June 25, 1958

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JULY 9, 1958

TRANSISTORS '58

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HIGHLIGHTS OF ISSUE

Sixth Annual Transistor Data Chart . . following p 70

Over 600 transistors are tabulated according to manufacturer and type to provide the circuit designer with a single comprehensive transistor data chart. Included are pertinent parameters which determine the operating characteristics of each transistor.

Diffused Base Transistor . . . 12

With the development of the diffused base transistor the circuit designer has now at his disposal high frequency devices with alpha cut-off values in the 500 to 1000 mc range. Because of their many commercial and military application possibilities two typical diffused base transistors are discussed in terms of their operating characteristics.

Voltage Limiter 20

Here is a reliable voltage limiter that effectively protects transistorized equipment from overvoltage. It achieves this by a novel voltage limiting technique.

The PNN and NPP 106

These two interesting transistor devices can be assembled from ordinary junction type transistors. Soon available commercially, they can eliminate the need of an inverter in a push-pull transistor circuit.

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Decade of Transistor Progress

Alexander E. Takacs
Assistant Editor

PROGRESS over the past ten years in the transistor field has been feverish and exciting. The transistor chart in this issue which lists 619 units, indicates the growth of the transistor field. Our first transistor chart in 1953 listed 43 available types. From 1948, the year of the invention of the transistor, to 1958 when transistors provide the radio voice in our satellites, a few of the potentialities of the transistor realized were:

- Diffused base transistors now operate in the 1000 mc range;
- Rise, storage, and fall times of switching transistors in the order of 10 millimicrosec;
- Operating junction temperature over 100 C with silicon transistors;
- Germanium power transistors available with power gains of 35 db and collector currents of 13 amp.

In this report the highlights of transistor developments are discussed. We also take a look at the current and future status of transistors.

Areas of Application

Audio. One common type of junction transistors produced is the diffused alloy type. The procedure is basically melting indium dots into a wafer of germanium. However, diffused alloy transistors have their limitations by being only suited for medium power and audio frequency work. Because of the high capacitance between collector and base, the device does not perform effectively at high frequencies.

High Frequencies. The rate grown junction transistor is an improvement, being more stable at higher frequencies. The manner of construction is essentially different from the diffused alloy type. From a melt which has been doped with small amounts of antimony and gallium, a germanium bar is grown. The characteristics of the bar change from p type to n type according to temperature and rate of growing. This technique of fabrication has the advantage of avoiding non-uniform junctions which occur in ordinary junction-growing methods.

Over the past year the production of diffused base transistors increased greatly as manufacturers raced to exploit its advantages. By diffusing gaseous impurities into a semiconductor an incredibly small base width in the order of 1.5×10^{-4} cm is produced. The change in resistivity, from high conductivity near the emitter to almost intrinsic near the collector, reduces the transit time of the holes in a pnp type. The 1000 mc range could then be reached, which is 10 to 50 times higher than using alloy and grown junction types. It became suited for computer and switching circuits.

Diffused silicon types were also produced. A typical value for silicon base width is 3.8×10^{-4} cm. Though they operate at a lower frequency, they are useful for high temperature applications. Silicon diffused base transistor can also be used as an electronic switch because of its high impedance when non-conducting

Power. The upper limit for germanium power transistors was 10 to 15 w several years ago, with maximum operating junction temperatures of 80 C. Today transistors are available as high as 55 w at 95 C maximum junction temperature. However, there is still a need for transistors operating at higher voltages.

Silicon power transistors proved useful because of their high ambient temperature range. With each passing year higher temperature materials associated with the fabrication of silicon transistors are developed.

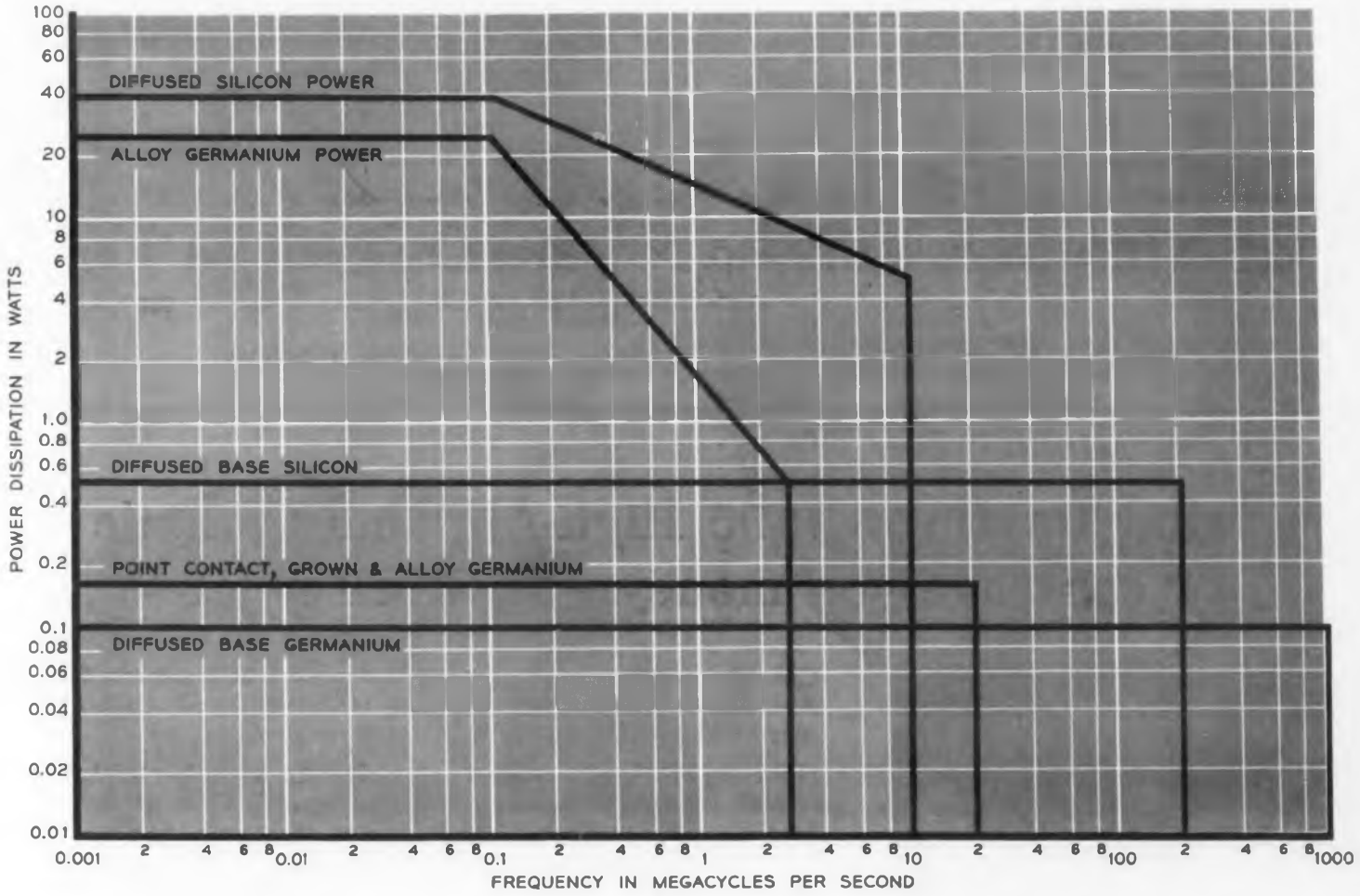


Fig. 1. Frequency vs power dissipation curves of various types of transistors.

Table 2. Impedance Levels

Configuration	Power rating
Common emitter	low (under 100 mw) over half watt
Common base	under 10 mw over half watt
Common collector	under 100 mw over half watt

Configuration	Input impedance
Common emitter	500-20,000 ohm 20-500 ohm
Common base	10-500 ohm 0.2-20 ohm
Common collector	10,000-0.5 meg 400-10,000 ohm

Configuration	Output
Common emitter	10,000-200,000 ohm 200-10,000 ohm
Common base	50,000-2 meg 1000-50,000 ohm
Common collector	10-500 ohm 0.2-20 ohm

Eventually silicon power transistors will be available with operating junction temperatures of 200-300 C. ***Switching.*** Transistors were readily adapted to switching applications: germanium alloy pnp transistors for low speed switching applications such as dc to dc converters; diffused base transistors for high speed switching where rise times in the order of a few millimicrosec are required; and power switching handling voltages up to 100 v and currents of 10 amp. Higher power transistors are required to operate in the range between 10 and 100 μsec.

In the past year high speed germanium switching transistors became more available for commercial use. Typical switching applications are generation of rectangular and sawtooth waveforms, time delays, gating, amplifying and lengthening pulses.

Transistor Performance

Power Gain. The important feature of a power transistor is delivering useful gains at high current levels.

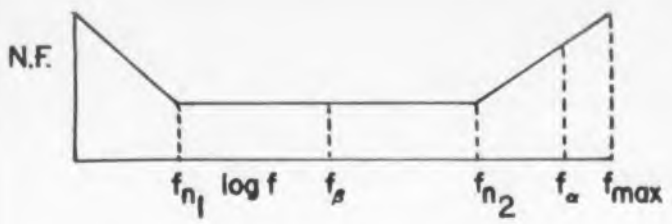


Fig. 2. Noise figure vs frequency curve.

The power gain in a transistor is a result of the relatively small amount of current drawn by the base-emitter circuit in producing a current change in the emitter-collect circuit. The current change produced in the collector circuit is developed at high impedance. A typical high power audio transistor is the Sylvania type 2N173 which provides a power gain of 34 db and maximum collector current of 13 amp.

The amount of power gain in a transistor amplifier, like that in a tube amplifier, depends on the circuit configuration. The maximum gain, 40 to 50 db, is obtained with the input signal on the base and the output taken from the collector. Somewhat less gain, 30 db, is obtained when the input signal is introduced into the emitter and the output taken from the collector; and even less gain, about 20 db, with the input signal into the base and the output taken from the emitter.

Frequency Response. Limitations in the frequency response of transistors have been overcome by technological breakthroughs such as diffused base techniques. The principal parameters affecting frequency response are r_b', and g_f and C_{bc} and C_{eb}. Often preliminary design is based on the assumption (frequently the assumption is invalid) that the base spreading resistance r_b' may be neglected. If the input source impedance to the transistor is less than the reactance of the input capacitance, C_{bc}, then, for r_b negligible, a relatively uniform response may be obtained. Since the value of C_{bc} for a transistor depends on the uniformity of current flow across the base and on the thickness of the base, an increase in the allowable source impedance can be obtained only by the selection of a transistor having a smaller value of C_{bc}. This capacitance may be small as 100 μμf or possibly less, and as large as 0.1 μf.

Frequency of operation is plotted in Fig. 1 as a function of power dissipation for various types of transistors presently available. Values of alpha cutoff frequencies are used. For oscillator applications, higher values of frequency are possible, while lower values would apply for broadband applications. Areas under the curves show the continuing trend of transistor device development toward the latest types of structures with wider ranges of operating characteristics.

As the power rating of a transistor is increased through enlarging the active areas of the emitter and collector, a corresponding increase in the value of C_{bc} is inevitable, reducing the operating frequency range. The use of diffusion techniques to produce a graded

base or drift transistor extends the frequency range for any given power device. Typical limiting frequencies for standard type transistors are indicated in Table I.

Noise Figure. The noise figure of present-day transistors for the range of frequencies for which thermal noise is the predominant component may be as small as two to twelve db, depending on the processing and the circuit conditions under which the transistor is used. A typical noise figure vs frequency curve is shown in Fig. 2. The noise developed by the transistor depends on both the circuit and on the currents and voltages applied to it.

The deterioration of noise figure at a low frequency is usually attributed to semiconductor noise and surface recombination noise. The frequency f_{n1} at which the low frequency deterioration sets in varies from transistor to transistor, and may be as high as several megacycles. The deterioration above the switch limit frequency f_{n2} is caused primarily by the non-uniformity in the diffusion of the minority carriers through the base region.

Impedance Levels. The input and output impedances for the three circuit configurations differ substantially. The actual values depend on the characteristics of the transistor and also the values of the associated circuit components. The range of typical values is shown in Table 2.

Other Transistor Types

Field Effect Transistor. Typical junction type transistors depend upon both minority and majority carriers for operation. The unipolar field effect transistor, however, involves only the flow of one carrier, either holes or electrons. It is constructed by forming pn junctions on a bar of germanium. The bulk resistance is modulated by the application of an electric field. A change in the n-type material-depleted of carriers, is produced by a voltage change across the pn junction.

In the May 14 issue of ELECTRONIC DESIGN a field effect transistor was described using an electrolyte-semiconductor interface. Between the two ends of the semiconductor, oppositely biased with respect to an electrolyte, a neutral point exists which shifts back and forth with changing biasing grid voltage. The resistance changed accordingly and a current flowed following the driving frequency. This experimental amplifier operated at 1000 cps with 15 db gain.

However, the field effect transistor has not been investigated to the extent that typical junction transistors were. A question mark still hangs over the future role of the field effect transistor.

