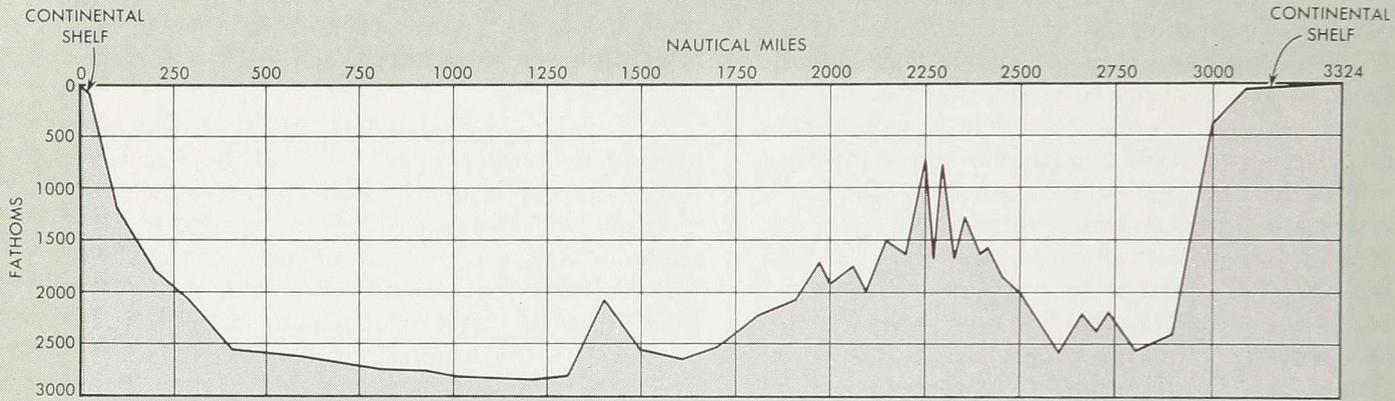
In short, part of the energy of excitation is converted to vibrational energy by the generation of a phonon in the crystal lattice. The frequency of the laser oscillation is partly determined by the energy of this phonon. The larger the phonon energy, the lower the laser frequency. Thus the laser oscillation results not from a nickel ion transition alone, but from a transition of the crystal as a whole.

The reason laser oscillation does not occur in the purely electronic transitions of the nickel ions is that photons emitted at these shorter wavelengths tend to be absorbed in the crystal. The longer wavelength photons associated with the phonon generation are not absorbed so much, and most of them are, therefore, available to stimulate further emission. Thus, a magnesium fluoride crystal doped with nickel ions breaks into laser oscillation at a wavelength associated with the phonon generation and at a pumping power level much lower than would be required to cause laser action at the shorter wavelength associated with purely electronic transitions.

In the current experiment, with the crystal at either 20°k or 78°k, the wavelength of laser emission is at 1.62 microns.



PROFILE OF ROUTE OF LATEST CABLE



# First Direct Submarine Cable Link Between United States and England Completed

A new transatlantic telephone cable—the first to link the United States with England directly—was placed in service in October. Construction of the \$47,000,000 system was a joint undertaking of the Long Lines Department of American Telephone and Telegraph Company and the British Post Office, which furnishes telephone service in the United Kingdom.

The cable is the world's longest, extending 3,500 nautical miles (3,800 statute miles) from Tuckerton, N. J. to Widemouth Bay in Cornwall, England. At the United States end, the cable comes in across Long Beach Island and Barnegat Bay to the Tuckerton underground terminal. The British underground terminal is located near the town of Bude in Cornwall. Terminal stations at each end house equipment needed to provide electrical power for the cable. About 5,500 volts are required at each end, for example, to power new underwater repeaters for the system.

The new cable can transmit 128 simultaneous conversations, more than three times as many as the first transatlantic telephone cable when it was placed in service in 1956.

The cable in the system is a new "armorless" type developed by Bell Laboratories. Unlike earlier types of cable with steel armoring on the outside, the new "armorless" cable gets its strength from a core of 41 steel spiraling wires. The core is enclosed in a thin copper jacket which serves as the inner conductor. A layer of plastic insulates the conductor from the outer copper return conductor. A final layer of a high-density plastic compound covers the whole cable. The over-all diameter of the deep-sea portion is 1¼ in.—approximately the same size as earlier submarine telephone cables. It weighs about 14 ounces per foot. The portion of the cable used in shallow water on the Continental Shelf has steel armor wire around the outside for protection. It varies in thickness from 1.85 to 2.7 in., depending upon the amount and size of armor used.

An amplifying device—a rigid repeater—is spliced into the cable every 20 nautical miles (23 statute miles) along the route. Developed by Bell Laboratories, the repeater is a complex of some

5,000 precision parts encased in a beryllium copper case. Torpedo shaped, it is three feet long, one foot in diameter, and weighs 500 pounds.

Included in each repeater are directional filters which permit voices to travel in both directions over a single cable. Earlier systems use two cables, one for each direction of speech.

The cable for this project was manufactured by the Western Electric Company in Baltimore and by Standard Telephones and Cables, Ltd., in Southampton, England. The 190 repeaters used in the system were made at Western Electric's Clark Township, N. J. facility.

The Bell System's new cable ship, *C. S. Long Lines*, placed nearly 3,000 miles of the transatlantic cable during this summer and fall. The 17,000-ton vessel paid out the cable and the 500-pound rigid repeaters at speeds up to eight knots in her first cable laying assignment. The *HMTS Alert*, a British Post Office cable ship, placed the shore-ends off the southern New Jersey coast and Widemouth Bay.

The new cable was provided to handle a demand for more telephone circuits between this country and the United Kingdom, and countries in Europe served via England.

In addition to the United Kingdom, 13 countries have circuits on the cable: Austria, Belgium, Denmark, France, West Germany, Greece, Ireland, Italy, The Netherlands, Norway, Spain, Sweden, and Switzerland.

Telephone traffic between the United States and England has more than tripled since 1956 when the first transatlantic telephone cable was opened between Oban, Scotland and Sydney Mines, Nova Scotia, via Clarendville, Newfoundland.

During 1927, when telephone service was inaugurated over a single radiotelephone circuit between New York and London, about 2,500 calls were completed between the two countries. By 1955, the annual traffic volume rose to 101,500. Last year it climbed to 429,000.

Today, the rate for a three-minute call to the United Kingdom is \$12 during the day and \$9 at night and on Sunday. When service was first provided in 1927, the charge was \$75.

#### GAS LASER USED TO STUDY MOLECULAR STRUCTURE

For the first time scientists have successfully used a continuously operating laser to produce a light-scattering phenomenon known as the Raman effect. The scientists who conducted these experiments, H. Kogelnik and S. P. S. Porto of Bell Laboratories, believe this technique will provide an inexpensive method of gaining new insights into the structure of molecules.

Raman spectra are essentially extra spectral lines that appear near prominent lines of the spectrum when very strong light shines through a transparent liquid such as carbon tetrachloride. The lines result from the frequency mixing of an excitation light (in this case, a laser beam) and the characteristic vibrations of molecules in a particular liquid or gas.

In addition to obtaining photographs of Raman spectra, Mr. Porto and R. C. C. Leite have made continuous photoelectric recordings of the Raman effect in several non-absorbing, non-turbid liquids.

Scientists at Bell Laboratories believe this technique will be useful for Raman effect studies of non-absorbing non-turbid liquids, and probably important for Raman spectroscopy of gases. They also expect this technique will aid in studying the physics of Raman scattering in detail since the wavelength, polarization, and direction of the Raman radiation are very well defined.

#### UNDERWATER OCEAN NOISES PROBABLY DUE TO WHALES

Whales probably generate the intense, subsonic throbbings that oceanographers first detected in parts of the Atlantic and Pacific Oceans a decade ago. This conclusion and a review of the supporting evidence was recently presented by Richard A. Walker of Bell Laboratories in an issue of the "Journal of the Acoustical Society of America."

In 1954 Bell Laboratories' oceanographers studying acoustical problems in the North Atlantic detected subsonic sounds so energetic that they often rose 30 or 40 decibels above the level of the background noise. Observations made with hydrophones south of New England on the continental shelf suggested that some animal was responsible for the sonic pulses. If whales turn out to be the sources of these sounds, the knowledge gained could be useful to cetologists—scientists who study whales—and the whaling industry, says Mr. Walker. Few methods of tracking are now available.

