Abstracts of Bell System Technical Papers* Not Published in this Journal

Principles and Applications of Converters for High-Frequency Measurements. D. A. ALSBERG[1]. *I.R.E., Proc.*, **40,** pp. 1195–1203, Oct., 1952. (Monograph 2030).

The heterodyne method permits measurements over wide frequency bands with the standards operating at a fixed frequency. The accuracy of such measurements depends upon the performance of heterodyne conversion transducers or converters. Design principles are derived to maximize linearity and dynamic range and minimize zero corrections. These principles have been applied to point-to-point and sweep measurements of delay, phase, transmission, and impedance.

Ferroelectric Storage Elements for Digital Computers and Switching Systems. J. R. ANDERSON[1]. *Elec. Engg.*, **71,** pp. 916–922, Oct., 1952. (Monograph 2014).

These ferroelectric storage devices, although still comparatively new, show great promise. They can store up to 2,500 bits of information per square inch in a surface only a few thousandths of an inch thick with pulses less than a microsecond long.

Transistors in Switching Circuits. A. E. ANDERSON[1]. *I.R.E., Proc.*, **40,** pp. 1541–1558, Nov., 1952. Corrections to Figs. 17, 18 and 19 giving synopses published in December issue, pp. 1732 and 1733.

The general transistor properties of small size and weight, low power and voltage, and potential long life suggest extensive application of transistors to pulse- or switching-type systems of computer or computer-like nature.

It is possible to devise simple regenerative circuits which perform the normally employed functions of waveform generation, level restoration, delay, storage (registry or memory), and counting. The discussion is limited to point-contact type transistors in which the alpha or current gain is in excess of unity and to a particular feedback configuration.

Such circuits, which are of the so-called trigger type, are postulated to involve negative resistance. On this basis an analysis, which approximates the negative-resistance characteristic by three intersecting broken lines, is developed. Con-

* Certain of these papers are available as Bell System Monographs and may be obtained on request to the Publication Department, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y. For papers available in this form, the monograph number is given in parentheses following the date of publication, and this number should be given in all requests.

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clusions which are useful to circuit and device design are reached. The analysis is deemed sufficiently accurate for first-order equilibrium calculations.

Transistors having properties specifically intended for pulse service in the circuits described have been developed. Their properties, limitations, and parameter characterizations are discussed at some length.

Mobility of Electrons in Germanium. P. P. DEBYE[1] and ESTHER M. CONWELL[1]. Letter to the Editor. *Phys. Rev.*, **87,** pp. 1131–1132, Sept. 15, 1952.

The Telephone Industry in National Defense. C. A. ARMSTRONG[2]. *Telephony*, **143,** pp. 44–46, 114, Oct. 25, 1952.

Infrared Absorption in High Purity Germanium. H. B. BRIGGS[1]. Letter to the Editor. *Jl. Opt. Soc. Am.*, **42,** pp. 686–687, Sept., 1952.

New Infrared Absorption Bands in p-Type Germanium. H. B. BRIGGS[1] and R. C. FLETCHER[1]. Letter to the Editor. *Phys. Rev.*, **87,** pp. 1130–1131, Sept. 15, 1952.

Automatic Switching for Nation-Wide Telephone Service. A. B. CLARK[1] and H. S. OSBORNE[2]. *A.I.E.E., Trans. Commun. and Electronics Sect.*, **2,** pp. 245–248, Sept., 1952. (Monograph 2015).

Western Electric's Service with Standards. K. B. CLARKE[3]. *Standardization*, **23,** pp. 332–338, Oct., 1952.

Properties of Silicon and Germanium. ESTHER M. CONWELL[1]. *I.R.E., Proc.*, **40,** pp. 1327–1337, Nov., 1952.

This article provides the latest experimental information on those fundamental properties of germanium and silicon which are of device interest, currently or potentially. Electrical properties, especially carrier density and mobility, have been treated in greatest detail. Descriptive material has been provided to the extent necessary to give physical background.