Intrinsic Barrier Transistor. The distinguishing characteristic of an pnip intrinsic barrier transistor is a layer of nearly intrinsic material next to the collector. This layer which in some respects compares to the grid of an electron tube, serves several functions. First, close control of the carriers is permitted. Second, separating the input from the output allows the device to operate at higher voltages. Last, lower collector ca-

Table 1. Limiting Transistor Frequencies

Type	Approx. f_{max}
Junction transistors	
High Power	100 kc to 10 mc
Low Power	1 kc to 20 kc
Thin-base transistors	10 mc to 75 mc
Surface barrier transistors	10 mc to 200 mc
Double-base transistor	200 mc
Diffused base transistor	
Low Power	50 mc to 1000 mc
High Power	20 kc to 10 mc

pacitance is achieved. The device can operate with cutoff frequency of over 300 mc.

Tetrode. The tetrode is basically an npn grown-junction transistor with a double base connection. A potential drop is set up across the base. Electron flow is confined to a small region near to one base control, and a lower effective base resistivity results because of the shorter path. This permits the device to be designed with a higher cutoff frequency.

Point-Contact. Because of the advantages of junction type transistors, the point-contact transistor has almost been reduced to historical importance only. It was the first transistor to be developed. The distinctions are lower power capabilities, more noisy and lower collector impedance. It has been used mainly for switching applications.

Thyristor. The thyristor is a transistor that acts like a thyratron. It can be riggered "on" and "off" with low power and has a collector voltage drop of only about 0.5 v during conduction. It is almost a perfect switch having a collector current rise and fall time of less than 0.1 μsec. The speed of switching is limited by the Thyristor design and the input and the output capacities. Since the high frequency response is good the rise and fall times below one tenth μsec are easy to obtain. Ring counters, shift registers and similar type devices may be made by using the Thyristor collector current triggering characteristics.

Silicon Controlled Rectifier. This semiconductor switch combines both transistor and rectifier features for high power switching at μsec speeds. This device operates at low power levels. Ratios of load power to control power of 100,000 to 1 have been obtained. The future of silicon controlled rectifier is promising. We expect to see many manufacturers producing this type device in the near future. A few of the devices it can replace are thyratrons, relays and typical rectifiers. It can replace the power transistor in servo motor amplifiers.

Transistor Art Today

Transistors are superior to electron tubes because of their long life, rugged construction and smaller size. But they were initially inferior in other ways. The inherent noise limited minimum signals. Internal capacitance limited maximum frequency. Internal heat-

ing and distortion limited maximum power. Large temperature coefficient limited ambient temperature range. However in recent years some of these limitations were overcome. Diffusion techniques shorter transit times of the carriers and higher frequency ranges were reached. The use of silicon permitted high ambient temperature range.

Today the transistor does not perform as many functions as the electron tube. But there is little doubt that in the future years transistor device research will make deep inroads on the earlier successes of the electron tube. This will be dependent on technological breakthroughs not only in device research but investigation of the bulk and surface properties of semiconductor materials.

There are many semiconductor materials other than silicon and germanium. Yet only these two have been exploited, germanium to a greater extent than silicon. There is a constant search for other suitable semiconductor materials that would make the transistor a more versatile device. A promising family of semiconducting material is the intermetallic semiconductor group. They have characteristics similar to germanium and silicon. In this group the indium phosphide and antimonide compounds are most promising.

Acknowledgment

Appreciation for contributing valuable transistor data to this issue is expressed to K. C. Pullen, Ballistic Research Lab., Aberdeen Proving Ground, Md.

CIRCUITS WANTED

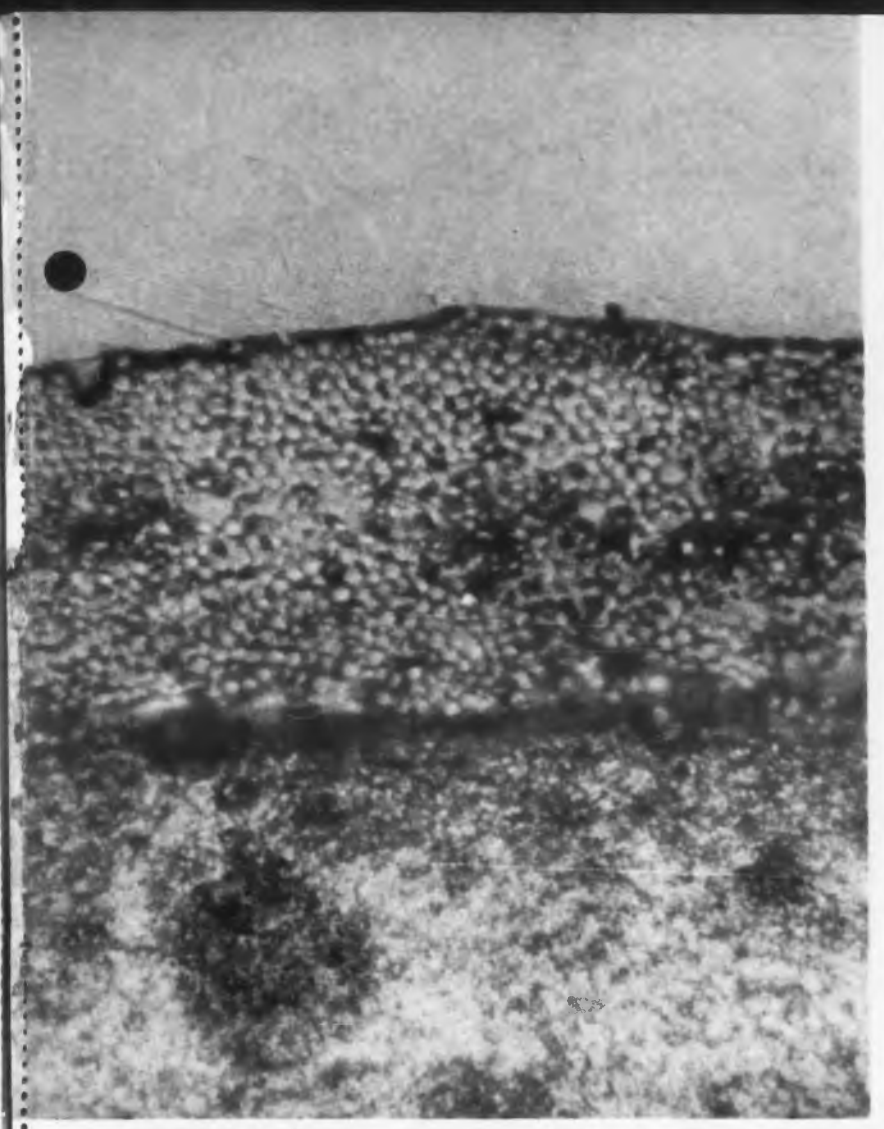
The Bureau of Ships recently awarded a contract to Transistor Applications, Inc. to prepare a "Selected Semiconductor Circuits Handbook."

The Boston firm will invite companies, government organizations and individuals to submit reliable transistor and diode circuits and their descriptions for possible inclusion in the handbook. Among the many circuits to be covered will be amplifiers, oscillators, mixers and converters, switches, and power supplies.

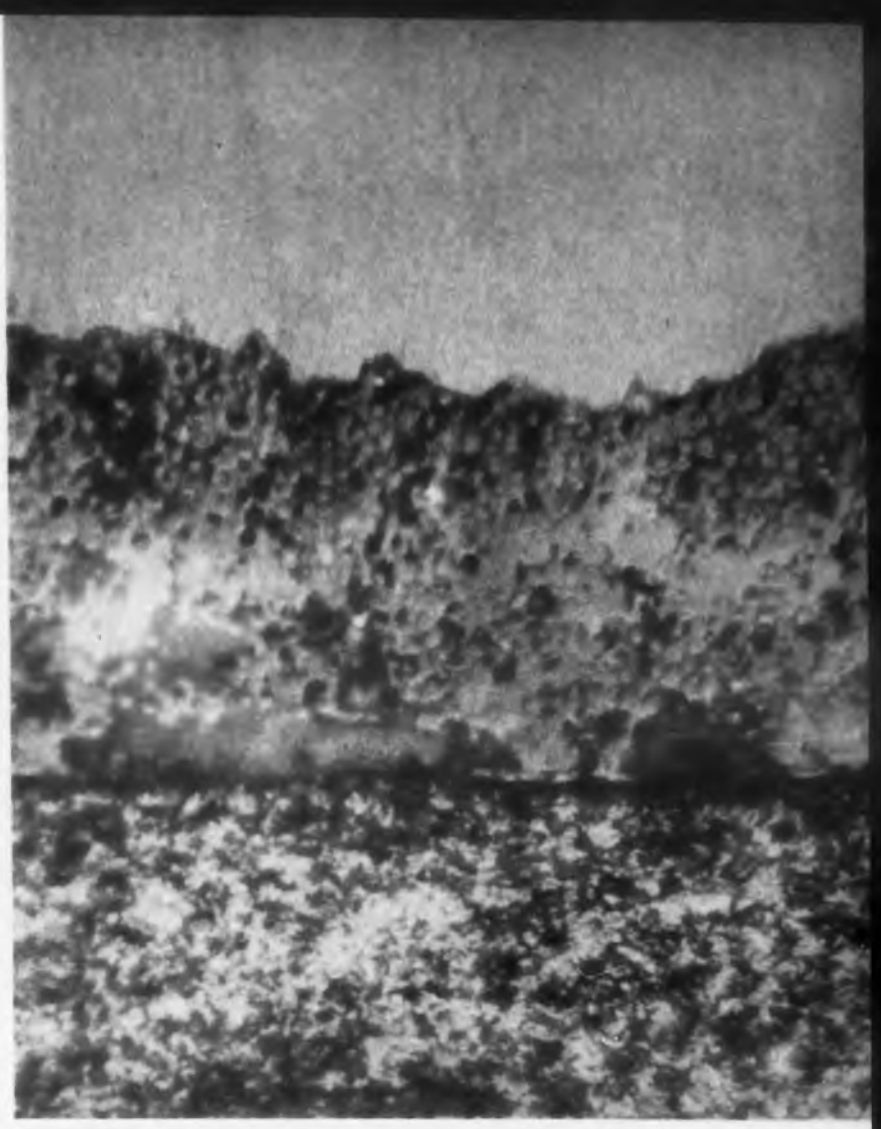
All circuits will be reviewed by a committee of technical authorities, and all contributors will receive full credit.

The handbook, it is hoped, will encourage better engineering practice by transistor circuit engineers, in designing circuits for military electronic equipment.

We, at ELECTRONIC DESIGN, hope this project will lead to some standardization in semiconductor circuitry. Our readers can help by sending their contributions to the Research Director at Transistor Applications, Inc., 50 Broad St., Boston, Mass.



VITROTEX, magnified approximately 400X. The lower layer is the copper wire; the upper layer, the glass insulation. The glass fiber-ends appear as small circles in the photograph. The sections between fibers are occupied by bonding varnish. Notice the fibers are close together, well distributed.



VITROTEX-D, magnified approximately 400X. The upper layer consists of glass fibers in fused Dacron*. Notice the even distribution which provides uniform insulation value—no large "islands" where fibers are missing.

*Reg. U. S. Pat. Off., Dupont

Let these Anaconda photomicrographs help you select high-temperature Magnet Wire with glass-type insulation

These two longitudinal sections of Anaconda magnet wires have been blown up 400 times—to show you the difference between Anaconda Vitrotex and Vitrotex-D (both 130°C—AIEE Class B).

Maximum high-temperature protection in glass-type insulation depends on the proportion of the glass fibers present. Maximum resistance to winding damage, however, can call for reducing the number of glass fibers and adding a "damage reducing" agent such as Dacron.

This is essentially the difference between Vitrotex and Vitrotex-D.

Anaconda provides both—in complete size ranges, in rounds, squares and rectangulars. You, the designer, must weigh the need for insulation and heat-resistance against those properties which affect windability.

Vitrotex, as the left-hand photograph shows, consists of all glass fibers—therefore, where winding damage is controllable, Vitrotex offers you greater insulation value.

Sometimes, however, the risk of winding damage cannot be avoided. For these situations, Anaconda offers Vitrotex-D. The Dacron acts as a bonding agent—holds the fibers in place and protects them during winding.

The pictures above show more than the difference in glass-fiber content. They show how Anaconda engineering and manufacturing care provide uniform fiber distribution in both types . . . how each has been designed to do a different job—and do it well!

Ask the Man from Anaconda for additional details on (1) Vitrotex, (2) Vitrotex-D, (3) Silotex† (180°C—AIEE Class H) and (4) Silotex-D†. See "Anaconda" in your phone book, in most principal cities, or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

†Reg. U. S. Pat. Off.