# PATENTS

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

- Anderson, L. T. and Crane E. G., Jr. — *Automatic Telephone Switching System*—3,102,930.
- Anderson, F. B. and Pearsall, S. H., Jr.—*Pulse Generator*—3,105,169.
- Aigrain, P. R. and Chynoweth, A. G.—*Semiconductive Device Utilizing Quantum-Mechanical Tunneling*—3,105,177.
- Ashkin, A.—*Parametric Electron Beam Devices*—3,101,449.
- Babb, J. G. and H. J. Hershey—*Space Saver Dial*—3,105,122.
- Baker, W. E. and Froehlich, F. E.—*Self-Synchronizing Delay Line Data Translation*—3,107,344.
- Berkowitz, D. A.—*Positive or Negative High Gain Image Amplifier*—3,107,303.
- Bobeck, A. H.—*Magnetic Memory Arrays*—3,105,226.
- Bobeck, A. H.—*Magnetic Memory Circuits*—3,105,962.
- Bobeck, A. H.—*Electrical Selection Circuits*—3,109,161.
- Buhrendorf, F. G.—*Magnetic Recording and Reproducing System*—3,108,260.
- Callaway, W. B.—*Equipment Holding Time Distribution Analyzer*—3,105,115.
- Chasek, N. E.—*Frequency Modulated Balanced Discriminator*—Re 25,436.
- Chynoweth, A. G., see Aigrain, P. R.
- Cirone, F. P. and Lowry T. N.—*Supervisory Circuits for Telephone Subscriber's Lines* — 3,102,168.
- Courtney-Pratt, J. S.—*Optical Focus and Resolution Testing Methods and Apparatus*—3,100,239.
- Crane, E. G., Jr., see Anderson, L. T.
- Crowell, M. H.—*Electron Beam Tube for Translating Gray Code to Binary Code*—3,108,203.
- Cutler, C. C.—*Antenna for Active Satellite Repeaters*—3,100,892.
- Damen, T. C. and Hall, W. G.—*Self-Adjusting Encoder*—3,103,629.
- David, E. E., Jr.—*Sound Control System*—3,109,066.
- David, E. E., Jr. and Pierce, J. R.—*Pitch Synchronous Autocorrelation Vocoder*—3,109,070.
- DeFina, A. L.—*Preset Call Transmitter*—3,105,123.
- Dickieson, A. C.—*Signal Controlled Steering Systems*—3,102,505.
- Dimond, T. L.—*Machine Reading of Handwritten Characters*—3,108,254.
- Dorros, I.—*Transmitter and Receiver Signaling Circuits*—3,103,647.
- Ellis, A. E., Jr.—*Transistor Memory Circuit*—3,102,207.
- Eisentraut, R. A.—*Grooved Reflecting Surface for Discriminating Between Thermal and Microwave Radiation* — 3,108,279.
- Farnsworth, D. W. and Steinberg, J. C.—*High Speed Telegraphy*—3,105,111.
- Feiner, A.—*Multiple Station Communication Circuit*—3,108,157.
- Field, J. M.—*Repertory Dialer*—3,105,121.
- Fennick, J. H. and Kaenel, R. A.—*High Speed Stepping Switch Circuit*—3,109,108.
- Froehlich, F. E., see Baker, W. E.
- Gordon A. M. and Meacham, L. A.—*Dual Channel Frequency Selective Attenuator Utilizing Cross Coupled Impedance Networks Between Input and Output Terminals*—3,103,601.
- Gordon, E. I.—*Cyclotron Wave Electron Beam Parametric Amplifier*—3,109,146.
- Haas, C. W., Jr.—*Constant-width Rectangular Pulse Generator Utilizing Transformer Having Two Primary Windings in Regenerative Feedback Circuit*—3,104,329.
- Hall, W. G., see Damen, T. C.
- Hamilton, B. H.—*Regulator Protection Circuits*—3,106,674.
- Henning, H. A.—*Data Transmission*—3,100,890.
- Hershey, H. J. and Spencer, R. A.—*Gong*—3,102,510.
- Hershey, H. J., see Babb, J. G.
- Kaenel, R. A., see Fennick, J. H.
- Kahng, D.—*Electricfield Controlled Semiconductor Device*—3,102,230.
- Kamentsky, L. A.—*Spatially Oriented Data Processing Apparatus*—3,106,699.
- Kassig, J. J.—*Power Separation Filter*—3,105,125.
- Katzin, L.—*Magnetic Core Assembly*—3,106,703.
- Koening, W., Jr.—*Signaling System*—3,105,114.
- Kunzler, J. E.—*Superconducting Device*—3,102,973.
- Lee, C. A.—*Circuit Employing Negative Resistance Asymmetrically Conducting Devices Connected in Series Randomly or Sequentially Switched* — 3,109,109.
- Lentz, N. E.—*Blocking Oscillator Frequency Divider*—3,108,198.
- Lepselter, M. P.—*Semiconductor Device Fabrication*—3,106,489.
- Ligenza, J. R. and Shapiro, H. M.—*Selective Diffusion Technique*—3,108,915.
- Lowry, T. N., see Cirone, F. P.
- Marino, P. J.—*Hub Control Circuit*—3,105,112.
- Mason, W. P.—*High Strain Non-Linearity Compensation of Semiconductive Sensing Members*—3,102,420.
- Mattke, C. F.—*Space Saver Dial*—3,108,159.
- Maurushat, J., Jr.—*Automatic-Test Equipment for Carrier Type Communication Systems*—3,105,881.
- McAfee, K. B., Jr.—*Light Gas Detector Using Thin Walled Glass Tubes for Diffusion*—3,100,868.
- McDonald, H. S.—*Apparatus for Encoding Pitch Information in a Vocoder System*—3,109,142.
- McSkimin, H. J.—*Method and Apparatus for Measuring Time Delay in Transmission Paths*—3,107,329.
- Meacham, L. A., see Gordon, A. M.
- Mills, J. K.—*Output Voltage Control for Power Conversion Apparatus*—3,106,672.

## PATENTS (CONTINUED)

- Mills, J. K.—*Compensating Apparatus for Frequency Sensitive Regulators*—3,109,133.
- Mitchell, C. E., Prescott, R. E., Schenker L. and Tweed, D. G.—*Telephone Call Transmitter*—3,109,071.
- Montesano, L.—*Polysulfide Polymer Containing Styrene Oxide as an Odor Masker, and Mixture Thereof with an Epoxy Resin*—3,101,326.
- Pearsall, S. H., Jr., see Anderson, F. B.
- Pierce, J. R., see David, E. E., Jr.
- Prescott, R. E., see Mitchell, C. E.
- Pruden, D. H. and Timko, J. W.—*Servo-Mechanism Control Circuit*—3,109,128.
- Raisbeck, G.—*Prevention of Corona Discharge*—3,102,161.
- Rappeport, M. A.—*Timing Recovery Circuit*—3,105,194.
- Schenker, L., see Mitchell, C. E.
- Schroeder, M. R.—*Vocoder Excitation Generator*—3,102,928.
- Seidel, H.—*Nonreciprocal Wave Transmission Components* —3,102,244.
- Shapiro, H. M., see Ligenza, J. R.
- Spencer, R. A., see Hershey, H. J.
- Stahler, R. E.—*Storage System*—3,102,998.
- Steinberg, J. C., see Farnsworth, D. W.
- Timko, J. W., see Pruden, D. H.
- Torresen, J. L.—*Stowage Rack*—D 196,129.
- Tweed, D. G., see Mitchell, C. E.
- Unger, S. H.—*Parallel Data Processing Apparatus*—3,106,698.
- Witt, F. J.—*Nonreciprocal Wave Translating Network*—3,109,147.
- Wolfe, R. M.—*Ferroelectric Shift Register*—3,100,887.
- Ziegler, A. W.—*Hermetic Seal Terminal*—3,109,055.

## PAPERS

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

- Aisen, P., see Blumberg, W. E.
- Alburger, D. E., Donovan, P. F. and Wilkinson, D. H. *The Beta Decay of Lithium-8*, Phys. Rev. 132, 334-42, Oct. 1, 1963.
- Alexander, S., Corenzwit, E., Matthias B. T., Shulman, R. G. and Wyluda, B. J., *Knight Shifts in Niobium-Molybdenum Alloys*, Phys. Rev. 129, 2481, Mar. 15, 1963.
- Anderson, E. W., see McCall, D. W.
- Anderson, L. K., *Microwave Modulation of Light Using Ferromagnetic Resonance*, J. Appl. Phys. 34, 1230-1, Apr., 1963.
- Anderson, L. K., *Measurement of the Microwave Modulation Frequency Response of Junction Photodiodes*, Proc. IEEE, 51, 846, May, 1963.
- Anderson, P. W., see Rowell, J. M.
- Andus, J. V., Higgins, E. F., Murray, J. L. and Schaefer, F. J., *The Precision Tracker* BSTJ, 42, 1309-56, July, 1963.
- Atal, B. S., see Schroeder, M. R.
- Auld, B. A., see Comstock, R. L.
- Baba, P. D., Gyorgy, E. M. and Schnettler, F. J., *Two-Phase Measurements*, J. Chem. Phys. 38, 2257-64, May 1, 1963.
- Barns, R. L., Laudise, R. A. and Shields, R. M., *The Solubility of Corundum in Basic Hydrothermal Solvents*, J. Phys. Chem. 67, 835-9, Apr., 1963.
- Bateman, T. B., see Mason, W. P.
- Bateman, T. B., see Spencer, E. G.
- Batterman, B. W., see Patel, J. R.
- Battista, R. N., Morrison, C. G. and Nash, D. H., *Signaling System and Receiver for Touch-Tone Calling*, IEEE Trans. on Commun. and Electronics, 65, 9-17, Mar., 1963.
- Becker, G. E. and Gobeli, G. W., *Surface Studies by Spectral Analysis of Internally Reflected Infrared Radiation-Hydrogen on Silicon*, J. Chem. Phys. 38, 2942-5, June, 1963.
- Benes, V. E., *General Stochastic Processes in the Theory of Queues*, New York, Addison Wesley, 1963.
- Bennett, S. B., see Hatch, R. W.
- Bennett, W. R. and Salz, J., *Binary Data Transmission by FM Over a Real Channel*, BSTJ, 42, 2387-2426, Sept., 1963.
- Bennett, W. R. and Rice S. O., *Spectral Density and Auto-correlation Functions Associ-*
- Ferrites for High-Speed Switching*, J. Appl. Phys. 34, 1125-6, Apr., 1963.
- Balacek, F. P., *Ruggedizing the Wire Spring Relay*, Bell Labs. RECORD, 41, 363-5, Oct., 1963.
- Baldwin, G. L. and Snow, N. E., *Remote Operation of a Computer by High-Speed Data-Link*, in—1962 Fall Joint Computer Conf. Philadelphia, Dec., 1962 Washington, Spartan Books, 1963, p. 170-6.
- Ballman, A. A. and Laudise, R. A., *Hydrothermal Growth*, In—*The Art and Science of Growing Crystals*, Ed. by J. J. Gilman, New York, Wiley, 1963, p. 231-51.
- Bangert, J. T., Engebrecht, R. S., Harkless, E. T., Sperry, R. V. and Walsh E. J., *The Spacecraft Antennas*, BSTJ, 42, 869-98, July, 1963.
- Baraff, G. A. and Buchsbaum, S. J., *Anisotropic Electron Distribution and the DC and Microwave Avalanche Breakdown in Hydrogen*, Phys. Rev. 130, 1007, Aug. 1, 1963.
- Barker, A. S. and Tinkham, M., *Far-Infrared Dielectric Meas-*