Effects of Space-Charge Layer Widening in Junction Transistors. J. M. EARLY[1]. *I.R.E., Proc.*, **40,** pp. 1401–1406, Nov., 1952.

Some effects of the dependence of collector barrier (space-charge layer) thickness on collector voltage are analyzed. Transistor base thickness is shown to decrease as collector voltage is increased, resulting in an increase of the current-gain factor (α) and a decrease in the emitter potential required to maintain any

[1] Bell Telephone Laboratories.
[2] American Telephone and Telegraph Company.
[3] Western Electric Company.

fixed emitter current. These effects are shown to lead to two new elements in the theoretical small-signal equivalent circuit. One, the collector conductance (g_c'), is proportional to emitter current and varies inversely with collector voltage. This term is the dominant component of collector conductance in high-quality junction transistors. The other element, the voltage feedback factor (μ_{ec}), is independent of emitter current, but varies inversely with collector voltage. The latter element is shown to modify the elements of the conventional equivalent tee network.

Four-Terminal p-n-p-n *Transistors*. J. J. EBERS[1]. *I.R.E., Proc.*, **40,** pp. 1361–1364, Nov., 1952.

The equivalent circuit of a *p-n-p-n* transistor is obtained. It is demonstrated that a *p-n-p* transistor and an *n-p-n* transistor can be connected so that the combination has the same equivalent circuit as the *p-n-p-n* structure. A simplified circuit is obtained which can be used when the *p-n-p-n* transistor is connected as a hook-collector transistor. A method of adjusting the current gain of *p-n-p-n* transistors by external means is given as well as experimental results.

Dynamics of Transistor Negative-Resistance Circuits. B. G. FARLEY[1]. *I.R.E., Proc.*, **40,** pp. 1497–1508, Nov., 1952.

A general method is presented for calculating approximately the behavior of many nonlinear circuits by dividing the region of operation into subregions, within each of which the circuit may be considered linear to a good approximation. The method is applied to a high-speed transistor switching circuit as an illustrative example.

Regenerative Amplifier for Digital Computer Applications. J. H. FELKER[1]. *I.R.E., Proc.*, **40,** pp. 1584–1596, Nov., 1952.

A description of the negative-resistance properties of the point-contact transistor is presented as an introduction to the description of a regenerative amplifier. The choice of circuit parameters for the amplifier is discussed and a sample design presented. The illustrative amplifier regenerates digital information at a megacycle rate and develops pulses with rise times of less than 0.05 μsec. It operates from supply voltages of +6 and −8 volts, with a battery drain of less than 0.05 watt. A complete set of computer building blocks has been designed around the amplifier. Their use is illustrated in two computer applications.

Evidence for Domain Structure in Anti-ferromagnetic CoO From Elasticity Measurements. M. E. FINE[1]. Letter to the Editor. *Phys. Rev.*, **87,** p. 1143, Sept. 15, 1952.

Optical Position Encoder and Digit Register. H. G. FOLLINGSTAD[1], J. N. SHIVE[1] and R. E. YAEGER[1]. *I.R.E., Proc.*, **40,** pp. 1573–1583, Nov., 1952.

The usefulness of transistors in systems has been given a feasibility proof through the construction and operation of a six-digit position encoder and serial-

[1] Bell Telephone Laboratories.

output digit register. This system performs the functions of photoelectric encoding, pulse regeneration, digit storage, reflected-to-natural binary translation, and digit shifting by means of circuits using transistors and other semi-conductor devices. The model occupies a volume of about ¼ cubic foot, weighs seven pounds, and consumes 16 watts of power.

Comparison of Recording Processes. J. G. FRAYNE[4], *I.R.E., Trans.*, PGA-7, pp. 5–8, May, 1952. *S.M.P.T.E., Jl.*, **59,** pp. 313–318, Oct., 1952.

The three common forms of sound recording may be classed as mechanical (disk), photographic and magnetic. All three methods are in common use today and each is employed in a field for which it appears to be peculiarly fitted. The purpose of this article is to examine briefly the factors which determine the fidelity of each method. By fidelity we mean how true the tonal range can be reproduced, the amount and nature of harmonic distortion present, the signal-to-noise ratio possible with each method, and the amount of wow or flutter that may be expected under average conditions of reproduction for each recording process.