SEE THE MAN FROM ANACONDA® *FOR* **MAGNET WIRE**

For more details on the characteristics of Vitrotex and Vitrotex-D, please turn the page—

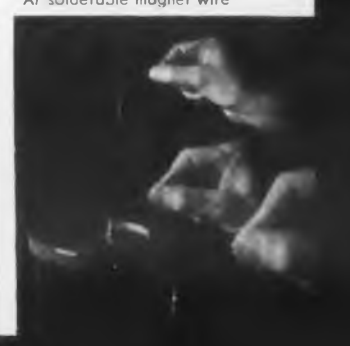
ANATHERM 155°C (AIEE Class F) high temperature resistance

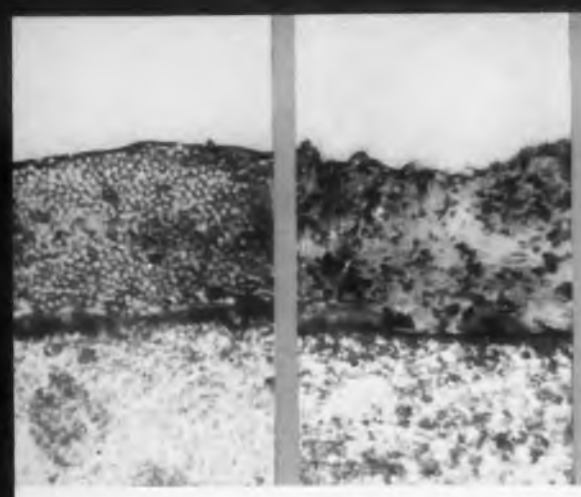
NYFORM 105°C (AIEE Class A) superior windability

PLAIN ENAMEL 105°C (AIEE Class A) low-cost enameled magnet wire

FORMVAR 105°C (AIEE Class A) established dependability

ANALAC 105°C (AIEE Class A) solderable magnet wire





MAGNET WIRE DATA SHEET

from

Anaconda Wire & Cable Co.

IMPORTANT FACTS FOR YOUR WORK...

. . . about Anaconda Vitrotex 130°C (AIEE Class B) Magnet Wire

HIGH TEMPERATURE OVERLOAD PROTECTION. Even under severe overload conditions, Vitrotex provides protection. This exceptional high-temperature resistance is Vitrotex's outstanding advantage—and can be put to use even in totally enclosed applications.

REDUCTION IN FRAME SIZE. Because of the higher temperature stability, excellent space factor (compared with cotton), and the high heat conductivity of the glass fibers, Vitrotex-wound motors and generators can be produced in smaller frame sizes for equal rating or with increased ratings in comparable size frames.

TECHNICAL PROPERTIES

MECHANICAL PROPERTIES. Vitrotex has the necessary abrasion-resistance for most winding applications. It is suitable wherever controllable winding is possible. Vitrotex possesses remarkable space factor, especially when considering its ability to withstand high operating temperatures. Single Vitrotex has a space factor better than single cotton of equal gage. Double Vitrotex has a space factor better than double cotton of equal gage. Vitrotex has good "mesh" factor—windings expand no more than other insulations so that special precautions are unnecessary in design of windings.

ELECTRICAL PROPERTIES. Vitrotex is offered as a 130°C (AIEE Class B) magnet wire. Its high-grade organic bonding varnish plus the glass, give Vitrotex high electrical qualities. Vitrotex will retain sufficiently high dielectric strength to operate satisfactorily at temperatures above the destruction point of organic fiber insulation. At high relative humidity, Vitrotex retains its dielectric strength to a marked degree.

CHEMICAL PROPERTIES. Vitrotex is compatible with most Class B bonding varnishes and materials. Windings with Vitrotex can be baked after impregnation at temperatures that would destroy ordinary insulations. Windings can be impregnated with commercial varnishes or other compounds by standard methods. While the glass fibers themselves will not absorb liquids or compounds, the interspaces of the insulation will take up and retain the impregnant. Allows great latitude in design.

THERMAL PROPERTIES. Vitrotex is a 130°C (AIEE Class B) magnet wire by definition. However, the precise temperature at which Vitrotex wire can be operated will depend on the design of the apparatus. For example, Vitrotex is excellent for use in dry-type transformers under Group 2 NEMA classification for operation at 150°C hottest spot. Under severe overload conditions where all bond and varnish are destroyed, the inorganic glass remains to protect against shorting.

. . . about Anaconda Vitrotex-D 130°C (AIEE Class B) Magnet Wire

WINDABILITY. Vitrotex-D is a high-temperature AIEE Class B magnet wire with special abrasion-resistance properties. Where a controllable winding operation is not possible (making the use of all glass insulation impractical), Vitrotex-D is recommended.

PRECAUTION: Dacron is a polyester. Therefore the use of this wire is limited to ventilated equipment.

TEAR OUT FOR YOUR FILE

TECHNICAL PROPERTIES

MECHANICAL PROPERTIES. Vitrotex-D exhibits superior abrasion-resistance. It is ideally suited to those situations where a high-temperature Class B magnet wire is needed, but where the winding operations from the standpoint of abrasion, small bending radii or forming stresses are too severe to permit the use of all glass insulated wire. Use of Vitrotex-D on rectangulars results in thinner insulation and thus improves space factor.

ELECTRICAL PROPERTIES. As in the case of Vitrotex, Vitrotex-D is offered as a 130°C (AIEE Class B) magnet wire. The same high-grade, organic bonding varnish is used in Vitrotex-D as in Vitrotex—giving this wire similar high electrical properties.

CHEMICAL PROPERTIES. The chemical properties of Vitrotex-D are similar to those of Vitrotex except, since Dacron is a polyester, care should be taken in the selection of the proper varnish.

THERMAL PROPERTIES. Vitrotex-D shows the same general thermal properties as Vitrotex—with excellent aging and heat-resistance. Since less glass is present in the covering, less protection is provided under severe overload conditions.

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MAGNET WIRE

Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

EDITORIAL

Look for and Try for the Unexpected

Recognition of the 10th Anniversary of Transistors has produced so many words on the subject that this editor is reluctant to add more. No doubt, most every generalization and point of view worthwhile saying has been said. But in addition to being the Tenth birthday of transistors, it's our occasion for publishing the Sixth Annual Transistor Data Chart. We cannot forego saying a few words about it. Tedious as the compilation was, we enthuse and marvel over the picture of the industry it gives us. True there are no prices, no statement of the volume of business for the various types. Yet, every transistor listed represents a saleable item and every type will be sold. There are 619 transistors tabulated, the total different types listed are 535. The total number of transistors on the market by all USA manufacturers increased 38 per cent. The total number of different types increased 32 per cent. The difference is several manufacturers now make the same type. We begin to see a slight trend to settle on a few "standard" types.

That every manufacturer's transistor is not special is becoming more evident by the replacement or substitution guides put out by the manufacturers. Manufacturer A does have a type that can be used in place of Manufacturer B's device. We would have liked to publish such cross-reference guides but space would not permit. As a matter of fact, the tabulation has grown so that we have deferred until later issues many of our "how to apply" transistor design articles. We just didn't have the necessary space.

One can hardly appraise transistor developments without making comparison with tubes. We know practically everyone is investigating conversion from tubes to transistors. Despite this activity we suspect transistors are not being exploited as fully as they might. The reason: the designer has the wrong frame of reference. He approaches the problem "Can I use a transistor here more profitably than a tube?" This approach assumes tubes are the natural component. Transistors offer enough so that they ought to be the first consideration. The question should be "Is a tube better than a transistor in this application?" New concepts in thinking are needed.

We are certain the future of transistors holds surprises that are not even hinted at today. Walter H. Brattain, speaking of research in the June Proceedings of the IRE, said " . . . while a well thought of experiment may always give good results, nevertheless the really important experiment is the one that leads to new and unxpected results regardless of the original reason or expectation that inspired it." Can not this alertness to the new and unusual give us new insights into circuit design? We think so.

James C. Kyppha

Fig. 1. Minute electrode structure of a diffused base transistor.

1000 mc range reached with Diffused Base Transistors

C. H. Knowles and E. A. Temple*

HIGH FREQUENCY characteristics, rugged construction and relative temperature insensitivity were the main reasons why diffused base transistors were used in the Vanguard and Explorer satellites. They have been designed to operate in the 1000 mc range and maintain good characteristics up to about 100 C. A diffused base germanium transistor, shown in Fig. 1, now serves many functions previously reserved because of temperature considerations for a silicon transistor. In this article high and low frequency characteristics are discussed, along with the power rating and fabrication techniques. Important parameters of two typical diffused base transistors are listed in Table [1].

High Frequency Characteristics

The most common figure of merit for high frequency transistors is the maximum frequency of oscillation 1:

$$f_{max} = \sqrt{\frac{f_\alpha}{8\pi\ r'_b\ C_c}} \qquad (1)$$

where $f\alpha$ is the frequency at which the grounded base short circuit current gain is 3 db down, r'_b is the high frequency base resistance, and C_c is the collector depletion layer capacitance.

Because of its high value of around 1000 mc $f\alpha$ cannot be measured conveniently for the 2N509-2N537 series. Instead, the common emitter high frequency short circuit current gain is measured. This is easier to measure and it is related to the common base characteristics in a calculable way. Fig. 2 shows a typical plot of common emitter short circuit current gain, h_{fe}, versus frequency. By measuring h_{fe} at a low frequency, say 100 mc, f_{oe} can be extrapolated. Since f_{oe} is about three-fourths $f\alpha$ in this type of transistor, we have:

$$f_\alpha = h_{fe}\ (at\ 100\ mc) \times 100\ mc \times 4/3 \qquad (2)$$

Using the data of Table 1 in Eqs. 1 and 2, a typical 2N537 is found to have an f_{max} of 1000 mc. The amplitude of h_{fe} at 100 mc is 6.3. This value rather than the corresponding 16 db in Table 1 is used in Eq. 2.

The high frequency characteristics of the 2N509 and the 2N537 are relatively insensitive to temperature. For example, h_{fe} at 100 mc falls less than 1 db from —200 C to room temperature and about 1 db more from room temperature to 100 C. Ohmic base resistance rises about 20% from —200 C to room temperature and somewhat less from room temperature to 100 C. Collector barrier capacitance has a very low temperature coefficient as in all germanium and silicon transistors.

Variations of high frequency parameters with bias voltage and bias current are similar to those in other transistors. For example, the collector barrier capacitance varies approximately as the inverse square root of collector barrier voltage as in alloy transistors. This variation shows clearly that the collector barrier lies primarily in the p-type collector body.

At 100 mc h_{fe} increases with increasing emitter current. In this and the following figures parameters for the 2N509 and 2N537 are normalized to their respective values at $V_C = 10$ ma, $I_E = -10$ ma at room temperature. This variation may be understood from the dependence of h_{fe} on emitter current. This parameter is given at high frequencies by

$$h_{fe} \simeq \frac{2\pi\ f_{oe}}{2\pi f} = \frac{1}{2\pi f\ \tau_{oe}} \simeq \frac{1}{2\pi f(\tau_e+\tau_b+\tau_c+\tau_{x/2})} \qquad (3)$$

Here τ_e is the emitter barrier charging time constant $C_e \times kT/qI_e$, τb is the carrier transit time across the base, τ_c is the collector barrier charging time constant, $-r'_c C_c$, and τ_x is the carrier transit time through the collector barrier.

Rough calculations show that these times for a 2N509 biased at 10 ma and —10 v are:

$$\tau_e \approx 0.5 \times 10^{-10}\ \text{sec}$$

$$\tau_b \approx 1.2 \times 10^{-10}$$

$$\tau_c \approx 0.6 \times 10^{-10}$$

*C. H. Knowles is with Bell Telephone Lab., Inc., Murray Hill, N. J. and E. A. Temple is with Western Electric Co., Laureldale, Pa.

$$\tau_{x/2} \approx 0.25 \times 10^{-10}$$

$$\therefore \tau_{oe} \approx 2.60 \times 10^{-10}$$

$$f_{oe} \approx 615 \text{ mc}$$

The first of these terms, τ_e, accounts for a large part of the decrease in h_{fe} as emitter current is decreased.

Increase of collector voltage, while decreasing collector capacitance, increases h_{fe} and ohmic base resistance somewhat. The increase of h_{fe} results from a decrease in the base transit time associated with thinning of the base layer at higher voltages and from a reduction of τ_c. Increase of ohmic base resistance is caused by thinning of the base layer.

Low Frequency Characteristics

The collector reverse current, I_{co}, varies with temperature and voltage in the conventional fashion. It increases about 8 per cent per degree C, reaching 100 μa at 100 C. Breakdown voltages average around 40 v and I_{co} has essentially the low voltage value at 20 v.

Low frequency common base h-parameters change with temperature as shown in Fig. 3. The current gain defect $1 + h_{fb}$ decreases steadily with increasing temperature over the entire range. Although the basic physical cause of this variation is not understood, it is consistent with other observations on this parameter. The short circuit input impedance h_{ib} is nearly independent of temperature. It contains a term kT/qI_e which increases linearly with temperature and which apparently dominates at high temperatures.

Other variations are traceable to changes in $1 + h_{fb}$ and in r'_b. The open circuit voltage feedback ratio h_{rb} changes relatively little with temperature because its two major components have temperature coefficients of opposite sign. The space charge layer widening factor kT/qw $\delta w/\delta V_c$ increases linearly with temperature. Since the collector conductance h_{ob} decreases quite rapidly as temperature increases, its contribution to h_{rb}, $h_{ob}r'_b$, also decreases with rising temperature. The decrease of h_{ob} with increasing temperature results in part from the decrease of $1 + h_{fb}$ with increasing temperature and in part from a decrease of avalanche multiplication as temperature is increased.