- ated with Binary Frequency Shift Keying, BSTJ, 42, 2355-86, Sept., 1963.
- Benson, K. E., see Storm, A. R.
- Benson, M. L., Crutchfield, F. L. and Hopkins, H. F., *Application of Touch-Tone Calling in the Bell System*, IEEE Trans. on Commun. and Electronics, 65, 1-5, Mar., 1963.
- Bergh, A. A., *The Spreading of Molten Indium Over Germanium*, J. Electrochem. Soc. 110, 908-14, Aug., 1963.
- Blackman, R. B., see Claus, A. J.
- Blackmore, R. W., see Dolling, J. C.
- Blumberg, W. E., Eisinger, J., Aisen, P., Morell, A. and Scheinberg, I. H., *Physical and Chemical Studies on Ceruloplasmin Part-1 The Relation Between Blue Color and the Valence States of Copper*, J. Bio. Chem. 238, 1675-82, May, 1963.
- Blumberg, W. E., Eisinger, J. and Geschwind, S., *The Copper (111) Ion in Corundum*, Phys. Rev. 130, 900-9, May 1, 1963.
- Bode, J. D., see Smith, K. D.
- Bodmer, M. G., Laico, J. P., Olsen, E. G. and Ross, A. T., *The Satellite Traveling-Wave Tube*, BSTJ, 42, 1703-48, July, 1963.
- Bomberger, D. C., Brolin, S. J., Feldman, D., Trucksess, D. E. and Ussery, P. W., *The Spacecraft Power Supply System*, BSTJ, 42, 943-72, July, 1963.
- Bomberger, D. C. and Moose, L. F., *Nickel-Cadmium Cells For The Spacecraft Battery*, BSTJ, 42, 1687-1702, July, 1963.
- Bonner, A. L. and Longton, A. C., *T1 Carrier System Signaling*, Bell Labs. RECORD, 41, 307-13, Sept., 1963.
- Breitschwerdt, K. G., *Direct and Indirect Tunneling in Germanium at Different Temperatures*, J. Appl. Phys. 34, 2610-2, Sept., 1963.
- Bricker, P. D., *Would Time Delay be a Problem in Using a Synchronous Satellite*, In—Satellite Communication Physics, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 70-7.
- Brolin, S. J., see Bomberger, D. C.
- Brooks, C. E., Henry, J. L., Markthaler, G. E. and Sand, W. C., *Distributed Line Concentrator With Unique Intraconcentrator Completion Circuits* IEEE Trans. on Commun. and Electronics, 67, 313-448, July, 1963.
- Brown, W. L., see Mayo, J. S.
- Brown, W. L., Buck, T. M., Medford, L. V., Thomas, E. W., Gummel, H. K., Miller, G. L. and Smits, F. M., *The Spacecraft Radiation Experiment*, BSTJ, 42, 899-942, July, 1963.
- Brown, W. L., Gabbe, J. D. and Rosenzweig, W., *Results of the Telstar Radiation Experiment*, BSTJ, 42, 1505-59, July, 1963.
- Brown, W. L., Hess, W. N. and Van Allen, J. A., *Johnston-Island Artificial Radiation Belt (Introduction to Papers)*, J. Geophys. Res. 68, 605-6, Feb. 1, 1963.
- Brown, W. S., *The Alpak System For Nonnumerical Algebra on a Digital Computer, Part-1, Polynomials in Several Variables and Truncated Power Series With Polynomial Coefficients*, BSTJ, 42, 2081-2120, Sept., 1963.
- Buchsbaum, S. J., see Baraff, G. A.
- Buck, T. M., see Brown, W. L.
- Buff, F. P., *The Statistical Mechanical Theory of Double Layer Structure and Properties*, J. Chem. Phys. 39, 1911-23, Oct. 15, 1963.
- Byrne, C. J. and Scattaglia, J. V., *A Buffer Memory for Synchronous Digital Networks*, In—1962 Conf. Proc. 6th Mil-E-Con, Washington, June 25-27, 1962, Washington, McGregor and Werner, 1963, p. 134-42.
- Calbrick, C. J., *The Discovery of Electron Diffraction* by Davison and Germer, Am. Phys. Teacher, May 2, 1963.
- Carlson, C. P., see Smith, D. H.
- Carter, R. P., see Holmes, R. R.
- Chaffee, J. G., see Giger, A. J.
- Chandross, E. A., *A New Chemiluminescent System*, Tetrahedron Letters, 12, 761-5, July, 1963.
- Chang, J. J., see Shepard, R. N.
- Chapman, R. C., Critchlow, G. F. and Mann, H., *Command and Telemetry Systems*, BSTJ, 42, 1027-62, July, 1963.
- Chow Chin, L. Y., see Faust, W. L.
- Chrunev, M., see Uenohara, M.
- Cisek, J. G., see Harvey, F. K.
- Claus, A. J., Blackman, R. B., Halline, E. G. and Ridgway, W. C., *Orbit Determination and Prediction, and Computer Programs*, BSTJ, 42, 1357-82, July, 1963.
- Clogston, A. M., see White, J. A.
- Cochran, W. T., *Testing Equipment For Telephone Subscriber Loops*, IEEE Trans. on Commun. and Electronics, 66, 168-72, May, 1963.
- Cohen, R. L., *Determination of the Nuclear Magnetic Moment of the First Excited State of Thulium-169 Using Mossbauer Effect*, Bull. Am. Phys. Soc. 8, 43, Jan. 23, 1963.
- Collier, R. J., Helm, G. D., Laico, J. P. and Striny, K. M., *The Ground Station High-Power Traveling-Wave Tube*, BSTJ, 42, 1829-62, July, 1963.
- Collins, R. J., *High Order Cavity Modes in Optical Masers*, In—Int. Conf. on Magnetic and Electric Resonance and Relaxation, Eindhoven, 1962, Amsterdam, North Holland Pub. Co., 1963, p. 58-70.
- Comstock, R. L., see Varnerin, L. J.
- Comstock, R. L. and Dean, W. A., *Extension of Coincidence Limiting Frequency Range in Ferromagnets*, J. Appl. Phys. 34, 1275-7, Apr., 1963.
- Comstock, R. L., Book Review—*Entitled Microwave Ferrites and Ferrimagnetics* by Lax and Button, Solid State Electronics, 6, 392-3, July-Aug., 1963.
- Comstock, R. L. and Auld, B. A., *Parametric Coupling of the Magnetization and Elastic Strain in a Ferromagnet, Part-*

## PAPERS (CONTINUED)

- 1, *Parametric Excitation of Magnetostatic and Elastic Modes*, J. Appl. Phys. 34, 1461-4, May, 1963.
- Comstock, R. L. and Hansen, W. W., *Parametric Coupling of the Magnetization and Strain in a Ferrimagnet, Part-2, Parametric Excitation of Magnetic and Elastic Plane Waves*, J. Appl. Phys. 34, 1465-8, May, 1963.
- Cook, J. S. and Lowell, R., *The Autotrack System*, BSTJ, 42, 1283-1308, July, 1963.
- Corenzwit, E., see Alexander, S.
- Cortney-Pratt, J. S., *How can we Make Optical Measurements on a Satellite*, In—*Satellite Communication Physics*, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 53-61.
- Crawford, A. B., Cutler, C. C., Kompfner, R. and Tillotson, L. C., *The Research Background of the Telstar Experiment*, BSTJ, 42, 747-64, July, 1963.
- Critchlow, G. F., see Chapman, R. C.
- Crowley, T. H., *The Computer as an Aid to the Design and Manufacture of Systems*, IEEE Intern. Conv. Record, 11, pt.-4, 47-51, 1963.
- Crutchfield, F. L., see Benson, M. L.
- Cutler, C. C., see Crawford, A. B.
- Cutler, C. C., *Coherent Light or the Strange Appearance of the Monochromatic World*, Intern. Sci. and Tech. 1, 8, Sept., 1963.
- Cutler, C. C., Kompfner, R. and Tillotson, L. C., *A Self-Steering Array Repeater*, BSTJ, 42, 2013-32, Sept., 1963.
- Cuttriss, D. B., see Smith, K. D.
- Dalbora, J. B., see Upthegrove, H. N.
- Davis, C. G., Hutchinson, P. T., Witt, F. J. and Maunsell, H. I., *The Spacecraft Communications Repeater*, BSTJ, 42, 831-68, July, 1963.
- Dammont, F. R., see Salovey, R.
- Dean, R. E. and Fitch, A. H., *Spurious Signals Resulting From Second Longitudinal Mode Propagation in Stepped-Thickness Dispersive Strip Delay*, IEEE Intern. Conv. Record, 11, pt. 8, 102-8, 1963.
- Dean, W. A., see Comstock, R. L.
- Dean, W. A., see Varnerin, L. J.
- Delange, O. E., *Long-Distance Light Propagation*, Proc. IEEE, 51, 1361, Oct., 1963.
- Delchamps, T. B., Jonasson, G. C. and Swift, R. A., *The Spacecraft Test and Evaluation Program*, BSTJ, 42, 1007-26, July, 1963.
- Denton, R. T., see Spencer, E. G.
- Denton, R. T. and Spencer, E. G., *Acoustic Measurements on Magnetic Materials*, J. Appl. Phys. 34, 1832-3, June, 1963.
- Dick, G. W., *Performance of the Core Equivalent of the Transfluxor Shift Register*, In—*Proc. of the Int. Conf. on Nonlinear Magnetics*, Washington, 1963, New York, IEEE, 1963, p. 14-1-1-8.
- Dickieson, A. C., *The Telstar Experiment*, BSTJ, 42, 739-46, July, 1963.
- Dillon, J. F. and Remeika, J. P., *Ferromagnetic and Paramagnetic Resonance Line Widths in Chromium Chloride and Chromium Bromide*, In—*Int. Conf. on Magnetic and Electric Resonance and Relaxation*, Eindhoven, 1962, Amsterdam, North Holland Pub. Co., 1963, p. 480-7.
- Dimarcello, F. V., see Gallagher, P. K.
- Dimarcello, F. V., see Mac Chesney, J. B.
- Dolling, J. C., Blackmore, R. W., Kindermann, W. J. and Woodward, K. B., *The Mechanical Design of the Horn Reflector Antenna and Radome*, BSTJ, 42, 1137-86, July, 1963.
- Donovan, P. F., see Alburger, D. E.
- Douglass, D. C., see Fratiello, A.
- Dove, D. B., see Stilwell, G. R.
- Dove, D. B., *Photography of Magnetic Domains Using the Transverse Kerr Effect*, J. Appl. Phys. 34, 2067, July, 1963.
- Dragone, C., see Hogg, D. C.
- Eisele, K. M., see Uenohara, M.
- Eisinger, J., see Blumberg, W. E.
- Eisinger, J., *Proton Relaxation Measurements as a Means of Studying Ion Binding and Certain Biological Systems*, In—*Paramagnetic Resonance*, Proc. of the 1st Int. Conf. Held in Jerusalem, July 16-20, 1963, Ed. by W. Low, New York, Academic Press, 1963, p. 501-8.
- Eisinger, J., Fawaz-Estrup, F. and Shulman, R. G., *Precipitation of Synthetic Polynucleotides by Magnesium (111)*, Biochem.-Biophys. Acta, 72, 120, 1963.
- Eisner, E., *Design of Sonic Amplitude Transformers For High Magnification*, J. Acoust. Soc. Am. 35, 1367-78, Sept., 1963.
- Eisner, E., *Brighter Spectrographic Images by use of Anamorphic Optics*, Appl. Opt. 2, 577, July, 1963.
- Eisner, E., *Design of Sonic Amplitude Transformers For High Magnification*, IEEE Intern. Conv. Record, 11, pt.-9, 76-9, 1963.
- Elicher, R. E., see Smith, D. H.
- Elliott, E. O., *Estimates of Error-Rates For Codes on Burst-Noise Channels*, BSTJ, 42, 1977-98, Sept., 1963.
- Engbrecht, R. S., see Bangert, J. T.
- Evans, M. J., Myers, G. H. and Timko, J. W., *Command Guidance of Telstar Launch Vehicle*, BSTJ, 42, 2153-68, Sept., 1963.
- Fabian, E. L., *The Design of Rectangular Bar Transducers For Use With Ultrasonic Dispersive Strip Delay Lines*, IEEE Intern. Conv. Record, 11, pt.-8, 96-101, 1963.
- Faust, W. L. and Chow Chin, L. Y., *Hyperfine Structure of Metastable Atoms*, Phys. Rev. 129, 1214-20, Feb. 1, 1963.
- Fawaz-Estrup, F., see Eisinger, J.
- Fawcett, E., see Walsh, W. M.
- Feldman, D., see Bomberger, D. C.
- Ferguson, J., Wood, D. L. and Knox, K., *Crystal Field Spectra of 3 Electron (Hole) Ions, IV, Potassium Cobalt (11) Fluoride*