Transistor Shift Register and Serial Adder. J. R. HARRIS[1]. *I.R.E., Proc.*, **40,** pp. 1597–1602, Nov., 1952.

A small set of basic functions, such as binary memory and elementary binary logic, can be remarkably versatile; such functions are important in switching and computing. This paper describes a piece of computing equipment which can store a pair of binary numbers and add them, producing the sum a digit at a time. The equipment is built from a basic set of functional blocks, all of which are designed around transistors. This set of building blocks consists of a binary cell, a pulse amplifier, a pulse amplifier with delay, and logic circuits. The binary cell is a flip-flop; amplifiers are monostable circuits, and logic is performed in diode gates. Some interesting special features arise from the use of transistors. These features are discussed and the designs are evaluated.

Charge Transfer and the Mobility of Rare Gas Ions. J. A. HORNBECK[1]. *Jl. Phys. Chem.*, **56,** pp. 829–831, Oct., 1952.

Ion-atom collisions in the rare gases between an atomic ion and a parent gas atom, such as Ne^+ and Ne, involve quantum mechanical symmetry effects which though rigorously inseparable have been listed as (a) a force of resonance attraction, (b) a force of resonance repulsion, and (c) charge exchange. Drift velocity measurements at high fields show that this complicated interaction may be represented to a good approximation by the hard sphere model of kinetic theory in which the collision cross section is several times the viscosity cross section of the atoms themselves.

Broad Band Matching with a Directional Coupler. W. C. JAKES[1]. *I.R.E., Proc.*, **40,** pp. 1216–1218, Oct., 1952. (Monograph 2033).

[1] Bell Telephone Laboratories.
[4] Westrex Corporation.

This paper presents the results of a theoretical and experimental study of a waveguide matching technique which allows a directional coupler to be located any distance away from the discontinuity causing the original mismatch and a broad-band match to still be obtained.

Design curves are included which give the required coupling coefficient of the directional coupler and the power loss for a given initial mismatch and desired vswr reduction. Experimental confirmation of the theory is also presented.

New General-Purpose Relay for Telephone Switching Systems. A. C. KELLER[1]. *Elec. Engg.*, **71,** pp. 1007–1012, Nov., 1952. Monograph 2034).

This new general-purpose electromagnetic relay, called the AF type is a wire spring relay. With variations providing slow release or marginal characteristics, it is known as the AG and AJ relay, respectively. It provides improved performance at lower cost.

Spherical Model of a Ferromagnet. H. W. LEWIS[1] and G. H. WANNIER[1]. Letter to the Editor. *Phys. Rev.*, **88,** pp. 682–683, Nov. 1, 1952.

In order to interpret the properties of the tetragonal crystal $ND_4D_2PO_4$ (deuterated ADP) a thermo-dynamic treatment has been developed which relates the observed crystal structure change and the dielectric constant change at the transition temperature to the appearance of spontaneous polarization. For an antiferroelectric crystal, the average spontaneous polarization is zero, being oppositely directed for adjacent layers, but the square of the spontaneous polarization is large. This results in quadratic strain components which cause a change in the crystal structure below the transition temperature. It is shown that the change observed is consistent with an antiferroelectric arrangement with one of the α axes being the antiferroelectric axis. The dielectric constants in all three directions suffer a large drop below the transition temperature.

Piezoelectric, Dielectric, and Elastic Properties of $ND_4D_2PO_4$ (Deuterated ADP). W. P. MASON[1] and B. T. MATTHIAS[1]. *Phys. Rev.*, **88,** pp. 477–479, Nov. 1, 1952. (Monograph 2036).

Transistors in Our Civilian Economy. J. W. MCRAE[1]. *I.R.E., Proc.*, **40,** pp. 1285–1286, Nov., 1952.