In both the 2N509 and the 2N537, $1 + h_{fb}$ decreases steadily as emitter current is increased. This effect is connected to the temperature dependence of $1 + h_{fb}$ and is not yet fully explained. The decrease of h_{ib} with increase of emitter current results primarily from a reduction in the term kT/qI_e as in other transistors and in small part from the reduction of $1 + h_{fb}$ at high I_e. The rise of h_{ob} with emitter current is that ordinarily found in junction triodes. This rise ac-

TABLE 1. Diffused Base Transistor Parameters

Parameter	Bias I_E, V_C ma. v.	2N509 Median	2N509 Spec. Limit	2N537 Median	2N537 Spec. Limit
h_{fe} (100 mc)—db	(10,–10)	16	>12	12	>10
r'_b—ohm	(10,–10)	70	<80		<30
C_C—mmf	(0,–10)	1.2	<1.5	1.2	<1.5
I_{co}—μa	(0.–20)	1.0	<5	1.0	<5
$1+h_{fb}$—	(10,–10)	.02	<.04	.07	<.10
h_{ib}—ohm	(10,–10)	5	<14	5	<10
h_{ob}—μmho	(10,–10)	9.0	<20	9.0	<20
h_{rb}—	(10,–10)	1.6×10^{-3}	$<3\times10^{-3}$	1.2×10^{-3}	$<3\times10^{-3}$

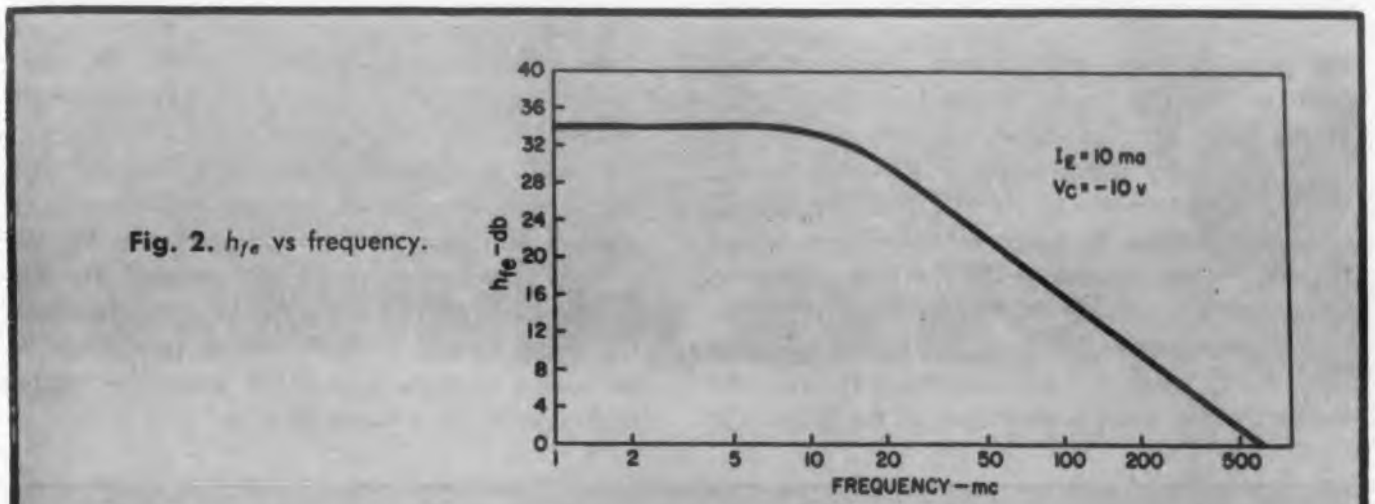

Fig. 2. h_{fe} vs frequency.

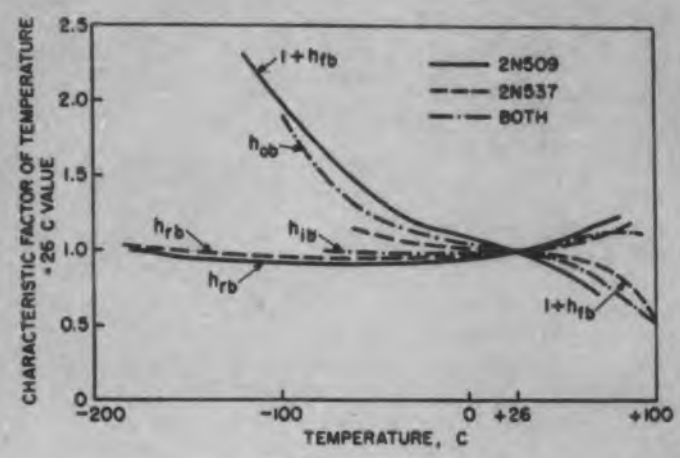

Fig. 3. How low frequency common base h-parameters change with temperature.

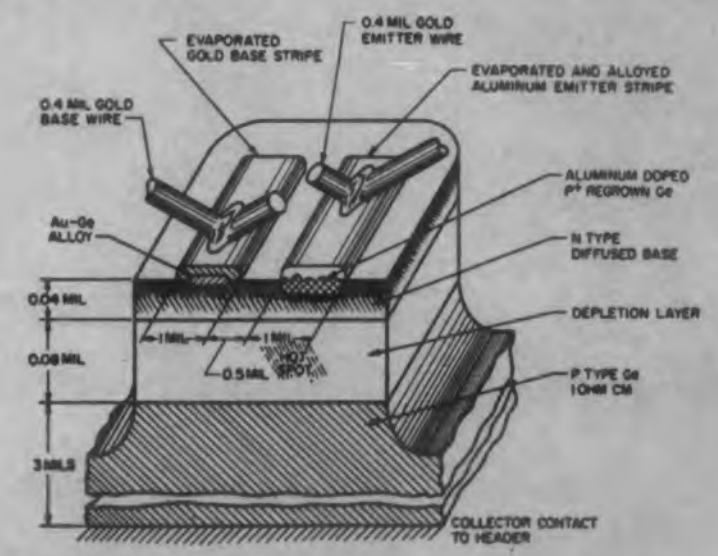

Fig. 4. Cutaway view of a germanium pnp diffused base transistor.

counts for the rapid increase of h_{rb} with emitter current, since $h_{ob}r'_b$ is the dominant term in h_{rb}.

Increase of collector voltage causes a monotonic decrease of $1 + h_{fb}$. At low voltages, the change of base layer thickness is largely responsible, but from about 12 v upward the increase of avalanche multiplication is responsible. The short circuit input impedance h_{ib} quite naturally reflects the decrease of $1 + h_{fb}$. The open circuit output admittance h_{ob} shows the effects of avalanche multiplication even at 8 to 10 v. The increase of $h_{ob}r'_b$ is, in turn, largely responsible for the rapid increase of h_{rb} at high voltages.

Power Rating

The 2N509 and the 2N537 can dissipate several hundred milliwatts when clamped to a cooling plate at room temperature. Power ratings have not been completely established and the values given here are conservative.

The tentative maximum junction temperature is 100 C. An increase to about 125 C is expected in a few months. B. Reich of the Evans Signal Laboratory has measured the thermal resistance from junction to can as 30 C per watt. M. A. Logan has measured 26 C per watt. Both workers used the I_{co} method for determining the rise. As shown in Fig. 4 the hottest spot in the transistor is the collector junction immediately across the base from the emitter. Straightforward thermal calculations indicate that the temperature rise at this hot spot is probably four to five times greater than the rise determined by the I_{co} method. The I_{co} method inherently averages temperature over the entire region in which the reverse current is generated.

Structure and Manufacture

A cut-away view of the active region of a germanium pnp diffused base transistor[2] is shown in Fig. 4. As this sketch suggests, the production steps are: preparation of thin slabs (0.003 in.) of 1 ohm centimeter p-type germanium; diffusion of an n-type impurity layer 0.04 mils deep with an impurity concentration of about 10^{17} at the surface; evaporation and alloying of the aluminum emitter stripe; evaporation and alloying of the gold base contact; mounting of the wafer onto a header; masking with wax and chemical etching of the mesa; bonding of the gold wires to the emitter and base stripes; sealing it into the can.

This structure is inherently rugged. Its most fragile parts are the 0.4 mil gold wires. However, the wire lengths are such that centrifuge acceleration of more than 20,000 g may be applied in any direction without damage.

The most important structural features of the semiconductor crystals used in the 2N509 and the 2N537 are the very thin, heavily doped base layers and the location of the collector barrier layer largely on the collector side of the base-to-collector p-n transition. These features are essential to obtaining the short carrier transit times, low ohmic base resistances, low collector capacitances, and reasonable breakdown voltages required for good high frequency transistor performance. Transit times through the very thin base layers of these transistors are shortened significantly by the gradient of impurities inherently produced by diffusion[3, 4, 5]. This gradient sets up an electric field in the base which speeds minority carriers through the base from emitter to collector.

The techniques of diffusion of impurities into semiconductors and the evaporation of electrodes onto semiconductors are highly controllable. They produce large numbers of transistors per square inch of semiconductor material used. Diffused base transistors are therefore very manufacturable.

We can summarize the advantages obtained from the thin base layers and proper location of the collector barrier in diffused base transistors and from the diffusion and evaporation-alloying

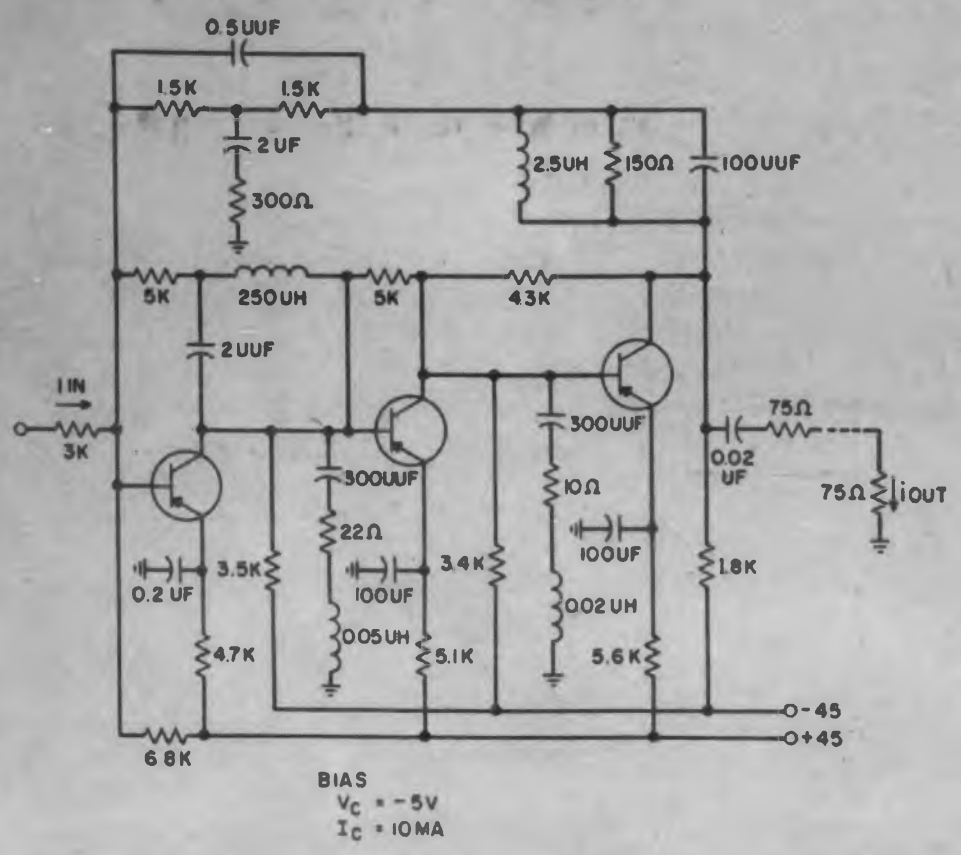

Fig. 5. Video amplifier circuit using 2N509 diffused base transistors.

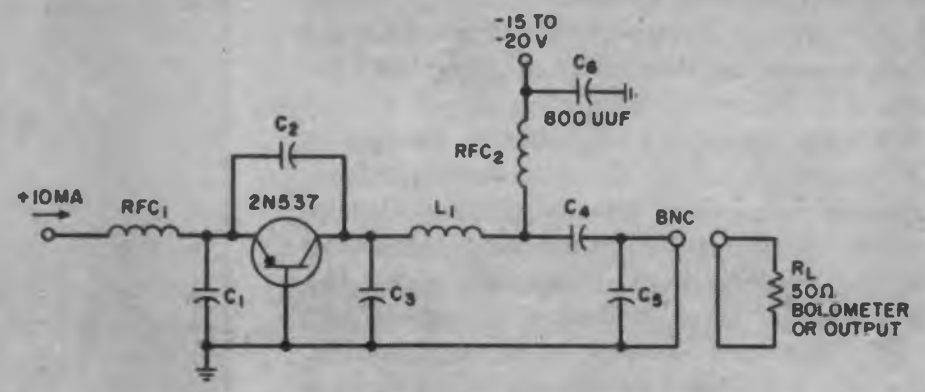

Fig. 6. Oscillator circuit employing the 2N537.

Table 2

		100 MC	250 MC	450 MC
C_1		3-12 UUF	2-7 UUF	<1UUF
C_2 (APPROX)		2	STRAY	STRAY
C_3		STRAY	STRAY	STRAY
C_5		15-90 UUF	7-45	8-13 UUF
L_1	DIA	1/2	3/8	1/4
	LENGTH	1 1/2	1	1/2
	WIRE	16	14	16
	TURNS	8	6	2
				COIL HAS 1/2" LEADS MOUNTING IS CRITICAL
APPROX POWER OUT		90 MW	60 MW	35 MW

techniques as:

- Very high $f\alpha$ (500-1500 mc);
- Low collector capacitance (0.3-1.5 mmf);
- Low base resistance (10-100 ohm);
- Relatively high voltage operation (in these types BV_{BC} — 40-45 v);
- Good manufacturability.