- ride, Cobalt Chloride, Cobalt Bromide, Cobalt Tungstate, J. Chem. Phys. 39, 881-9, Aug. 15, 1963.
- Ferguson, J., *Crystal-Field Spectra of D-3, 7 Ions, Part-1, Electronic Absorption Spectrum of Cobalt Chloride in Three-Crystalline Environments*, J. Chem. Phys. 39, 116-28, July 1, 1963.
- Fink, H. J., see Hanson, D. C.
- Finne, R. M., see Sullivan, M. V.
- Fitch, A. H., see Dean, R. E.
- Fitch, A. H., *Elastic-Pulse Propagation in Hollow Cylinders*, J. Acoust. Soc. Am. 35, 706-8, May, 1963.
- Fitch, A. H., *Observation of Elastic Pulse Propagation in Axially Symmetric and Non-Axially Symmetric Longitudinal Modes of Hollow Cylinders*, J. Acoust. Soc. Am. 35, 706-8, May, 1963.
- Flanagan, J. L., see Harris, G. G.
- Fletcher, H. J., Rongved, L. and Yu, E. Y., *Dynamics Analysis of a Two-Body Gravitationally Oriented Satellite*, BSTJ, 42, 2239-68, Sept., 1963.
- Gobeli, G. W., see Becker, G. E.
- Foster, F. G., *Gold as a Solder Contaminant*, Prod. Eng. 34, 59-61, Aug. 19, 1963.
- Foster, N. F., *The Diffusion Layer Ultrasonic Transducer*, J. Appl. Phys. 34, 990-1, Apr., 1963.
- Foster, R. M., *Satellite Communications*, In—Satellite Communication Physics, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 11-38.
- Fratiello, A. and Douglass, D. C., *NMR Shift and Diffusion Study of Electrolytes in 50 Per Cent Dioxane-Water Mixtures*, J. Chem. Phys. 39, 2017-22, Oct. 15, 1963.
- Frisch, H. L. and Stillinger, F. H., *Contribution to the Statistical Geometric Basis of Radiation Scattering*, J. Chem. Phys. 38, 2200-7, May 1, 1963.
- Fuller, C. S. and Wolfstirn, K. B., *Acceptors in Donor-Doped Gallium Arsenide Resulting From Lithium Diffusion*, J. Appl. Phys. 34, 1914-20, July, 1963.
- Fuller, C. S. and Wolfstirn, K. B., *Changes in Electron Concentration of Donor-Doped Gallium Arsenide Crystals Caused by Annealing*, J. Appl. Phys. 34, 2287-9, Aug., 1963.
- Fuller, C. S. and Wolfstirn, K. B., *Defects in Gallium Arsenide Produced by Lithium*, Appl. Phys. Letters, 2, 45-7, Feb. 1, 1963.
- Gabbe, J. D., see Brown, W. L.
- Gagne, D. J. and Schutz, C. J., *Central Office and PBX Arrangements for Touch-Tone Calling*, IEEE Trans. on Commun. and Electronics, 65, 5-8, Mar., 1963.
- Gale, D. H., see Kroning, R. D.
- Gallagher P. K., see MacChesney, J. B.
- Gallagher, P. K., Schrey, F. and Dimarcello, F. V., *Preparation of Semiconducting Titanates by Chemical Methods*, J. Am. Ceram. Soc. 46, 359-65, Aug., 1963.
- Gallagher, W. P., see Holmes, R. R.
- Gershenzan, M., see Thomas, D. G.
- Geschwind, S., see Blumberg, W. E.
- Geschwind, S., *Optical Detection of Paramagnetic Resonance in the Excited Metastable State of Chromium (111) and Aluminum Oxide*, In—Int. Conf. on Magnetic and Electric Resonance and Relaxation, Eindhoven, 1962, Amsterdam, North Holland Pub. Co., 1963, p. 548-54.
- Geyling, F. T., *How Do We Calculate a Satellite's Orbit*, In—Satellite Communication Physics, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 41-7.
- Gianola, U. F., *Disturb Thresholds in Cylindrical Film Memory Wire*, J. Appl. Phys. 34, 1131, Apr., 1963.
- Giger, A. J., and Chaffee, J. G., *The FM Demodulator With Negative Feedback*, BSTJ, 42, 1109-35, July, 1963.
- Giger, A. J., Wickliffe, P. R. and Pardee, S., *Ground Transmitter and Receiver*, BSTJ, 42, 1063-1108, July, 1963.
- Gilbert, E. N., *Masks to Pack Circles Densely*, J. Soc. Motion Picture and Television Engrs. 72, 606-8, Aug., 1963.
- Gilbert, E. N., *Functions Which Represent All Integers*, Amer. Math. Monthly, 70, 736-8, Aug./Sept., 1963.
- Gilbert, E. N., *Cyclically Permutable Error - Correcting Codes*, IEEE Trans. on Inform. Theory, 1T-9, 175-82, July, 1963.
- Ginsberg, A. P. and Robin, M. B., *The Structure, Spectra and Magnetic Properties of Certain Iron Halide Complexes*, Inorg. Chem. 2, 817-22, Aug., 1963.
- Giordmaine, J. A. and Howe, J. A., *Induced Optical Absorption in Carbon Disulfide*, Phys. Rev. Letters, 11, 207-9, Sept. 1, 1963.
- Githens, J. A., Kelly, H. P., Lozier, J. C. and Lundstrom, A. A., *The Antenna Pointing System Organization and Performance*, BSTJ, 42, 1213-22, July, 1963.
- Githens, J. A. and Peters, T. R., *Digital Equipment For the Antenna Pointing System*, BSTJ, 42, 1223-52, July, 1963.
- Gnanadesikan, R., see Wilk, M. B.
- Gobeli, G. W., see Becker, G. E.
- Gobeli, G. W., see Lander, J. J.
- Gordon, J. P., Louisell, W. H. and Walker, L. R., *Quantum Fluctuations and Noise in Parametric Processes, Part-2*, Phys. Rev. 129, 481, Jan. 1, 1963.
- Griffiths, J. E., *Preparation of Germane*, Inorg. Chem. 2, 375, Apr., 1963.
- Grodkiewicz, W. H. and Van Uitert, L. G., *The Synthesis of Forsterite, Diopside, Akermanite and Wollastonite From Molten Lead Oxide*, J. Am. Ceram. Soc. 46, 356, July, 1963.
- Grosh, R. J., see Holt, V. E.
- Grunwald, E., see Leffler, J. E.
- Grunwald, E. and Jumper, C. F., *Kinetics and Mechanism of the Proton Transfer Between Methyloxonium Ion and Benzoic*