I. R. E. Editor's Note: At relatively long intervals there appear on the technical and industrial horizons devices of such broad scope and major significance that they profoundly affect the fields of their use. One of these epochal developments is the transistor, which bids fair to take its place beside the electron tube as one of the foundation stones of future communications and electronics.

It is accordingly timely and suitable that certain of the probable future industrial uses and effects of the transistor should be here analyzed in a guest editorial by an engineer especially qualified for this task, and who is a Fellow and Director of the Institute, and a Vice President of Bell Telephone Laboratories.

[1] Bell Telephone Laboratories.

Domain Properties in $BaTiO_3$. W. J. MERZ[1]. Letter to the Editor. *Phys. Rev.*, **88,** pp. 421–422, Oct. 15, 1952.

Notes on Methods of Transmitting the Circular Electric Wave Around Bends. E. S. MILLER[1]. *I.R.E., Proc.*, **40,** pp. 1104–1113, Sept., 1952. (Monograph 2037).

The tendency for energy to be converted out of the circular electric wave in bent round pipe may be avoided by one of three general approaches: (1) by removing the degeneracy between TE_{01} and TM_{11}, (2) by converting to a normal mode of the bent guide at both ends of the bend, and (3) by utilizing dissipation in the unwanted modes to prevent power transfer to them. All three approaches are discussed. Normal attenuation in round pipe should be effective in moderating straightness requirements. Elliptical guide and special waveguide structures may be used to negotiate intentional bends; bending radii in the range one to 1,000 feet appear acceptable at 50,000 mc for waveguides $\frac{3}{8}$-inch to 2 inches in diameter, respectively.

Multi-Element Directional Couplers. S. E. MILLER[1] and W. W. MUMFORD[1]. *I.R.E., Proc.*, **40,** pp. 1071–1078, Sept., 1952. (Monograph 2038).

It is shown that the backward wave in a directional coupler is related to the shape of the function describing the coupling between transmission lines by the Fourier transform. This facilitates the design of directional couplers for arbitrary directivities over any prescribed frequency band. Tightly coupled directional couplers are analyzed in simple terms, and it is shown that any desired loss ratio, including complete power transfer between lines, may be achieved. The theories are verified using waveguide models operating at 4,000, 24,000 and 48,000 mc, and it is indicated that the work is applicable to many types of electrical and acoustic transmission lines.

Transistor Noise in Circuit Applications. H. C. MONTGOMERY[1]. *I.R.E., Proc.*, **40,** pp. 1461–1471, Nov., 1952.

Linear circuit problems involving multiple noise sources can be handled by familiar methods with the aid of certain noise spectrum functions, which are described. Several theorems of general interest dealing with noise spectra and noise correlation are derived. The noise behavior of transistors can be described by giving the spectrum functions for simple but arbitrary configurations of equivalent noise generators. From these, the noise figure can be calculated for any desired external circuit.

Transistor Noise in Circuit Applications. H. C. MONTGOMERY[1]. *I.R.E., Proc.*, **40,** pp. 1314–1326, Nov., 1952.

The invention of the transistor provided a simple, apparently rugged device that could amplify — an ability which the vacuum tube had long monopolized. As with most new electron devices, however, a number of extremely practical limitations had to be overcome before the transistor could be regarded as a

[1] Bell Telephone Laboratories.

practical circuit element. In particular, the reproducibility of units was poor — units intended to be alike were not interchangeable in circuits; the reliability was poor — in an uncomfortably large fraction of units made, the characteristics changed suddenly and inexplicably; and the "designability" was poor — it was difficult to make devices to the wide range of desirable characteristics needed in modern communications functions. This paper describes the progress that has been made in reducing these limitations and extending the range of performance and usefulness of transistors in communications systems. The conclusion is drawn that for some system functions, particularly those requiring extreme miniaturization in space and power as well as reliability with respect to life and ruggedness, transistors promise important advantages.

In Search of the Missing 6 *Db*. W. A. MUNSON[1] and F. M. WIENER[1]. *Acoustical Soc. Am., Jl.*, **24,** pp. 498–501, Sept., 1952. (Monograph 2019).