Typical Applications

The 2N509 is designed for moderate power video and uhf amplifier service. Fig. 5 shows a 50 mc video amplifier circuit designed by R. P. Abraham using 2N509's. This amplifier, designed to couple an fm discriminator to a 75 ohm line, has 35 db of current gain over its 50 mc band. The amplifier has 34 db of feedback. Reduction of the input resistor from 3000 ohm to 75 ohm would yield 35 db of stable power gain out to 50 mc with feedback of 28 db.

Median characteristics and specification limits of the 2N509 and the 2N537 are shown in Table I. Note that the principal differences are the high alpha in the 2N509 and the low ohmic base resistance r'_b in the 2N537.

The 2N537 is designed as a power oscillator for the vhf and low uhf range. Fig. 6 shows an oscillator circuit for the 2N537 designed by R. L. Lowell. The output powers shown in the Table 2 are for bias powers of 150 to 200 mw. Somewhat higher efficiencies are obtained at larger emitter currents. R. L. Lowell has designed a 1000 mc oscillator which radiates tens of milliwatts using selected 2N537's. This oscillator is to be displayed at the World Fair in Brussels this summer.

Summary

Two types of transistors, capable of operating in the 1000 mc range are now beyond the development stage and into production. These transistors are the 2N509, suitable for amplifier service, and the 2N537, intended for oscillator service.

The two transistors are intended for several hundred milliwatts of internal power dissipation, and operate in the hundreds of mc with high efficiency (10 to 45 per cent). These transistors maintain good characteristics up to about 100 C, hence will serve many functions previously reserved for silicon transistors.

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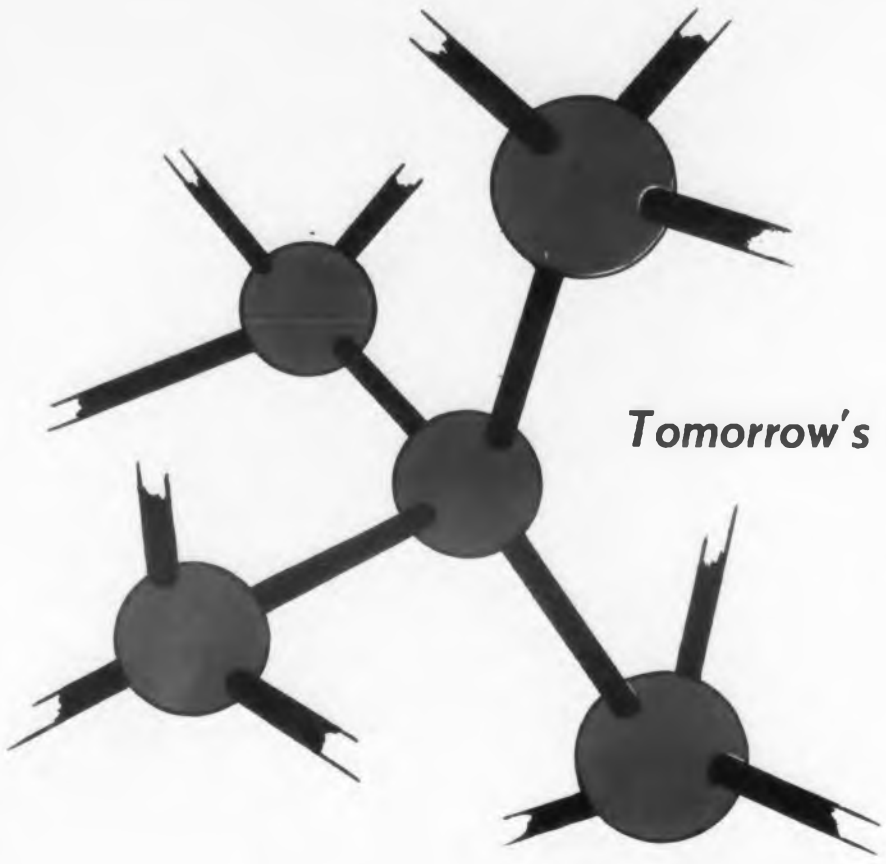

Tomorrow's Transistors Depend on Better . . .

Semiconductor Bulk Properties

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Boston 35, Mass.

DEVELOPMENT of solid state devices depends upon the purity and perfection of semiconductor crystals. In designing the ideal transistor, crystal characteristics are often in contrariety. In the case of leakage current problems at high temperatures, a large energy gap is required. The reverse is true if greater mobility of holes and electrons is required. Therefore better semiconductor materials must be made available having wider ranges of energy gap, mobility, conductivity, and lifetime. This article after discussing these electrical properties, describes how the need for a higher degree of crystal perfection is leading to improved devices and fabrication techniques. The magnitudes of the bulk properties (energy gap, mobility, conductivity, and lifetime) are listed in Table 1, along with the significant concentration of impurity.

The Need for Higher Energy Gaps

In germanium, with an energy gap of 0.7 electron-volt, the effects of leakage current are very serious at temperatures above 80 C. For many applications higher impedance pn junctions would be desirable at room temperature. Silicon with an energy gap of 1.1 ev gives exceptionally high impedance junctions at room temperature and operates satisfactorily even above 200 C. Higher energy gaps are available in intermetallic compounds such as gallium arsenide (1.45 ev), indium phosphide (1.25 ev), and silicon carbide (3 ev). These materials will make possible the operation of semiconducting devices at temperatures in excess of 500 C.

Mobilities of Germanium and Silicon

For high frequency devices high mobility of holes or electrons is required. Germanium is

Table 1 Magnitudes of Important Bulk Properties

Property	Desirable Characteristics	Significant Impurity Concentration (atom fraction)
Energy Gap	0.7 electron-volt	10^{-3}
Mobility	1000 cm^2/v sec	10^{-6}
Conductivity	Controlled magnitude, type, and geometry.	10^{-8}
Lifetime	10^{-5} sec	10^{-10}
Surface Properties	Stability	
Crystal Perfection	Highly perfect	10^{-3} dislocations/cm^2

Table 2 Energy Gaps and Electron Mobilities

Semiconductor	Energy Gap (electron volts)	Electron Mobility (cm^2/volt sec.)
Ge	0.68	3800
Si	1.10	1700
Ge-Si Alloys	0.8-1.0	~3000
GaAs	1.45	~4000
InP	1.25	~3400
GaSb	0.77	~4000
InAs	0.35	~23,000
InSb	0.18	77,000
$CuInSe_2$	0.9	~1000

superior in this respect to silicon since the mobility of charge carriers is about twice as great. However, certain of the intermetallic compounds with small energy gaps have extremely high mobilities, as much as a factor of 30 higher than that of germanium. Devices employing these compounds will be discussed subsequently. Table 2 lists the room temperature energy gaps and electron mobilities for germanium, silicon, and some of the intermetallic compounds.

Effects of Crystal Imperfections

Most semiconductor devices require adjacent regions of opposite conductive types (pn, np junctions), whose widths must be very accurately controlled. In high frequency transistors these regions may be as thin as 0.00005 in. In order to control junction geometry the semiconductor material must also have a high degree of crystal perfection including crystallographic orientation, low dislocation densities, and the absence of such gross imperfections as lineage and slip. Dislocations may be thought of as mistakes made in the ordinarily perfect arrangement of atoms in a crystal lattice. They arise from either accidents in the crystal growing process or the application of plastic deformation to the crystal. Since the dislocations are stress centers they will dissolve during alloying faster than the more perfect regions of lattice and thus make it difficult to control junction formation. In addition they tend to lower the junction breakdown voltage, increase reverse currents and limit the transfer of carriers. Thus the control and avoidance of these imperfections is fundamental to the production of semiconductor material suitable for device fabrication.

Lifetime Degrading Impurities

The lifetime, τ, of an injected carrier is the time constant describing the rate at which carriers of one type recombine with carriers of the opposite type. Preserving minority carrier lifetime places the most stringent requirements on purity and crystal perfection. Impurities such as nickel and copper in germanium and gold and iron in silicon of one part in ten billion are sufficient to markedly decrease the lifetime. Since the low level grounded emitter gain of a transistor, β, is given by:

$$\beta = \frac{2D\ \tau}{W_B{}^2}$$

where W_B is the base width of the transistor, the gain may be affected by the presence or absence of lifetime degrading impurities. Similarly dislocation densities must be less than 10^4 per cm^2 to insure high lifetime, and high gain as well as ease of fabrication.

(Continued on page 18)

Processes. The diffusion of impurities from the vapor phase into the solid semiconductor promises an extremely reliable and controllable process for fabricating closely spaced, uniform junctions. The need for such junctions is one of the limitations on the frequency response of junction transistors. Units have been made by this technique which amplify and oscillate at frequencies well over 1000 mc with controlled impurity layers as thin as 0.00003 in. In addition, a given gradient of impurities in the diffused layers may be obtained by the proper choice of both diffusion temperatures and impurity vapor pressures.

Zone-refining has made it possible to prepare germanium and silicon with no more than one part per billion of electrically-active impurities. In zone-refining a molten zone is swept through an ingot of the semiconductor material, sweeping impurities to one end of the bar, taking advantage of the fact that the solubility of the impurities in the liquid is greater than in the solid material.

Since copper and nickel diffuse very rapidly into germanium, and gold and iron diffuse rapidly into silicon at the temperatures necessary for the fabrication of devices, efficient methods for removing these undesirable impurities must be found. Various techniques such as getting materials on the semiconductor surfaces, forming a metal semiconductor eutectic which leaches out the impurity, and annealing to precipitate the impurity, are being investigated.

The requirement for a higher degree of crystal perfection has led to improvements in the crystal growing process. Crystals of germanium and silicon can now be produced almost free from lattice defects.

Materials. The intermetallic compounds promise new and interesting devices. These may be divided into three classes: higher temperature and frequency transistor-like devices; infrared, ultraviolet and visible light sensing devices; and magnetic sensing devices. The first class of devices depends on the very large energy gap of certain of the intermetallics. For instance, use of silicon carbide as a semiconductor should permit transistor operation above 500 C. Furthermore the large carrier mobilities of the intermetallics makes possible the much higher attainment of frequency response than now possible (as large as a factor of ten greater than that of germanium).

Sensitivity to radiation of a particular wave length is also possible with these compounds because of their wide variation of energy gap. When these effects are better understood we have available photo-sensing devices set for fixed frequencies or bands of frequencies.

The electrical properties of these materials also show very large changes in the presence of magnetic fields. In indium antimonide very large magneto-resistance effects including resistance changes of as much as 20:1 are obtainable with convenient magnetic fields. This property can be used to make variable resistors without sliding contacts, such resistors being electronically controlled for use in servo-systems or current stabilizers.

New Devices. A whole family of devices stem from the use of the Hall effect. Devices for measuring magnetic field strength, an electric compass, a high sensitivity magneto-meter, clip on current ammeters for dc systems, multiplying elements in analog computers, a dc Hall amplifier are a few of the possibilities. The attractiveness of indium antimonide for these devices arises from its high power efficiency which is some 300 times higher than for germanium. The sharp conductivity change of indium antimonide when subjected to a magnetic field may also be adapted to a relay with no moving parts which can be switched from on to off with the application of a magnetic field.

Since work on the intermetallic semiconductors was started relatively recently their purity and crystal perfection does not equal that available for germanium and silicon and the carrier mobilities are still limited by impurities and imperfections. Further work is required to control their conductivity sufficiently for transistor applications.

The advent of new techniques and devices must be examined against a background of the economics concerned. Semiconductor progress in the beginning encountered great difficulties in manufacture with yields of usable devices as low as 15 to 20 per cent of starts. Much of this difficulty has been overcome with standard devices in mass production operations and a continual effort is directed towards increasing yields and in reclaiming as much waste material as possible.

Silicon has proved to be more difficult to process than germanium because of its extreme activity and high melting point. Uncontrolled impurity variations from lot to lot of the raw material are reflected in lower device yields and in higher unit costs. Silicon cannot be purified by ordinary zone melting techniques as can germanium, because the impurity element boron possesses a distribution coefficient in silicon of nearly unity and does not segregate on zone melting. In addition, quartz, the only crucible material found practical for melting silicon, contains sufficient boron so that repeated recrystallization in quartz results in the contamination of silicon by the quartz. Before silicon is competitive with germanium, the industry must reduce the cost of the basic material by overcoming these technological difficulties.

Fig. 1. Model 66 voltage limiter.

Voltage Limiter

Protects Transistors

TRANSISTORIZED equipment is cleverly protected by this voltage limiter that both instantaneously clamps the dc voltage and removes input power from the power source. In many transistor applications, the briefest overvoltage causes the transistor to start over-heating and possibly race away to destruction. This can be very costly where a large amount of semiconductor equipment is undergoing life or heat tests. The voltage limiter described here has been developed to protect transistors from damaging overvoltages, particularly those overvoltages of a transient nature.