## PAPERS (CONTINUED)

- Acid in Methanol Solution*, J. Am. Chem. Soc. 85, 2051-2, July 20, 1963.
- Grunwald, E. and Meiboom, S., *Kinetics of Proton Transfer in Methanol For a Series of Carboxylic Acids of Varying Strength*, J. Am. Chem. Soc. 85, 2047-50, July 20, 1963.
- Guggenheim, H., *The Growth of Highly Perfect Fluoride Single-Crystals For Optical Masers.*, J. Appl. Phys. 34, 2482-5, Aug., 1963.
- Gummel, H. K., see Brown, W. L.
- Gummel, H. K., see Mayo, J. S.
- Gummel, H. K., see Smith, K. D.
- Gyorgy, E. M., see Baba, P. D.
- Halline, E. G., see Claus, A. J.
- Ham, J. H. and West, F., *A Touch-Tone Caller For Station Sets*, IEEE Trans, on Commun. and Electronics, 65, 17-24, Mar., 1963.
- Hamasaki, J., *A Wide-Band High-Gain Transistor Amplifier at L-Band*, In—Intern. Solid-State Circuits Conf., Digest of Tech. Papers, New York, Lewis Winner, 1963, p. 46-7.
- Hansen, W. W., see Comstock, R. L.
- Hanson, D. C., see Uenohara, M.
- Hanson, D. C., Fink, H. J. and Uenohara, M., *Varactor Diode Amplifier at Liquid Helium Temperature*, In—Intern. Solid-State Circuits Conf., Digest of Tech. Papers, New York, Lewis Winner, 1963, p. 54-5.
- Harkless, E. T., see Bangert, J. T.
- Harris, G. G., Flanagan, J. L. and Watson, B. J., *Binaural Lateralization of a Click With a Click-Pair*, J. Acoust. Soc. Am. 35, 672-8, May, 1963.
- Harvey, F. K., Cisek, J. G., Maclean, D. J. and Schroeder, M. R., *Some Subjective Aspects of Stereophony Applicable to Conference Use*, J. Audio Eng. Soc. 11, 212-17, July, 1963.
- Hatch, R. W., Bennett, S. B. and Kinzer, J. P., *Results of the Telstar System Communications Tests*, BSTJ, 42, 1561-1630, July, 1963.
- Hathaway, S. D., Sagaser, D. D. and Word, J. A., *The TL Radio Relay System*, BSTJ, 42, 2297-2354, Sept., 1963.
- Haury, P. T., see Shennum, R. H.
- Hebel, L. C. and Wolff, P. A., *Quantum Effects in the Infrared Reflectivity of Bismuth*, Phys. Rev. Letters, 11, 368-70, Oct. 15, 1963.
- Hebel, L. C., *Spin Temperature and Nuclear Relaxation in Solids*, Solid State Phys. 15, 409-91, Fall, 1963.
- Heidenreich, R. D., *On the Diffraction of Fast Electrons After Single Plasmon Loss*, J. Appl. Phys. 34, 964-6, Apr., 1963.
- Helm, G. D., see Collier, R. J.
- Hempstead, C. F., see Kim, Y. B.
- Henry, J. L., see Brooks, C. E.
- Herber, R. H., see Wertheim, G. K.
- Herrmann, D. B., see Peters, H.
- Hess, W. N., see Brown, W. L.
- Higgins, E. F., see Andus, J. V.
- Higuchi, J., *Note on the Effect of the Bond Angle in the Electron Spin-Spin Interaction—Methylene Derivatives*, J. Chem. Phys. 39, 1339-41, Sept. 1, 1963.
- Higuchi, J., *Electron Spin-Spin Interaction in Higher Molecular Spin Multiplets*, J. Chem. Phys. 39, 1847-52, Oct. 1, 1963.
- Hines, J. N., Li, T. and Turrin, R. H., *The Electrical Characteristics of the Conical Horn-Reflector Antenna*, BSTJ, 42, 1187-1212, July, 1963.
- Hittinger, W. C., *Components For the Telstar Project*, BSTJ, 42, 1659-64, July, 1963.
- Hogg, D. C. and Dragone, C., *Wide Angle Radiation Due to Rough Phase Fronts*, BSTJ, 42, 2285-96, Sept., 1963.
- Holmes, R. R., Gallagher, W. P. and Carter, R. P., *The Relative Acceptor Properties of Phosphorus-V Chlorofluorides and Antimony Pentachloride, A Calorimetric Investigation*, Inorg. Chem. 2, 437-41, June, 1963.
- Holmes, R. R. and Gallagher, W. P., *The Preparation and Fluorine-19 Nuclear Magnetic Resonance Investigation of the Phosphorus Chlorofluorides*, Inorg. Chem. 2, 433-7, June, 1963.
- Holt, V. E. and Grosh, R. J., *Free Convection Heat Transfer to Fluids Up to Near-Critical Conditions*, Nucleonics, 21, 122-5, Aug., 1963.
- Hopfield, J. J., see Thomas, D. G.
- Hopkins, H. F., see Benson, M. L.
- Hoth, D. F., O'Neill, E. F. and Welber, I., *The Telstar Satellite System*, BSTJ, 42, 765-99, July, 1963.
- Howe, J. A., see Giordmaine, J. A.
- Howe, J. A., *Observations on the Maser-Induced Graphite Jet*, J. Chem. Phys. 39, 1362-3, Sept. 1, 1963.
- Hrycak, P., *The Problem of Solidification With Newtons Cooling at the Surface*, J. Am. Inst. Chem. Engrs. 9, 585-9, Sept., 1963.
- Hrycak, P., *What Color Should a Satellite Be*, In—Satellite Communication Physics, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 48-52.
- Hrycak, P., Koontz, D. E., Maggs, C., Stafford, J. W., Unger, B. A. and Wittenberg, A. M., *The Spacecraft Structure and Design Considerations*, BSTJ, 42, 973-1006, July, 1963.
- Hutchinson, P. T., see Davis, C. G.
- Hutchinson, P. T. and Swift, R. A., *Results of Telstars Space Experiment*, BSTJ, 42, 1475-1504, July, 1963.
- Huyett, M. J., see Wilk, M. B.
- Iwama, M., Norton, J. A. and Lozier, J. C., *The Servo System For Antenna Positioning*, BSTJ, 42, 1253-82, July, 1963.
- Jaccarino, V. and Peter, M., *Ultra-High Field Superconductivity*, Phys. Rev. Letters, 9, 290-2, Oct. 1, 1962.
- Jaccodine, R. J., *Stacking Faults in Epitaxial Material*, Appl. Phys. Letters, 2, 201-2, June, 1963.
- Jakes, W. C., *Participation of the Holmdel Station in the Telstar Project*, BSTJ, 42, 1421-48, July, 1963.
- Johnson, D. A. and Robertson, G. I., *The High School Science Program*, Bell Telephone Mag. 42,

- 16-23, Summer, 1963.
- Johnson, L. F., *New Optical Maser Materials Incorporating Trivalent Rare-Earths*, In—Int. Conf. on Magnetic and Electric Resonance and Relaxation, Eindhoven, 1962, Amsterdam, North Holland Pub. Co., 1963, p. 541-7.
- Jonasson, G. C., see Delchamps, T. B.
- Jones, H. J. and Sturzenbecker, C., *High Performance Servomagnetic Amplifier*, IEEE Trans. on Commun. and Electronics, 66, 462-8, Jan., 1963.
- Julesz, B., *Conditions For Stereopsis or Binocular Rivalry of Contours*, J. Opt. Soc. Am. 53, 994-9, Aug., 1963.
- Jumper, C. F., see Grunwald, E.
- Kahng, D., *Conduction Properties of the Gold-N-Type Silicon Schottky Barrier*, Solid State Electronics, 6, 281-95, May/June, 1963.
- Kalish, H. M., *Machine-Aided Preparation of Electrical Diagrams*, Bell Labs. Record, 41, 338-45, Oct. 1963.
- Kamimura, H. and Tanabe, Y., *Antiferromagnetic Ordering Effect on the Infrared Absorption Spectrum of Cobalt Fluoride*, J. Appl. Phys. 34, 1239, Apr., 1963.
- Kane, E. O., *Perturbation-Moment Method—Application to Band Structure of Impure Semiconductors*, Phys. Rev. 131, 1553-64, Aug. 15, 1963.
- Kasuya, T., see Lecraw, R. C.
- Keith, H. D. and Padden, F. J., *A Phenomenological Theory of Spherulitic Crystallization*, J. Appl. Phys. 34, 2409-21, Aug., 1963.
- Kelly, H. P., see Githens, J. A.
- Kennedy, J. T. and Rosson, J. W., *The Use of Solar Emission for The Measurement of Radar Angle Errors (Abstract)*, In—1962 Conf. Proc. 6th Mil-E-Con, Washington, June 25-27, 1962, Washington, McGregor and Werner, 1963, p. 254.
- Kim, Y. B., Hempstead, C. F. and Strnad, A. R., *Flux Creep in Hard Superconductors*, Phys. Rev. 131, 2486-95, Sept. 15, 1963.
- Kindermann, W. J., see Dolling, J. C.
- Kinzer, J. P., see Hatch, R. W.
- Klein, D. L., see Sullivan, M. V.
- Kleinman, D. A., see Miller, R. C.
- Klemmer, E. T. and Shrimpton, N. W., *Preference Scaling Via a Modification of Shepards Proximity Analysis Method*, Human Factors, 5, 163-8, Apr., 1963.
- Kluver, J. W., *Elimination of Slip and Instability Effects in Certain M-Type Electron Beams*, Proc. IEEE, 51, 868, May, 1963.
- Knox, K., see Ferguson, J.
- Knox, K., Shulman, R. G. and Sugano, S., *Covalency Effects in Potassium Nickel (11) Fluoride*, Part-2, Optical Studies, Phys. Rev. 130, 512-6, Apr. 15, 1963.
- Kolb, G. A., see Sullivan, M. V.
- Kolding, A. R., see Upthegrove, H. N.
- Kompfner, R., see Crawford, A. B.
- Kompfner, R., see Cutler, C. C.
- Koontz, D. E., see Hrycak, P.
- Kordos, R. W., see Varnerin, L. J.
- Kroning, R. D. and Gale, D. H., *Automatic Training For Operators of the 100A TSP*, Bell Labs RECORD, 41, 314-22, Sept., 1963.
- Kuebler, N. A., see Nelson, L. S.
- Kuper, A. B., *Surface Dependence of Germanium High-Frequency, High-Gain Transistors*, Solid-State Electronics, 6, 71-94, Feb., 1963.
- Laico, J. P., see Bodmer, M. G.
- Laico, J. P., see Collier, R. J.
- Lander, J. J., Morrison, J. and Gobeli, G. W., *Structural Properties of Cleaved Silicon and Germanium Surfaces*, J. Appl. Phys. 34, 2298-2306, Aug., 1963.
- Laudise, R. A., see Ballman, A. A.
- Laudise, R. A., see Barns, R. L.
- Laudise, R. A., *Molten Salt Solvents*, In—The Art and Science of Growing Crystals, Ed. by J. J. Gilman, New York, Wiley, 1963, p. 252-73.
- Lecraw, R. C. and Kasuya, T., *Magnetoelastic Coupling Constants of Terbium and Europium Iron Garnets*, J. Appl. Phys. 34, 1293, Apr., 1963.
- Lecraw, R. C. and Kasuya, T., *Long Wavelength Collective Excitations in Ferromagnetic Insulators*, Part-1, Strong Coupling of Acoustic Modes to Spin-Wave Modes, Phys. Rev. 130, 50-7, Apr. 1, 1963.
- Leffler, J. E. and Grunwald, E., *The Rates and Equilibria of Organic Reactions*, New York, Wiley, 1963, 450P.
- Li, T., see Hines, J. N.
- Liehr, A. D., *The Coupling of Vibrational and Electronic Motions in Degenerate and Non-degenerate Electronic States of Inorganic and Organic Molecules*, Part-3, Nondegenerate Electronic States, In—Progress in Inorganic Chemistry, Ed. by F. A. Cotton, New York, Wiley, 1963, p. 385-430.
- Lockwood, W. H., see Peters, H.
- Logan, R. A., see White, H. G.
- Longton, A. C., see Bonner, A. L.
- Louisell, W. H., see Gordon, J. P.
- Lowell, R., see Cook, J. S.
- Lozier, J. C., see Githens, J. A.
- Lozier, J. C., see Iwama, M.
- Lucky, R. W., *A Functional Analysis Relating Delay Variation and Intersymbol Interference in Data Transmission*, BSTJ, 42, 2427-83, Sept., 1963.
- Lundstrom, A. A., see Githens, J. A.
- Luongo, J. P., see Peters, H.
- Luz, Z. and Meiboom, S., *Nuclear Magnetic Resonance Study of the Protolysis of Trimethylammonium Ion in Aqueous Solution—Order of the Reaction With Respect to Solvent*, J. Chem. Phys. 39, 366-70, July 15, 1963.
- Mcadoo, K. L., *Speech Volumes on Bell Systems Message Circuits*, 1960 Survey, BSTJ, 42, 1999-2012, Sept., 1963.
- McCall, D. W. and Anderson, E. W., *Proton Magnetic Relaxation in Polyamides*, Polymer 4, 93-103, Mar., 1963.
- McCune, R. J., see Smith, D. H.