The unexplained difference in sound pressure in the ear canal which appears to exist when equally loud low frequency tones are presented alternately from an earphone and from a loudspeaker has bedeviled acousticians for many years and, unfortunately, still continues to do so. There are presented here the results of some of the measurements carried out at the Bell Telephone Laboratories which show the magnitude of the effect and various attempts at explaining it. While no satisfactory explanation has been found, it is hoped that publication of these results will stimulate interest in the problem.

Nation-Wide Numbering Plan. W. H. NUNN[2]. *A.I.E.E., Trans., Commun. and Electronics Sect.*, **2,** pp. 257–260, Sept., 1952. *Elec. Engg.*, **71,** pp. 884–888, Oct., 1952. (Monograph 2015).

At the present time a great variation in the types of telephone numbers exists. This is because of the number of telephones in communities of different sizes. With the advent of local dialing and now nation-wide dialing, a uniform numbering system has become necessary.

How to Detect the Type of an Assignable Cause. P. S. OLMSTEAD[1]. *Ind. Quality Control*, **9,** pp. 32–34, **36,** Nov., 1952.

Silicon p-n *Junction Alloy Diodes*. G. L. PEARSON[1] and B. SAWYER[1]. *I.R.E., Proc.*, **40,** pp. 1348–1351, Nov., 1952.

A new type of p-n junction silicon diode has been prepared by alloying acceptor or donor impurities with n- or p-type silicon. The unique features of this diode are: (a) reverse currents as low as 10^{-10} amperes, (b) rectification ratios as high as 10^8 at 1 volt, (c) a Zener characteristic in which $d(\log I)\ d(\log V)$ may be as high as 1,500 over several decades of current, (d) a stable Zener voltage

[1] Bell Telephone Laboratories.
[2] American Telephone and Telegraph Company.

which may be fixed in the production process at values between 3 and 1,000 volts and (e) ability to operate at ambient temperatures as high as 300°C.

Hard Rubber. H. PETERS[1]. *Ind. and Eng. Chem.*, **44,** pp. 2344–2345, Oct., 1952.

As judged by the literature, the general trend during the past year on the subject of hard rubber has been toward de-emphasis of fundamental research and more emphasis on use. Plastics, through substitution, continue to make gains in the field of hard rubber. A renewed interest is again shown in the use of latex ebonite for industrial applications. The patent situation appears to be unusually active and the interest in synthetic hard rubbers continues to increase.

Application of Information Theory to Research in Experimental Phonetics. G. E. PETERSON[1]. *Jl. Speech and Hearing Disorders*, **17,** pp. 175–188, June, 1952.

Principles of Zone-Melting. W. G. PFANN[1]. *Jl. of Metals*, **4,** pp. 747–753, July, 1952. *A.I.M.E. Trans.*, **194,** pp. 747–753, 1952. (Monograph 2000).

In zone-melting, a small molten zone of zones traverse a long charge of alloy or impure metal. Consequences of this manner of freezing are examined with respect to solute distribution in the ingot, with particular reference to purification and to prevention of segregation. Results are expressed in terms of the number, size, and direction of travel of the zones, the initial solute distribution, and the distribution coefficient.

Nonsynchronous Time Division with Holding and with Random Sampling. J. R. PIERCE[1] and A. L. HOPPER[1]. *I.R.E., Proc.*, **40,** pp. 1079–1088, Sept., 1952. (Monograph 2041).

There is a general type of system in which an indefinitely large number of transmitters can have access to any of an indefinitely large number of receivers over a medium of limited bandwidth. In these systems, signal-to-noise ratio goes down as more transmitters are used simultaneously. This paper describes a particular system which sends samples by means of coded pulse groups sent at random times. The signal-to-noise ratio is good in the absence of interference and the effect of interference is minimized by holding the previous sample if a sample is lost. An experimental system worked satisfactorily and gave close to the predicted signal-to-noise ratio. Such a system might be used to provide communication and automatic switching in rural telephony, or for other applications.