Effective Voltage Limiting

Model 66 voltage limiter manufactured by Electronic Measurement Co., Inc., combines the best features of typical voltage limiters. Upon overvoltage, the dc voltage is instantaneously clamped, and while the clamp is holding the voltage, input power is quickly removed from the power source.

Operation of the voltage limiter shown in Fig. 1 is straightforward, requiring no special procedures. A glance at Fig. 2 is sufficient to determine the required connections. The cut-off point may be set to any value between 0 and 50 v by means of a continuously variable front panel control.

A semiconductor provides a clamp with an adjustable operating level. The return path for the clamp current is through the winding of relay *K1*. If the power supply voltage E_o exceeds the operating level at which the clamp is set, clamp current operates relay *K1* which in turn short circuits the dc line and disconnects ac power. During the time required for the relay to operate,

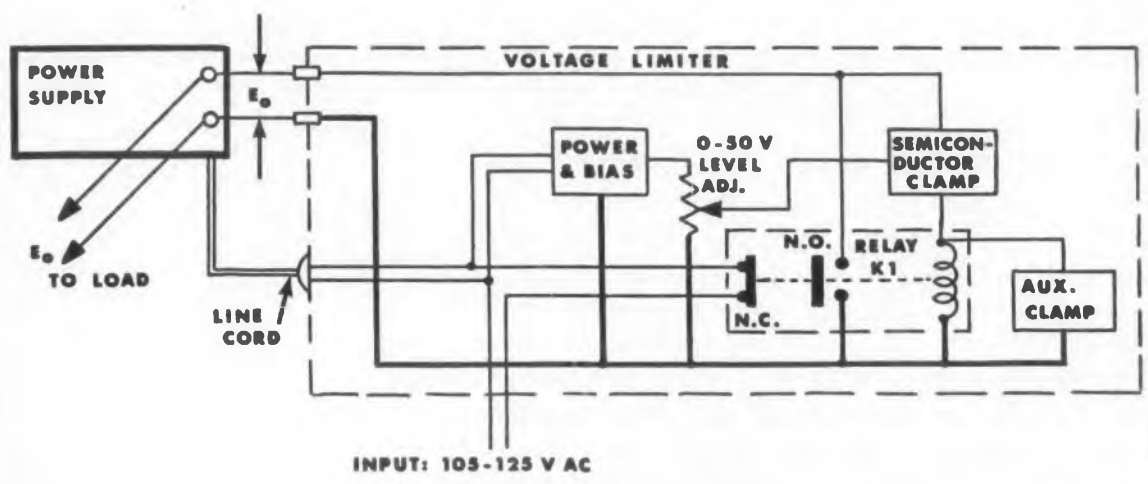


Fig. 2. Simplified functional diagram.

the clamp continues passing current, holding E_o within very narrow limits of its initial value.

Operating Characteristics

The curves in Fig. 3 show the behavior of the clamp at two different operating levels, namely 10 and 50 v. With the clamp set at 50 v, trip-out occurs at less than 50.8 v. The 50.8 v point corresponds to 130 ma. This is the minimum current required for relay trip-out. If the power supply is capable of furnishing more than 130 ma during the surge, the limiter will absorb the additional current. However, there will be a slight increment of voltage due to the additional current. For example, as shown in the graph, an available current of 1 amp during clamp operation will produce a voltage of about 1.1 v above the nominal setting. At 2 amp the rise is still very low, being about 1.5 v above nominal. These slight increments are well below the level of the voltage spikes generally responsible for damage.

The voltage increment plotted against limiter current for the 10 v curve is approximately the same as for the 50 v curve. Although this represents somewhat of an increase percentagewise over the 50 v curve, it is still a small increase compared to the nature of most damaging transients. Additional curves for other voltages can be extrapolated.

Limiting occurs at the very beginning of an overvoltage, however, as indicated in the graph, the relay will not operate until the clamp current reaches or exceeds 130 ma. Therefore, the power supply should be capable of furnishing at least 130 ma, the minimum required for relay trip-out.

For more information, turn to the Reader-Service card and circle 15.

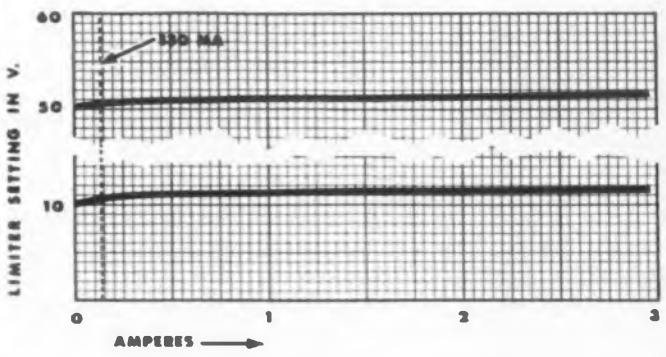


Fig. 3. Voltage increase above nominal limiter setting vs available current at time of limiter trip out.

Variations Of Transistor Parameters With Temperature

W. J. Maloney

General Electric Co.
Semiconductor Products Dept.
Syracuse, N. Y.

TRANSISTOR parameters variations wi small changes in temperature may be greate than suspected by the designer. The magnitude of variation of important transistor parameter are shown in Figs. 2-6. Ambient temperatur for testing range from 25 to 45 C (77 to 113 F The following parameters were considered:

- Grounded emitter power gain, G_e, at 455 kc
- Reverse voltage feedback, h_{rb}, at 1 m grounded base
- Collector current with base open, I_{CEO}
- DC beta, h_{FE}, with a constant base current

The parameters investigated are those direct affecting small signal radio frequency amplifier All tests were performed at $V_c = 5$ v and $I_E =$ ma except where other conditions are noted. Th power gain was measured in the circuit show in Fig. 1. The gain figures are in decibels an represent the circuit gain rather than the tra sistor gain. [Ozalid copies of other test circuit for various parameters may be obtained by writ ing to the editors.]

In addition to the difficult application proble classification of the units presents an associate

(Continued on page 2

W. J. Maloney joined the Sem conductor Division of GE thre years ago. Prior to obtaining h degree in electrical engineerin from Lehigh University, h served six years in the navy a electronic technician. His mai area of effort is the evaluatio of specification on products an specific applications encompass ing instrumentation, parametri variations, and product stabilit as they affect both the produc and its application. The author i shown demonstrating the impo tance of transistors to the young er members of his family.

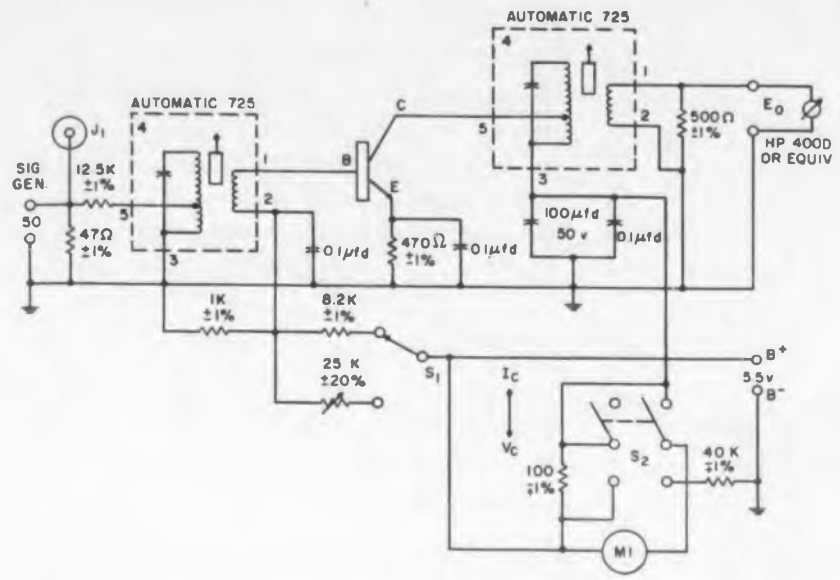


Fig. 1. Test circuit used to measure the effects of temperature on transistor parameters. 300 Ge, npn, rate grown transistors, types 2N168A, 2N292, 2N169 and 2N193, were tested. Figs. 2-6 show the changes in specific transistor parameters with temperature, assuming negligible effects of circuit parameters.

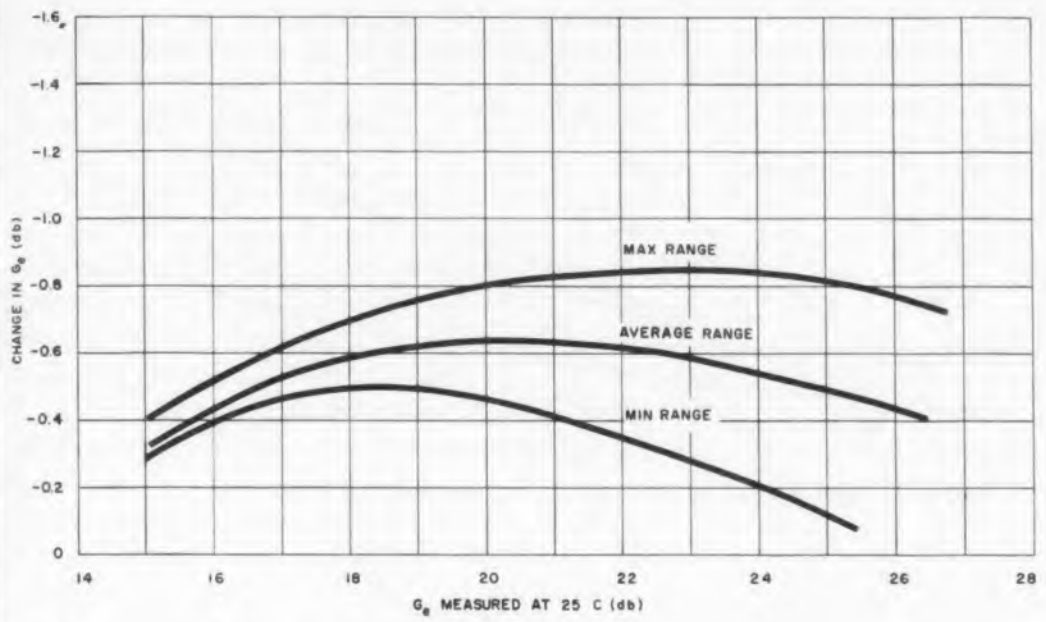


Fig. 2. The curves show the minimum, average and maximum changes in power gain, G_e, caused by increasing ambient transistor temperature from 25 to 35 C.

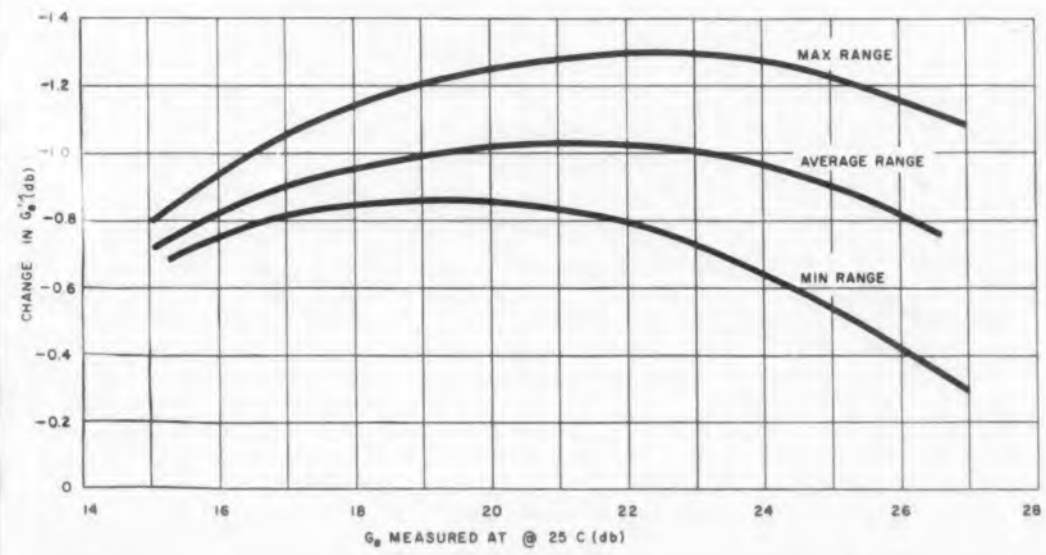


Fig. 3. Change in G_e caused by increasing ambient temperature from 25 to 45 C.

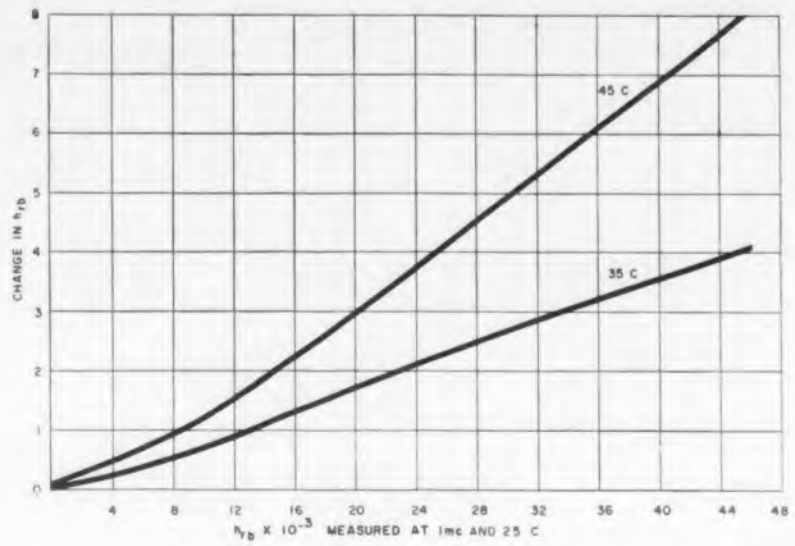


Fig. 4. Change in reverse voltage feedback ratio, h_{rb}, with increase in temperature.