## PAPERS (CONTINUED)

- McIlroy, M. D., *Transportation Problems With Distributed Loads*, In—Recent Advances in Mathematical Programming, Ed. by R. L. Graves and P. Wolfe, New York, McGraw Hill, 1963, p. 335-41.
- McLeod, B. A., see Upthegrove, H. N.
- MacChesney, J. B., Gallagher, P. K. and Dimarcello, F. V., *Stabilized Barium Titanates For Capacitor Dielectrics*, J. Am. Ceram. Soc. 46, 197-202, May, 1963.
- MacLean, D. J., see Harvey, F. K.
- Maggs, C., see Hrycak, P.
- Mallows, C. L., *A Generalization of the Chebyshev Inequalities*, Proc. London Math. Soc. 13, 385-412, July, 1963.
- Mann, H., see Chapman, R. C.
- Mann, H., see Mayo, J. S.
- Markthaler, G. E., see Brooks, C. E.
- Martens, H. H., *Torellis Theorem and A Generalization For Hyperelliptic Surfaces*, Commun. on Pure and Appl. Math. 16, 97-110, May, 1963.
- Mason, W. P., *Applications of Ultrasonics in Communications and Processing*, Electronics, 36, 33-9, Oct. 18, 1963.
- Mason, W. P. and Bateman, T. B., *Ultrasonic Attenuation and Velocity Changes in Doped N-Type Germanium and P-Type Silicon and Their use in Determining the Intrinsic Electron and Hole Scattering Times*, Phys. Rev. Letters, 10, 151, Mar. 1, 1963.
- Matthias, B. T., see Alexander, S.
- Manusell, H. I., see Davis, C. G.
- Mayo, J. S., Mann, H., Witt, F. J., Peck, D. S., Gummel, H. K. and Brown, W. L., *The Command System Malfunction of the Telstar Satellite*, BSTJ, 42, 1631-57, July, 1963.
- Medford, L. V., see Brown, W. L.
- Meiboom, S., see Grunwald, E.
- Meiboom, S., see Luz, Z.
- Meiboom, S. and O'Brien, J. P., *Level Indicator For Liquid Helium*, Rev. Sci. Instr. 34, 811, July, 1963.
- Miller, G. L., see Brown, W. L.
- Miller, R. C., Kleinman, D. A. and Savage, A., *Quantitative Studies of Optical Harmonic G Generation in Cadmium Sulfide, Barium Titanate and Potassium Dihydrogen Phosphate Type Crystals*, Phys. Rev. Letters, 11, 146-9, Aug. 15, 1963.
- Mills, G. W., *Comparing Permanent Electrical Connections*, Bell Labs. Record, 41, 366-9, Oct., 1963.
- Moose, L. F., see Bomberger, D. C.
- Morella, A., see Blumberg, W. E.
- Morrison, C. G., see Battista, R. N.
- Morrison, J., see Lander, J. J.
- Morrison, J. A., *On the Eigenfunctions Corresponding to the Bandpass Kernel*, In the Case of Degeneracy, Quart. Appl. Math. 21, 13-9, Apr., 1963.
- Murray, J. L., see Andus, J. V.
- Murray, R. W. and Trozzolo, A. M., *Photochemical Decomposition of Dichroic Diazo Compounds*, In—Intern. Symp. on Microchemical Techniques, Ed. by N. D. Cheronis, New York, Wiley, 1962, p. 233-42.
- Musa, J. D., *Discrete Smoothing Filters for Correlated Noise*, BSTJ, 42, 2121-52, Sept., 1963.
- Myers, G. H., see Evans, M. J.
- Nash, D. H., see Battista, R. N.
- Nelson, D. F., *East-Coast Conference on Aerospace and Navigational Electronics Report*, (Session on Optical Masers), Appl. Opt. 2, 449, Apr., 1963.
- Nelson, L. S. and Kuebler, N. A., *Vaporization of Tungsten Studied by Flash Heating and Kinetic Spectroscopy*, Part-1—Near Ultraviolet Region, J. Chem. Phys. 39, 1055-61, Aug. 15, 1963.
- Nelson, W. L., *Phase-Lock Loop Design for Coherent Angle-Error Detection in the Telstar Tracking System*, BSTJ, 42, 1941-76, Sept., 1963.
- Newhall, E. E., *The Use of Balanced Magnetic Circuits to Construct Digital Controllers*, In—Proc. of the Int. Conf. on Nonlinear Magnetism, Washington, 1963, New York, IEEE, 1963, p. 10-3-1-6.
- Newton, W. H., *Mechanical Development of the Touch-Tone Calling Receiver*, Bell Labs. RECORD, 41, 359-62, Oct., 1963.
- Nielsen, R. J., see Smith, K. D.
- Norton, J. A., see Iwama, M.
- O'Brien, J. P., see Meiboom, S.
- O'Connor, T. J., *A Computer-Aided Parts Data Processing System*, Bell Labs. RECORD, 41, 294-302, Sept., 1963.
- Ohm, E. A. and Snell, W. W., *A Radiometer for a Space Communication Receiver*, BSTJ, 42, 2047-80, Sept., 1963.
- Olsen, E. G., see Bodmer, M. G.
- O'Neill, E. F., see Hoth, D. F.
- Onoe, M., *Mechanical Input Admittance of Ultrasonic Delay-Lines Operating in Torsional or Shear Modes*, J. Acoust. Soc. Am. 35, 1003-8, July, 1963.
- Onoe, M. and Tiersten, H. F., *Resonant Frequencies of Finite Piezoelectric Ceramic Vibrators with High Electromechanical Coupling*, IEEE Trans. on Ultrasonic Eng. UE-10, 32-9, July, 1963.
- Ossanna, J. F., *The Collection, Digital Processing, and Spectral Analysis of Mobile Radio-Fading Signals, and a Theoretical Model for Fading Due to Building Reflections*, (Abstract), IEEE Intern. Conv. Record, 11, pt. 8, 3, 1963.
- Padden, F. J., see Keith, H. D.
- Pardee, S., see Giger, A. J.
- Patel, C. K. N., *Determination of Atomic Temperature and Doppler Broadening in a Gaseous Discharge with Population Inversion*, Phys. Rev. 131, 1582, Aug. 15, 1963.
- Patel, J. R. and Batterman, B. W., *Impurity Clustering Effects on the Anomalous Transmission of X-Rays in Silicon*, J. Appl. Phys. 34, 2716-22, Sept., 1963.
- Paterson, E. G. D., *Assuring Quality*, Intern. Sci. and Tech. 1, 33-9, Sept., 1963.
- Paul, B., West, J. W. and Yu, E. Y., *A Passive Gravitational Attitude Control System for Satellites*, BSTJ, 42, 2195-2238, Sept., 1963.