Fundamental Plans for Toll Telephone Plant. J. J. PILLIOD[2]. *A.I.E.E., Trans., Commun. & Electronics Sect.*, **2,** pp. 248–256, Sept., 1952. (Monograph 2015).

[1] Bell Telephone Laboratories.
[2] American Telephone and Telegraph Company.

Organization of the Engineering Profession. D. A. QUARLES[5]. *Elec. Engg.*, **71,** pp. 963, 964, Nov., 1952.

Since the organization of the American Society of Civil Engineers 100 years ago, professional engineering has assumed a major role in American life. The goal now to be attained is the closer organization of the entire engineering profession.

We begin a New Institute Year. D. A. QUARLES[5]. *Elec. Eng.*, **71,** pp. 867–868, Oct., 1952.

In an address before the recent Pacific General Meeting in Phoenix, Mr. Quarles, President of the Institute, evaluates the evolution in A.I.E.E. organization and policy as the Institute enters a new administrative year.

Mean Free Paths of Electrons in Evaporated Metal Films. F. W. REYNOLDS[1] and G. R. STILWELL[1]. Letter to the Editor. *Phys. Rev.*, **88,** pp. 418–419, Oct. 15, 1952.

Single-Sideband System for Overseas Telephony. N. F. SCHLAAK[1]. *Electronics*, **25,** pp. 146–149, Nov., 1952.

Single-sideband transmitter furnishes four voice channels for overseas telephone service. Pushbutton tuning permits rapid frequency shifts and load-control circuit minimizes interchannel crosstalk and out-of-band radiation. Copper-oxide and germanium varistors replace modulator tubes.

Automatic Toll Switching Systems. F. F. SHIPLEY[1]. *A.I.E.E., Trans., Commun. and Electronics Sect.*, **2,** pp. 261–269, pp. 889–897, Oct., 1952. (Monograph 2015).

The new system was designed to implement the nation-wide switching plan which integrates the telephone switching network of the entire nation into a single unit. Requiring a high order of mechanical intelligence, this system is one of the most comprehensive ever devised.

Properties of M-1740 p-n *Junction Photocells.* J. N. SHIVE[1]. *I.R.E., Proc.*, **40,** pp. 1410–1413, Nov., 1952.

The *p-n* junction photocell has a sensitivity of 30 ma per lumen for light of 2,400 degrees K color temperature, corresponding to a quantum yield approximately unity in the spectral range from visible to the long wave cutoff at 1.8 microns. Dark currents of a few microamperes are observed at room temperature, with a temperature coefficient of about +10 per cent per degree C. Both dark and light currents exhibit saturation in the range from 1 to 90 volts applied. The frequency response is flat into the 100-kc region. Short-circuit noise currents are observed around 20 $\mu\mu$a in a 1-cps band at 1,000 cps. The photocell element is encapsulated in a plastic housing $\frac{1}{4} \times \frac{3}{16} \times \frac{3}{8}$ inch in dimensions.

[1] Bell Telephone Laboratories.
[5] Sandia Corporation.

Interpretation of e/m Values for Electrons in Crystals. W. SHOCKLEY[1]. Letter to the Editor. *Phys. Rev.*, **88,** p. 953, Nov. 15, 1952.

Transistor Electronics: Imperfections, Unipolar and Analog Transistors. W. SHOCKLEY[1]. *I.R.E., Proc.*, **40,** pp. 1289–1313, Nov., 1952.

The electronic mechanisms that are of chief interest in transistor electronics are discussed from the point of view of solid-state physics. The important concepts of holes, electrons, donors, acceptors, and deathnium (recombination center for holes and electrons) are treated from a unified viewpoint as imperfections in a nearly perfect crystal. The behavior of an excess electron as a negative particle moving with random thermal motion and drifting in an electric field is described in detail. A hole is similar to an electron in all regards save sign of charge. Some fundamental experiments have been performed with transistor techniques and exhibit clearly the behavior of holes and electrons. The interactions of holes, electrons, donors, acceptors, and deathnium give rise to the properties of *p-n* junctions, *p-n* junction transistors, and Zener diodes. Point-contact transistors are not understood as well from a fundamental viewpoint. A new class of *unipolar* transistors is discussed. Of these, the *analog* transistor is described in terms of analogy to a vacuum tube.