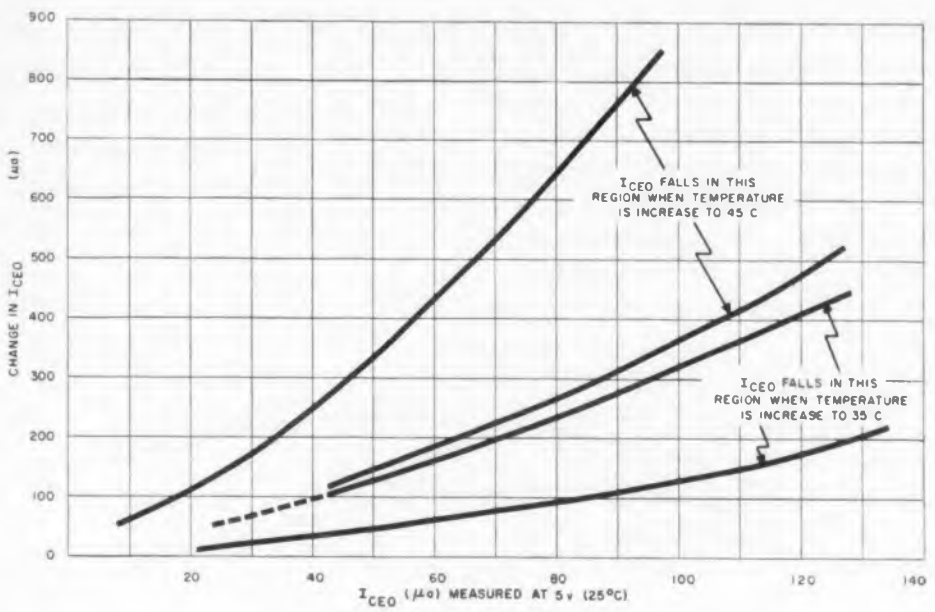


Fig. 5. Change in I_{CEO} for changes in transistor ambient temperature.

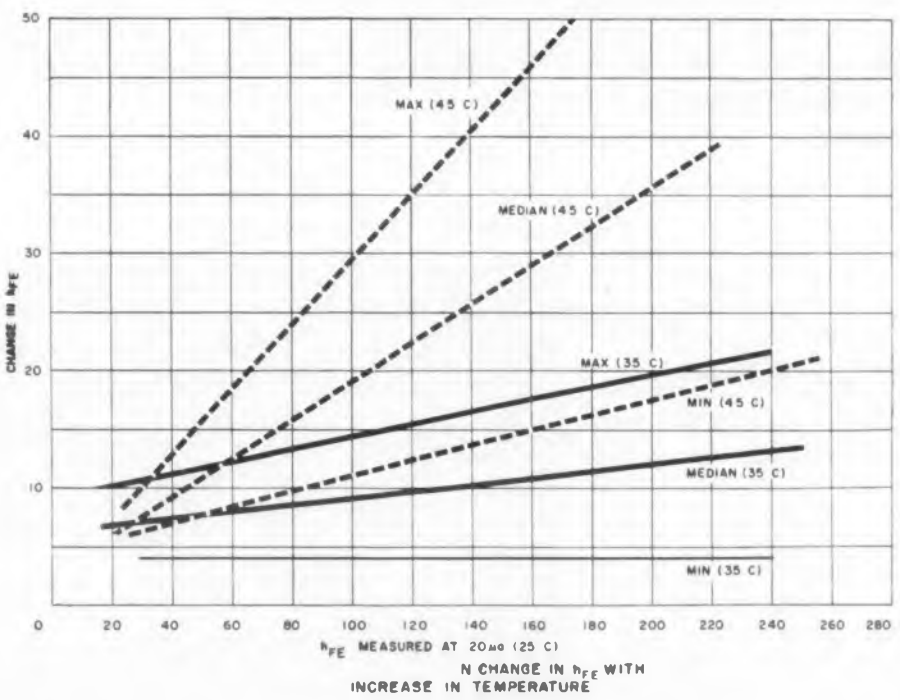


Fig. 6. Change in h_{FE} with increase in temperature.

problem where the value of any parameter will change with ambient temperature. This can be associated either with a manufacturer's production and quality control testing or with a customer's incoming inspection testing. The temperature of 25 to 45 C are typical ambient values encountered in production testing.

Parameters

Power gain, G_e, decreases with an increase in ambient temperature, as shown in Figs. 2 and 3. The magnitude of decrease is dependent on the original reading at room temperature and the temperature rise.

The change in reverse voltage feedback, h_{rb}, increases at a nearly linear rate with respect to the 25 C reading. See Fig. 4. The slope is dependent upon the new ambient temperature. The collector capacity increased. The change was essentially a constant equal to 0.25 μμf increase when the ambient was raised to 35 C and 0.4 μμf increase for an ambient of 45 C. Alpha cutoff frequency decreased. Again the change was constant amounting to 0.3 mc change when ambient temperature was raised to 35 C and 0.5 mc change for 45 C.

The breakdown voltage with the base open is constant with temperature. However the inherent current level increases with temperature. Fig. 5 shown a plot of I_{CEO}, the current level, at 5 v for various temperature conditions. Obviously I_{CEO} increases with temperature and when testing V_{CEO} or V_{CER} to a specified current level, the test may indicate a decrease in V_{CEO} or V_{CER} depending on the current level. The results will be influenced by I_{co}, h_{FE} and the specified current level as well as the temperature. Hence, specific conclusions must take these into account.

DC beta, h_{FE}, increases with temperature. See Fig. 6. Correlation to any readily available parameter is not apparent.

Conclusions

Changes in transistor parameters are large enough to cause major problems even with small changes in ambient temperature. Tolerances on inspection specifications must take this into account. In some cases, such as dc beta, the problem is compounded since the variations are large and erratic and not readily related to a simple measurement technique. These changes can cause major problems where large quantities of transistors are tested unless the ambient temperature is controlled.

Reference

High Frequency Power Gain of Junction Transistors, R. L. Pritchard, Proceedings of IRE, Vol. 43, pp 1075, Sept., 1955.

Transistor Impedance Nomogram

T. R. Nisbet
Alto Scientific Co.
Palo Alto, Calif.

MATCHING transistors to circuits and vice versa is made simpler with these nomograms. In each of the four nomograms, the key shows the method of operation. Where a curve is used, the traversing straightedge should be laid tangent to the curve. Certain scales can be multiplied by any factor, provided certain other scales are also multiplied. To make the arrangement easy to use, one point on each of the relative scales has been labeled with one alternative value. Scales bearing the same type of label (e.g. outlined by a single or double line) must be dealt with in the same way.

Because of the nature of the equations various amounts must be added to or subtracted from the data before or after using the nomograms. In many calculations, however, these amounts are negligible. Details are shown in a note on each nomogram.

Common Emitter Examples

A transistor with $r_b = 500$ ohms, $r_e = 50$ ohms, $r_c = 2$ megohms, $\alpha = 0.96$, is used in the following situations:

Ex. 1. Load resistance 20 K: find input resistance. Nomogram shows $R'_i = 960$. Add $r_e + r_b$. Input resistance = 1510 ohms.

Ex. 2. If input resistance is to be 5000 ohms, and load resistance is 20 K, find the series resistance to be added in emitter circuit. $R'_i = 5000 - r_e - r_b = 4450$ ohms. Nomogram shows emitter resistance to be 230 ohms. Subtract r_e. Required additional resistance = 180 ohms.

Ex. 3. Generator resistance is 400 ohms. Find output resistance. $R_g = 400 + r_e + r_b = 950$ ohms. Nomogram shows $R_o = 181$ K.

Common Collector Examples

Ex. 4. Assume the same transistor characteristics as listed for common emitter examples. Load resistance, 160 K; find input resistance. Using multiplier on nomogram scales, $R_i = 1.33$ megohms.

Ex. 5. Output resistance, 15.5 K; find generator resistance. Nomogram shows this to be 480 K.

A useful scale for converting between α and β is available on the *input vs load resistance, common collector* nomogram. *(Continued on page 28)*

ELECTRONIC DESIGN **Engineering Data**

Transistor Impedance Nomograms—1

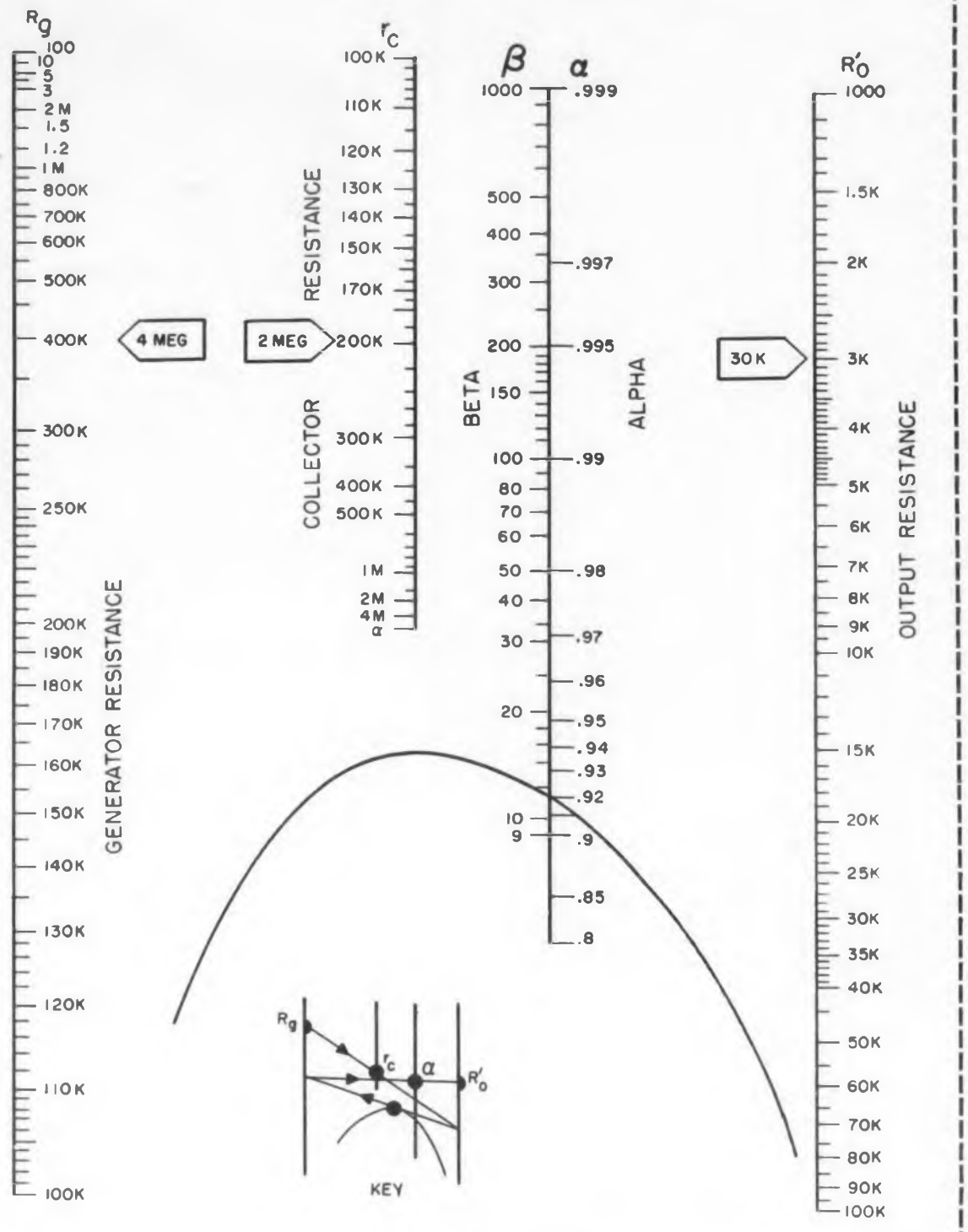


Fig. 1. Generator resistance vs output resistance, common collector. Note: nomogram uses R'_o as equal to the output resistance. True output resistance is $R_o = R_o + r_e$.