- Peck, D. S., see Mayo, J. S.
- Peck, D. S. and Wooley, M. C., *Component Design, Construction and Evaluation for Satellites*, BSTJ, 42, 1665-86, July, 1963.
- Peter, M., see Jaccarino, V.
- Peters, H., Herrmann D. B., Lockwood, W. H. and Luongo, J. P., *Comparison of Natural and Synthetic Natural Hard Rubbers*, In—4th Rubber Tech. Conf., Ed. by T. H. Messenger, London, Instn. Rubber Ind. 1963, p. 560-74.
- Peters, T. R., see Githens, J. A.
- Pfahnl, A., *Properties of Zinc Oxide Phosphors Doped with Lithium, Nickel and Copper*, J. Electrochem. Soc. 110, 301-4, May, 1963.
- Pierce, J. R., *Satellite Science and Technology*, Bell Telephone Mag. 42, 38-50, Summer, 1963.
- Pierce, J. R., *World-Wide Satellite Communication*, Astronaut. and Aerospace Eng. 1, 23-5, Sept., 1963.
- Pierce, J. R., Forward to Book—*Satellite Communication Physics*, In—Satellite Communication Physics, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 5.
- Pierce, J. R., *The Paper Dragon—A Tale of the Times*, Phys. Today 16, 45, Aug., 1963.
- Pierce, J. R., *Systems Research and Management*, In—Science, Technology and Management, Ed. by F. Kast, New York, McGraw-Hill, 1963, p. 70-6.
- Pierce, J. R., *Telstar and TV*, TV Guide, Jan. 19, 1963.
- Pinkham, R. S. and Wilk, M. B., *Tail Areas of the T-Distribution from a Mills-Ratio-Like Expansion*, Ann. Math. Stat. 34, 335-7, Mar., 1963.
- Pompliano, L. A., see Sullivan, M. V.
- Poole, J. F., *The New Numbering Plan in Panel Switching Offices*, Bell Labs. RECORD, 41, 323-7, Sept., 1963.
- Porto, S. P. S. and Wood, D. L., *Ruby Optical Maser as a Raman Source*, In—Developments in Applied Spectroscopy, Ed. by J. R. Ferraro and J. S. Fromek, New York, Plenum, 1963, p. 38-42.
- Ragains, W. G., *An Investigation of the Effects of Pulse Shape and Its Duration on the Mechanical Shock of a Single-Degree System*, MS Thesis, North Carolina State College, 1963.
- Read, W. T., *Tactical Nuclear War*, World Politics, 15, 390-402, Apr., 1963.
- Reid E. J., see Shennum, R. H.
- Reid, E. J., *How Can We Repair an Orbiting Satellite*, In—Satellite Communication Physics, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 78-85.
- Remeika, J. P., see Dillon, J. F.
- Rice, S. O., see Bennett, W. R.
- Rice, S. O., *Innage and Outage Intervals in Transmission Systems Composed of Links*, BSTJ, 42, 2267-84, Sept., 1963.
- Ridgway, W. C., see Claus, A. J.
- Robertson, G. I., see Johnson, D. A.
- Robillard, T. R., *The Pinhead Diode*, Bell Labs. RECORD, 41, 303-6, Sept., 1963.
- Robin, M. B., see Ginsberg, A. P.
- Rongved, L., see Fletcher, H. J.
- Rosenberg, S., *Behavior in a Continuous-Response Task with Noncontingent Reinforcement*, J. Exptl. Psych. 66, 168-76, Aug., 1963.
- Rosenzweig, W., see Brown, W. L.
- Rosenzweig, W., see Salovey, R.
- Rosenzweig, W., see Smith, K. D.
- Ross, A. T., see Bodmer, M. G.
- Rosson, J. W., see Kennedy, J. T.
- Rowell, J. M., *Magnetic Field Dependence of the Josephson Tunnel Current*, Phys. Rev. Letters, 11, 200-2, Sept. 1, 1963.
- Rowell, J. M., Anderson, P. W. and Thomas, D. E., *Image of the Phonon Spectrum in the Tunneling Characteristic Between Superconductors*, Phys. Rev. Letters, 10, 334-6, Apr. 15, 1963.
- Rupp, L. W., see Walsh, W. M.
- Sagaser, D. D., see Hathaway, S. D.
- Sageman, R. E., see Smith, D. H.
- Salovey, R. and Rosenzweig, W., *Radiation Dosimetry in Polyethylene with Silicon Solar Cells*, J. Poly. Sci. 1A, 2145-54, June, 1963.
- Salovey, R. and Dammont, F. R., *Irradiation of Polyethylene Oxide and Polypropylene*, J. Poly. Sci. 1A, 2155-62, June, 1963.
- Salovey, R., Shulman, R. G. and Walsh, W. M., *Electron Spin Resonance of Irradiated DNA*, J. Chem. Phys. 39, 839-40, Aug. 1, 1963.
- Salz, J., see Bennett, W. R.
- Sand, W. C., see Brooks, C. E.
- Sandberg, I. W., *On the Properties of Some Systems That Distort Signals—1*, BSTJ, 42, 2033-46, Sept., 1963.
- Savage, A., see Miller, R. C.
- Scattaglia, J. V., see Byrne, C. J.
- Schaefer, F. J., see Andus, J. V.
- Schmader, T. A., *Testing the Touch-Tone Telephone Set*, Bell Labs. RECORD, 41, 354-8, Oct. 1963.
- Schneider, H. A., *An Approach to Multichannel Access for the 150 and 450MC Mobile Bands*, IEEE Trans. on Vehicular Commun. 12, 22-7, Sept., 1963.
- Scheinberg, I. H., see Blumberg, W. E.
- Schnettler, F. J., see Baba, P. D.
- Schonhorn, H., *Thermal and Solvent Desorption of Radiolabeled Stearic Acid Monolayers from Aluminum*, J. Colloid Sci. 18, 445-52, June, 1963.
- Schonhorn, H., *Generalized Approach to Adhesion via the Interfacial Deposition of Amphipathic Molecules*, Part-1, Adhesion of Polyethylene to Aluminum, J. Poly. Sci. 1A, 2343-59, July, 1963.
- Schrey, F., see Gallagher, P. K.
- Schroeder, M. R., see Harvey, F. K.
- Schroeder, M. R. and Atal, B. S., *Computer Simulation of Sound Transmission in Rooms*, IEEE Intern. Conv. Record, 11, pt. 7, 150-5, 1963.
- Schutz, C. J., see Gagne, D. J.
- Sessler, G. M., *Electrostatic Mi-*

## PAPERS (CONTINUED)

- crophones With Electret Foil, *J. Acoust., Soc. Am.* 35, 1354-7, Sept., 1963.
- Shaltiel, D., *Effect of Hydrogenation on the Paramagnetic Resonance on Gadolinium in Lead and Lead Rich Alloys*, *J. Appl. Phys.* 34, 1190, Apr., 1963.
- Shennum, R. H. and Haury, P. T., *A General Description of the Telstar Spacecraft*, *BSTJ*, 42, 801-30, July, 1963.
- Shennum, R. H. and Reid, E. J., *The Design and Construction of the Electronics Package*, *BSTJ*, 42, 1749-64, July, 1963.
- Shepard, R. N., *Comments on Professor Underwoods Paper—"Stimulus Selection in Verbal Learning"*, In—*Verbal Behaviour and Learning—Problems and Processes*, Ed. by C. N. Cofer, New York, McGraw-Hill, 1963, p. 48-70.
- Shepard, R. N., *Analysis of Proximities as a Technique For the Study of Information Processing in Man*, *Human Factors*, 5, 33-48, Feb., 1963.
- Shepard, R. N. and Chang, J. J., *Forced-Choice Tests of Recognition Memory Under Steady-State Conditions*, *J. Verbal Learning and Verbal Behaviour*, 2, 93-101, July, 1963.
- Sherwood, R. C., see White, J. A.
- Shields, R. M., see Barns, R. L.
- Shrimpton, N. W., see Klemmer, E. T.
- Shulman, R. G., see Alexander, S.
- Shulman, R. G., see Eisinger, J.
- Shulman, R. G., see Knox, K.
- Shulman, R. G., see Salovey, R.
- Shulman, R. G., see Sugano, S.
- Shulman, R. G. and Sugano, S., *Covalency Effects in Potassium Nickel (11) Fluoride*, Part-1, *NMR Studies*, *Phys. Rev.* 130, 517-30, Apr. 15, 1963.
- Sibilia, J. T., see Tabor, W. J.
- Smith, D. H., Carlson, C. P., McCune, R. J., Elicher, R. E. and Sageman, R. E., *Planning, Operation, and External Communications of the Andover, Earth Station*, *BSTJ*, 42, 1383-1420, July, 1963.
- Smith, J. L., *The Waffle Iron—A New Memory Structure*, *J. Appl. Phys.* 34, 1167-8, Apr., 1963.
- Smith, K. D., *How do we Keep Solar Cell Power Plants Working in Space*, In—*Satellite Communication Physics*, Ed. by R. M. Foster, New York, Bell Telephone Laboratories, 1963, p. 62-9.
- Smith, K. D., Gummel, H. K., Bode, J. D., Cuttriss, D. B., Nielsen, R. J. and Rosenzweig, W., *The Solar Cells and Their Mounting*, *BSTJ*, 42, 1765-1817, July, 1963.
- Smith, W. L., see Sykes, R. A.
- Smits, F. M., see Brown, W. L.
- Snell, W. W., see Ohm, E. A.
- Snow, N. E., see Baldwin, G. L.
- Snow, W. B., see Spencer, E. G.
- Sodomsky, K. F., *Microwave Measurements of Moving Striations in a DC Glow Discharge*, *J. Appl. Phys.* 34, 1860, July, 1963.
- Speeth, S. D., *Sound Detection Techniques*, *Intern. Sci. and Tech.* 2, 20, Aug., 1963.
- Spencer, E. G., see Denton, R. T.
- Spencer, E. G., Denton, R. T., Snow, W. B. and Bateman, T. B., *Microwave Elastic Properties of Nonmagnetic Garnets*, *J. Appl. Phys.* 34, 3059-69, Oct., 1963.
- Spencer W. J., see Sykes, R. A.
- Sperry, R. V., see Bangert, J. T.
- Stafford, J. W., see Hrycak, P.
- Stillinger, F. H., see Frisch, H. L.
- Stillwell, A. L., see Uenohara, M.
- Stilwell, G. R. and Dove, D. B., *Surface Lines on Soda-Lime Glass Slides*, *J. Appl. Phys.* 34, 1941, July, 1963.
- Stockbridge, C. D., see Warner, A. W.
- Storm, A. R. and Benson, K. E., *Lanthanide-Copper Intermetallic Compounds Having the Cerium Copper-2 and Aluminum Borite Structures*, *Acta Cryst.* 16, 701-2, July, 1963.
- Striny, K. M., see Collier, R. J.
- Strnad, A. R., see Kim, Y. B.
- Sturge, M. D., *Strain—Induced Splitting of the R Lines of Vanadium (11) in Magnesium Oxide*, *Phys. Rev.* 131, 1456-8, Aug. 15, 1963.
- Sturzenbecker C., see Jones, H. J.
- Sugano, S., see Knox, K.
- Sugano, S., see Shulman, R. G.
- Sugano, S. and Shulman, R. G., *Covalency Effects in Potassium Nickel (11) Fluoride*, Part-3, *Theoretical Studies*, *Phys. Rev.* 130, 506-11, Apr. 15, 1963.
- Sullivan, M. V., Klein, D. L., Finne, R. M., Pompliano, L. A. and Kolb, G. A., *An Electro-polishing Technique for Germanium and Silicon*, *J. Electrochem. Soc.* 110, 412-19, May, 1963.
- Suurballe, J. W., *Network Algorithms for Combinatorial and Discrete Variable Optimization Problems*, In—*Recent Advances in Mathematical Programming*, Ed. by R. L. Graves and P. Wolfe, New York, McGraw-Hill, 1963, p. 343-4.
- Swift, R. A., see Delchamps, T. B.
- Swift, R. A., see Hutchison, P. T.
- Sykes, R. A., Smith, W. L. and Spencer, W. J., *Studies on High - Precision Resonators*, *Frequency*, 1, 18-22, Sept.-Oct., 1963.
- Tabor, W. J. and Sibilia, J. T., *Masers For The Telstar Satellite Communications Experiment*, *BSTJ*, 42, 1863-86, July, 1963.
- Tanabe, Y., see Kamimura, H.
- Thomas, D. E., see Rowell, J. M.
- Thomas, D. E., *Esaki Diode Junction Capacitance Measurement*, *IEEE Trans. on Electron Devices*, ED-10, 278, July, 1963.
- Thomas, D. G., Gershenzan, M. and Hopfield, J. J., *Bound Excitons in Gallium Phosphide*, *Phys. Rev.* 131, 2397-2404, Sept. 15, 1963.
- Thomas, E. W., see Brown, W. L.
- Tiersten, H. F., see Onoe, M.
- Tillotson, L. C., see Crawford, A. B.
- Tillotson, L. C., see Cutler, C. C.
- Timko, J. W., see Evans, M. J.
- Tinkham, M., see Barker, A. S.
- Trozzolo, A. M., see Murray, R. W.
- Trucksess, D. E., see Bomberger, D. C.
- Turner, W. O., *Traffic Simulation*,