Unipolar "Field-Effect" Transistor. W. SHOCKLEY[1]. *I.R.E., Proc.*, **40,** pp. 1365–1376, Nov., 1952.

The theory for a new form of transistor is presented. This transistor is of the "field-effect" type in which the conductivity of a layer of semiconductor is modulated by a transverse electric field.

Since the amplifying action involves currents carried predominantly by one kind of carrier, the name "unipolar" is proposed to distinguish these transistors from point-contact and junction types, which are "bipolar" in this sense.

Regarded as an analog for vacuum-tube triode, the unipolar field-effect transistor may have a m_μ of 10 or more, high output resistance, and a frequency response higher than bipolar transistors of comparable dimensions.

Control of Frequency Response and Stability of Point-Contact Transistors. B. N. SLADE[1]. *I.R.E., Proc.*, **40,** pp. 1382–1384, Nov., 1952.

The frequency response and stability of point-contact transistors are determined to a large degree by control of the point-contact spacing and germanium resistivity. Stability is particularly important in amplifiers in which the impedances of the emitter and collector circuits are very small in the frequency range in which the transistor is designed to operate. Satisfactory stability has been obtained with developmental transistors having a frequency cutoff (3-db drop in the current amplification factor, alpha) ranging from 10 to 30 mc. These transistors operate under approximately the same dc bias conditions used with lower-frequency transistors, and have an average power gain of approximately 20 db. By means of the methods outlined, transistors which oscillate at frequencies as high as 300 mc have been made.

[1] Bell Telephone Laboratories.

Junction Transistor. M. SPARKS[1]. *Sci. Am.*, **187,** pp. 29–32, July, 1952.
It is one of two forms of the remarkable device that amplifies electricity by the flow of electrons in a crystal. An account of its underlying principles and present state of development.

Telephone Answering Services. L. R. STANG[6]. *Telephony*, **143,** pp. 53–55, 123–124, Oct. 25, 1952.

Traffic Engineering Design of Dial Telephone Exchanges. J. A. STEWART[1]. *Telephony*, **143,** pp. 13–16, 41–42, Oct. 18, 1952.

Low-Drain Transistor Audio Oscillator. D. E. THOMAS[1]. *I.R.E., Proc.*, **40,** pp. 1385–1395, Nov., 1952.
A nine-element transistor audio oscillator is described. This oscillator operates with relatively low drain from a single 6-volt battery. The oscillator gives reliable performance with an output uniform to approximately ±1 db with substantially all type 1768 point-contact transistors and without any circuit element adjustment required for variation in transistor parameters from unit to unit or with transistor ambient temperature.

Transistor Amplifier — Cutoff Frequency. D. E. THOMAS[1]. *I.R.E., Proc.*, **40,** pp. 1481–1483, Nov., 1952.
The effect of positive feedback through the internal base resistance of a transistor on circuit cutoff frequency is considered.

Transistor Reversible Binary Counter. R. L. TRENT[1]. *I.R.E., Proc.*, **40,** pp. 1562–1572, Nov., 1952.
The feasibility of performing a fairly complex switching function using a few elementary transistor circuits is illustrated and experimentally verified. The specific function discussed is reversible vinary counting. The mechanism used to achieve reversibility and the circuitry within each building block is described. Operating margins and suggestions for design improvements for systems application are given.

Effect of Electrode Spacing on the Equivalent Base Resistance of Point-Contact Transistors. L. B. VALDES[1]. *I.R.E., Proc.*, **40,** pp. 1429–1434, Nov., 1952.
A theoretical expression for the equivalent base resistance r_b of point-contact transistors is derived here. This expression is shown to check experimental values reasonably well if the severity of some assumptions made for purposes of analysis is considered. Electrode spacing, germanium-slice thickness, and resistivity of the semiconductor are shown to be the properties that affect r_b primarily.

[1] Bell Telephone Laboratories.
[6] Illinois Bell Telephone Company.

Measurement of Minority Carrier Lifetime in Germanium. L. B. VALDES[1]. *I.R.E., Proc.*, **40,** pp. 1420–1423, Nov., 1952.

A method for measuring the lifetime of minority carriers in germanium is described. Basically, it consists of liberating the carriers optically on a flat face of a crystal and measuring the concentration of minority carriers as a function of distance from the point of liberation. The mathematical model is analyzed and experimental results are presented here.

Drift Velocities of Ions in Krypton and Xenon. R. N. VARNEY[1]. *Phys. Rev.*, **88,** pp. 362–364, Oct. 15, 1952. (Monograph 2028).

Drift velocities and mobilities of ions of Kr and Xe in their respective parent gases have been measured over a wide range of values of E/p_0, the ratio of electric field strength to normalized gas pressure. Two ions appear in each gas identified as Kr^+ and Kr_2^+ in Kr and Xe^+ and Xe_2 in Xe. The relation that drift velocity varies as $(E/p_0)^{\frac{1}{2}}$ at high E/p_0 has been found to hold for the atomic ions and has been used to determine the equivalent hard sphere cross sections at high fields. The cross sections are 157×10^{-16} cm^2 for Kr and 192×10^{-16} cm^2 for Xe. The Langevin theory of mobilities gives excellent agreement with experimental results extrapolated to zero field strength provided that, in the theory, the hard sphere cross section is taken as large for the atomic ions and very small for the molecular ions. The range of the polarization forces is such as to render them insignificant in atomic ion collisons and of primary importance in molecular ion collisions.

Junction Transistor Tetrode for High-Frequency Use. R. L. WALLACE[1], L. G. SCHIMPF[1] and E. DICKTEN[1]. *I.R.E., Proc.*, **40,** pp. 1395–1400, Nov., 1952.

If a fourth electrode is added to a conventional junction transistor and biased in a suitable way, the base resistance of the transistor is reduced by a very substantial factor. This reduction in r_b permits the transistor to be used at frequencies ten times or more higher than would otherwise be possible. Tetrodes of this sort have been used in sine-wave oscillators up to a frequency of 130 mc and have produced substantial gain as tuned amplifiers at frequencies of 50 mc and higher.

Nature of Solids. G. H. WANNIER[1]. *Sci. Am.*, **187,** p. 39 Dec., 1952.

The theory that explains their various properties is a comparatively recent development of physics. From it practical benefits already begin to flow.

Magnetic Double Refraction at Microwave Frequencies. M. T. WEISS[1] and A. G. FOX[1]. Letter to the Editor, *Phys. Rev.*, **88,** pp. 146–147, Oct. 1, 1952.

Stress Relaxation in Plastics and Insulating Materials. E. E. WRIGHT[1]. *A.S.T.M. Bull.*, **184,** pp. 47–49, Sept., 1952. (Monograph 2024).

[1] Bell Telephone Laboratories.

Organic materials are in ever-increasing use for mechanical and electrical devices where satisfactory performance is required over long periods of time and under a wide assortment of atmospheric influences. Although the dimensional stability of plastics and electrical insulating materials under no-load conditions has been established reasonably well, there is an important gap in existing knowledge with regard to a material's ability to maintain adequate counter-stresses under compressive loading.

A.S.T.M. Method of Test D 621 – 51[2] uses a constant load system and measures the material's resistance to gross deformation. However, this fails to simulate the usual application where the material is subjected to constant deflection (such as fastening devices, inserts, etc.) and is required to maintain adequate counter-stresses for the foreseeable life of the part. Therefore, it has been necessary to integrate data from Method D 621 with long practical experience in order to extrapolate between two dissimilar systems.

This paper describes a constant-deflection procedure for direct measurement of stress relaxation or change thereof, thereby permitting evaluation in terms of a material's ability to maintain a tight assembly under conditions simulating actual use. Apparatus for carrying out the test is described and typical data illustrating its usefulness are included.