## PAPERS (CONTINUED)

- Bell Labs RECORD, 41, 346-51, Oct., 1963.
- Turrin, R. H., see Hines, J. N.
- Uenohara, M., see Hanson, D. C.
- Uenohara, M., *Parametric Amplifier*, In — 1963 McGraw-Hill Year Book of Sci. and Tech. New York, McGraw-Hill, 1963, p. 418-20.
- Uenohara, M., Chroney, M., Eisele, K. M., Hanson, D. C. and Stillwell, A. L., *4GC Parametric Amplifier for Satellite Communication Ground Station Receiver*, BSTJ, 42, 1887-1908, July, 1963.
- Unger, B. A., see Hrycak, P.
- Upthegrove, H. N., Dalbora, J. B., Kolding, A. R. and McLeod, B. A., *Launching of the Telstar Satellite*, BSTJ, 42, 1449-74, July, 1963.
- Ussery, P. W., see Bomberger, D. C.
- Van Allen, J. A., see Brown, W. L.
- Van Uitert, L. G., see Grodkiewicz, W. H.
- Varnerin, L. J., Comstock, R. L., Dean, W. A. and Kordos, R. W., *The Satellite Ferromagnetic Power Limiter*, BSTJ, 42, 1817, 27, July, 1963.
- Wadsworth, D. V., *Vinti Solution for Free-Flight Rocket Trajectories*, AIAA J. 1, 1351-4, June, 1963.
- Walker, L. R., see Gordon, J. P.
- Walrafen, G. E., *Raman Spectral Studies of Aqueous Solutions of Selenic Acid*, J. Chem. Phys. 39, 1479-92, Sept. 15, 1963.
- Walsh, E. J., see Bangert, J. T.
- Walsh, W. M., see Salovey, R.
- Walsh, W. M., Rupp, L. W. and Wyluda B. J., *Paramagnetic Resonance Studies of Magnetic Ions Bound in Nucleic Acid Pseudocrystals*, In — Paramagnetic Resonance, Proc. of the 1st Int. Conf. Held in Jerusalem, July 16-20, 1962, Ed. by W. Low, New York, Academic Press, 1963, p. 836-54.
- Walsh, W. M. and Fawcett, E., *Cyclotron Resonance in Tungsten*, In—Int. Conf. on Magnetic and Electric Resonance and Relaxation, Eindhoven, 1962, Amsterdam, North Holland Pub. Co. 1963, p. 514-20.
- Warner, A. W. and Stockbridge, C. D., *Mass Measurements With Resonating Crystalline Quartz*, In — Vacuum Microbalance Techniques, Ed. by K. H. Behrndt, New York, Plenum, 1963, p. 55-73.
- Watson, B. J., see Harris, G. G.
- Welber, I., see Hoth, D. F.
- Wernick, J. H., see White, J. A.
- Wertheim, G. K. and Herber, R. H., *Iron-57 Mossbauer Effect in Ferrocene Derivatives*, J. Chem. Phys. 38, 2106-11, May 1, 1963.
- West, F., see Ham, J. H.
- West, J. W., see Paul, B.
- Westerman, H. R., *On Satellite Orbit Lifetimes*, Astron. J. 68, 385-8, Aug., 1963.
- Westerman, H. R., *Secular Effects of Atmospheric Drag on Satellite Orbits*, Astron. J. 68, 382-4, Aug., 1963.
- Westover, R. F., *A New Approach to the Extrusion of Plastics*, Modern Plastics, 40, 130-4, Mar., 1963.
- White, H. G. and Logan, R. A., *Gallium Phosphide Surface Barrier Diodes*, J. Appl. Phys. 34, 1990-7, July, 1963.
- White, J. A. and Clogston, A. M., *Temperature Dependence of Localized Moments in Metals*, J. Appl. Phys. 34, 1187-8, Apr., 1963.
- White, J. A., Williams, H. J., Wernick, J. H. and Sherwood, R. C., *Observation of a Possible Large Crystalline Stark Splitting in Metallic Cerium-Lanthanum Aluminum*, Phys. Rev. 131, 1039-42, Aug. 1, 1963.
- Wickliffe, P. R., see Giger, A. J.
- Wilk, M. B., see Pinkham, R. S.
- Wilk, M. B., Gnanadesikan, R. and Huyett, M. J., *Aids For The Separate Maximum Likelihood Estimation of Scale or Shape Parameters of the Gamma Distribution Using Order Statistics*, Biometrika, 50, 217-21, June, 1963.
- Wilkinson D. H., see Alburger, D. E.
- Williams H. J., see White, J. A.
- Witt, F. J., see Davis, C. G.
- Witt, F. J., see Mayo, J. S.
- Wittenberg, A. M., see Hrycak, P.
- Wolff, P. A., see Hebel, L. C.
- Wolfstirn, K. B., see Fuller, C. S.
- Wood, C. B., *Two Years With Telstar*, Monmouth College Bull., 109, 4-5, May, 1963.
- Wood, D. L., see Ferguson, J.
- Wood, D. L., see Porto, S. P. S.
- Wood, D. L., *Energy Levels of Ytterbium(111) in Garnets*, J. Chem. Phys. 39, 1671-3, Oct. 1, 1963.
- Woodard, K. B., see Dolling, J. C.
- Wooley, M. C., see Peck, D. S.
- Word, J. A., see Hathaway, S. D.
- Wyluda, B. J., see Alexander, S.
- Wyluda, B. J., see Walsh, W. M.
- Yafet, Y., *G Factors and Spin-Lattice Relaxation of Conduction Electrons*, In — Paramagnetic Resonance, Proc. of the 1st Int. Conf. Held in Jerusalem, July 16-20, 1962, Ed. by W. Low, New York, Academic Press, 1963, p. 739.
- Yu, E. Y., see Fletcher, H. J.
- Yu, E. Y., see Paul, B.
- Yu, E. Y., *Spin Decay, Spin Precession Damping, and Spin Axis Drift of the Telstar Satellite*, BSTJ, 42, 2169-94, Sept., 1963.

## AUTHORS

*R. H. Van Horn* joined the Laboratories in 1937 after obtaining his B.S.E.E. degree from Pennsylvania State University. He received his M.A. in physics from Columbia University in 1947 through the Laboratories part-time graduate study program.

Prior to World War II, Mr. Van Horn participated in the development of apparatus for step-by-step, panel, and crossbar switching systems. During World War II he engaged in the development of underwater hydrophones and sound projectors for a variety of sonar systems. Returning to Bell System developments after the war, he participated in the development of vibrating-reed selectors, and in 1948 was appointed supervisor of a group doing performance studies on the card translators, automatic trouble recorder, crossbar and step-by-step apparatus, and solderless wrapped connections.

In 1957 he was transferred to systems engineering where he was responsible for station arrangements used on private line and TWX telegraph systems.

Since May 1, 1959, he has been Head of the Common Systems Apparatus Department.

Mr. Van Horn lives in Montclair, New Jersey. He is vice-president of the Adult School of Montclair and has served on its curriculum committee for several years. He is a senior member of

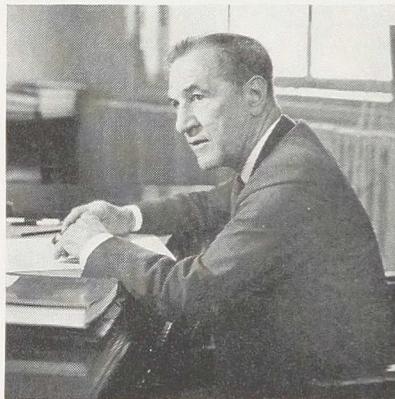


R. H. Van Horn

IEEE and a member of the Montclair Society of Engineers.

*E. G. D. Paterson* received his B. S. degree from Massachusetts Institute of Technology in 1919 and joined the Laboratories in 1920. He graduated from New York University with a M. B. A. degree in 1927 and has taken further graduate courses in mathematics and physical science.

At the Laboratories he has served successively as Specifications Engineer; Apparatus Design Engineer; Power, Outside Plant, and Systems Quality Engineer; Assistant Director and Director of Quality Assurance.



E. G. D. Paterson

Mr. Paterson is a Life Member of the American Institute of Electrical Engineers (now I.E.E.E.), a Fellow of the American Society for Quality Control, and a member of the M. I. T. Clubs of Westchester and New York. He is the author of numerous technical papers—here and abroad—on Quality Control and Reliability and received the Brumbaugh Award, A.S.Q.C., in 1961.

He is currently a member and past chairman of the Board of Trustees, Union Congregational Church of Tuckahoe, N. Y. and has been a Trustee (President for two years) of the Board of Education, District #1, Town of Eastchester for 21 years.



R. M. Averill

*R. M. Averill, Jr.*, co-author of "No. 101 ESS: The Time-Division Switch Unit" in this issue, received the B.S. degree in Engineering Science from Pennsylvania State University in 1959. He joined the Laboratories immediately after graduation and was assigned to work on the Nike-Zeus project. He graduated from the Communications Development Training program and received the degree of M.E.E. from New York University in 1961.

In 1960, Mr. Averill was transferred to the Electronic Switching Division and since then has worked on the No. 101 ESS. His primary concern has been circuit design for the system switch unit which is described in his article.

Mr. Averill is a member of Tau Beta Pi, Pi Mu Epsilon, and the IEEE. A native of Concord, New Hampshire, he now lives with his family in Little Silver, N. J.



R. C. Stone