ELECTRONIC DESIGN

Engineering Data

Transistor Impedance Nomograms—2

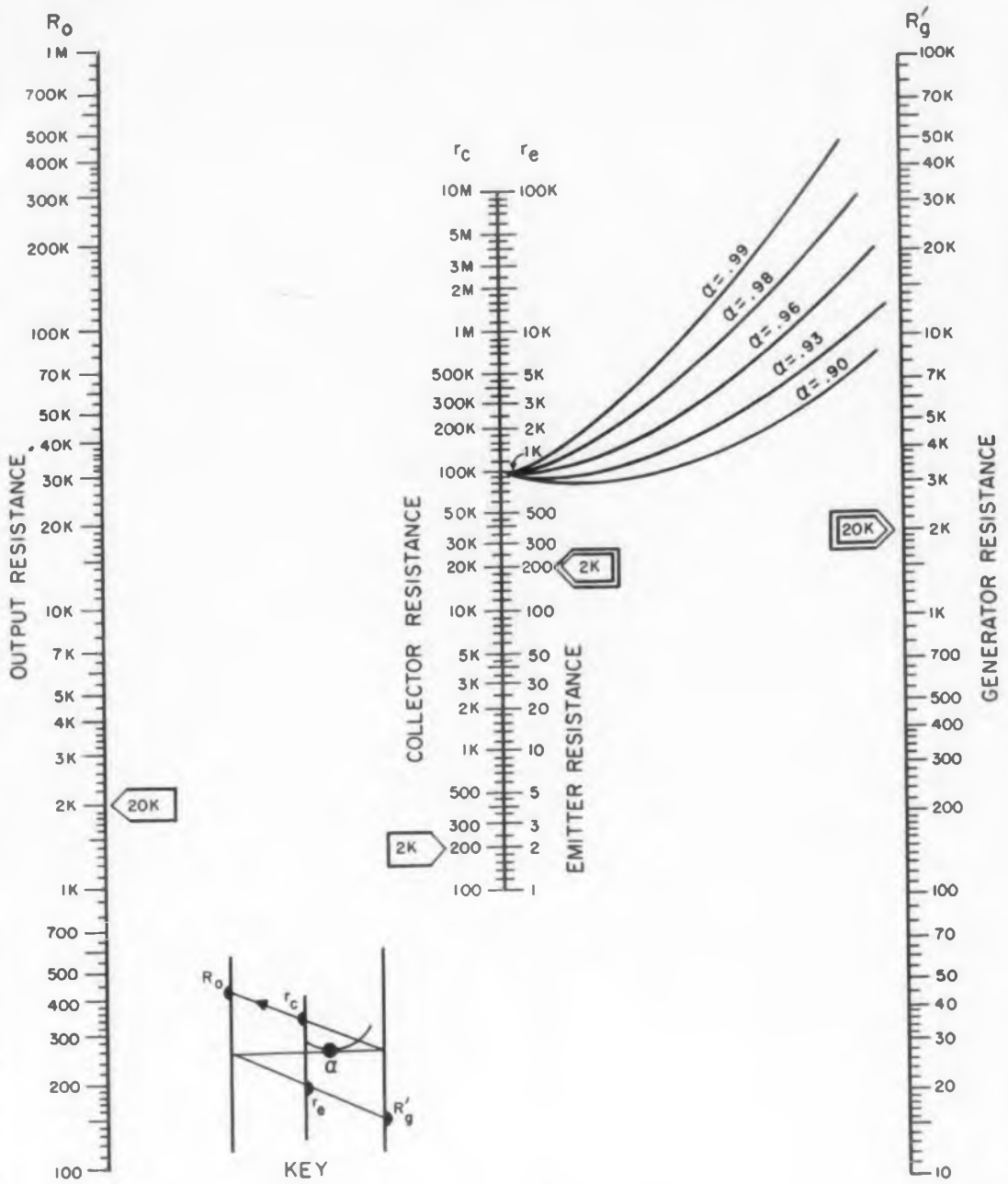


Fig. 2. Generator resistance vs output resistance, common emitter. Note that the nomogram uses R'_g as equal to the generator resistance, though true generator resistance is $R_g = R'_g - r_e - r_b$.

ELECTRONIC DESIGN Engineering Data

Transistor Impedance Nomograms—3

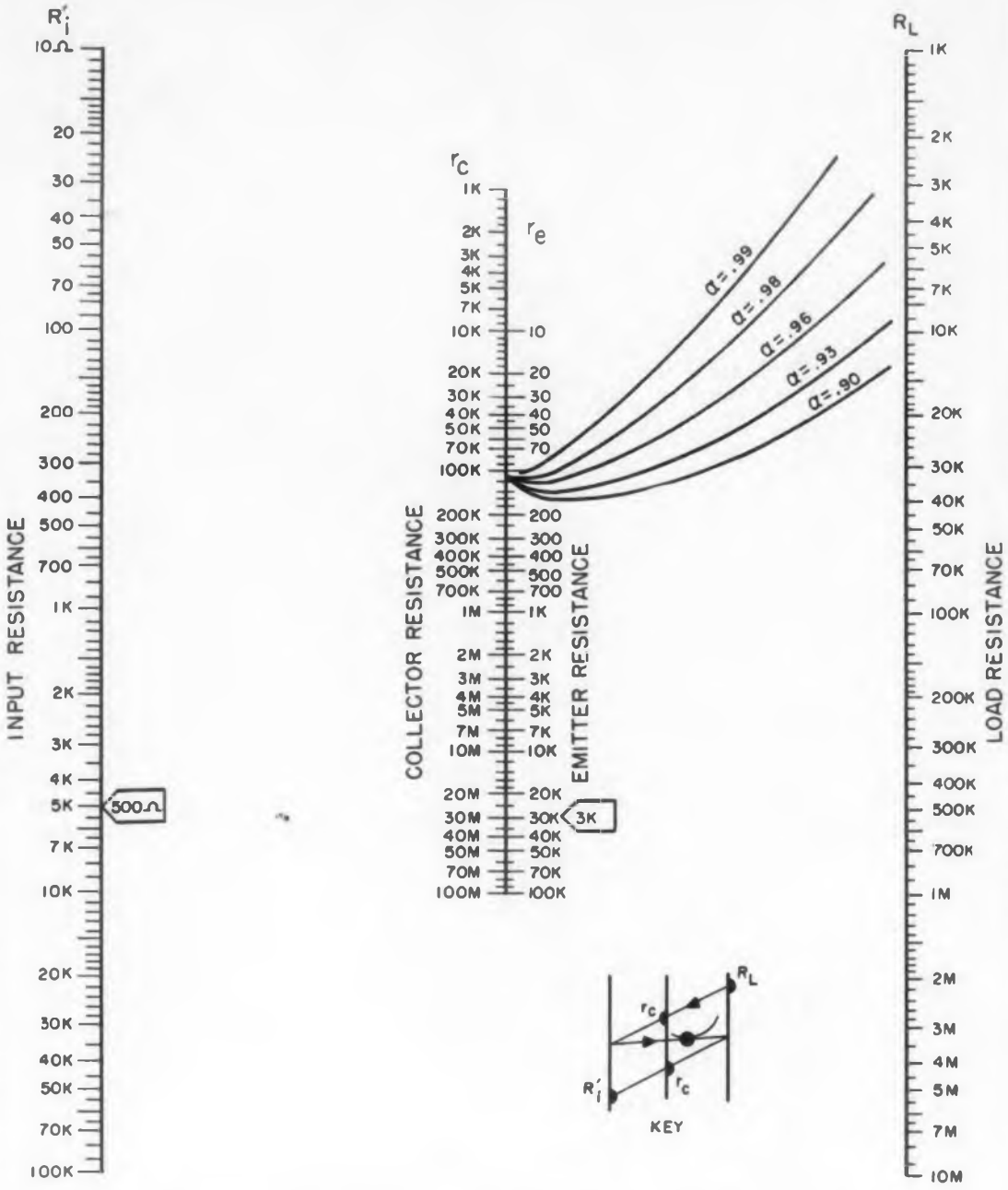


Fig. 3. Input resistance vs load resistance, common emitter. The nomogram uses R'_i equal to the input resistance. True input resistance is $R_i = R'_i + r_b + r_e$.

The equations from which these four nomograms have been developed are as follows:

Common emitter.

$$R_i = r_b + r_e\left[\frac{r_c + R_L}{r_e\,(1-\alpha) + R_L}\right]. \text{ No assumptions.}$$

$$R_o = r_c\,(1-\alpha) + r_e\left(\frac{\alpha\, r_c + R_g}{r_e + r_b + R_g}\right), \text{ assuming}$$

ELECTRONIC DESIGN

Engineering Data

Transistor Impedance Nomograms—4

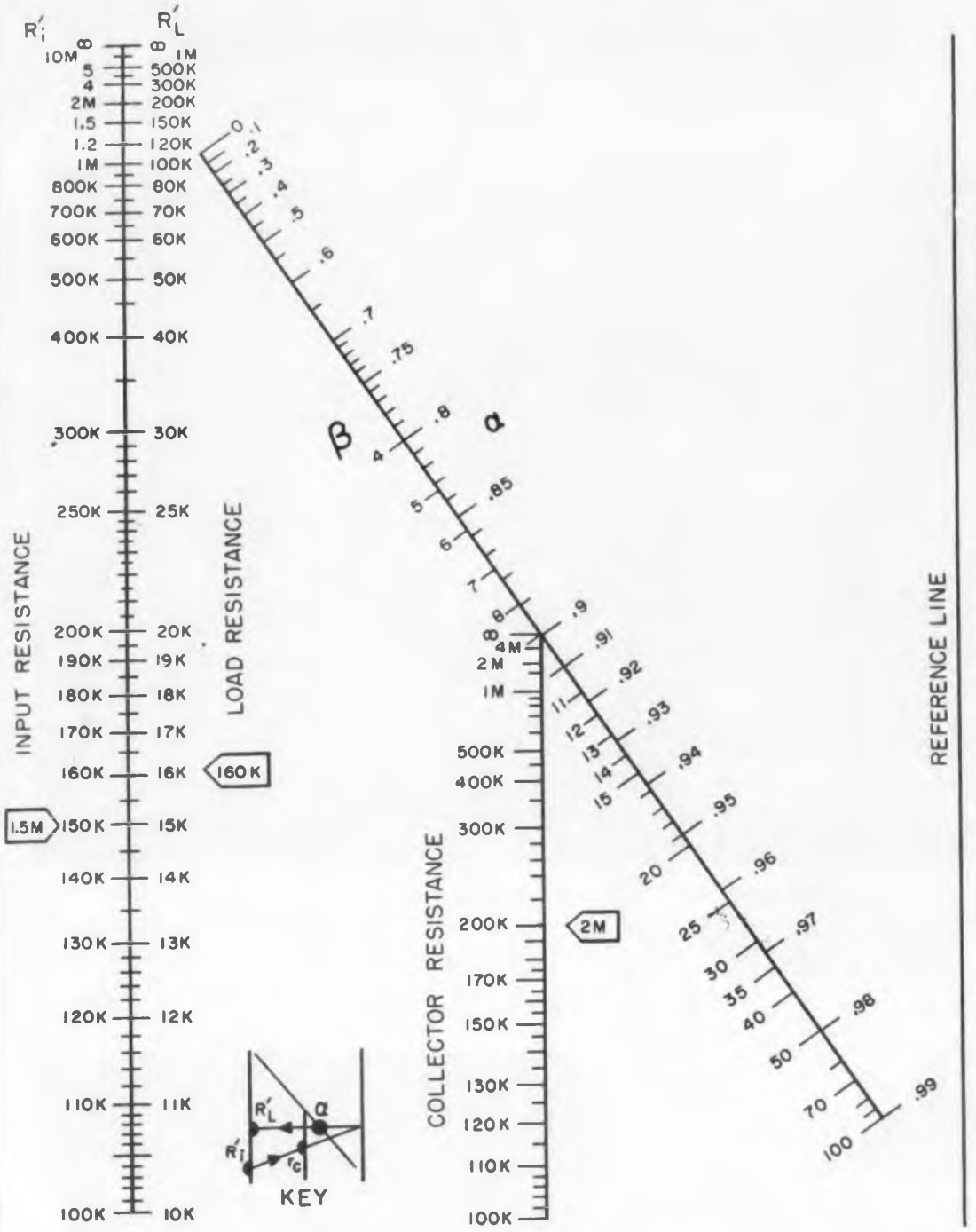


Fig. 4. Input resistance vs load resistance, common collector. In this nomogram R'_i = input resistance and R'_L = load resistance. True equations for these are $R_i = R'_i + r_b$; $R_L = R'_L + r_e$.

that $\alpha r_c \gg r_e + r_b$ and $R_o \gg r_e$.

Common collector.

$R_i = r_b + r_c\left(1 - \dfrac{r_c - \alpha r_c}{r_c + \alpha r_c + r_e + R_L}\right)$. No assumptions. Assuming that $r_c \gg r_b$, then $R_i = r_e + r_c - \alpha r_c - [(r_c - \alpha r_c)\, r_c/(r_b + r_c + R_g)]$.

GUARANTEED core performance limits will be a boon to designers of computer drive circuits, switching matrices, shift registers, core-diode memory systems and pulse transformers. Engineers can now buy bobbin cores with tight maximum and minimum limits on open circuit characteristics, core flux, and squareness.

By defining and guaranteeing performance limits, Magnetics, Inc. has taken the first step towards placing cores on the same catalog basis as vacuum tubes and resistors. The Butler, Pa. firm also guarantees performance limits on B_m, B_r/B_m, H_1, and gain for tape wound cores.

New Core Protection

Protections are now available for tape wound and bobbin cores. A tough glass polyester cap completely protects cores during handling and use, while a new finish for aluminum tape wound core boxes guarantees a minimum voltage breakdown of 1000 v at 60 cps.

Tough Core Caps

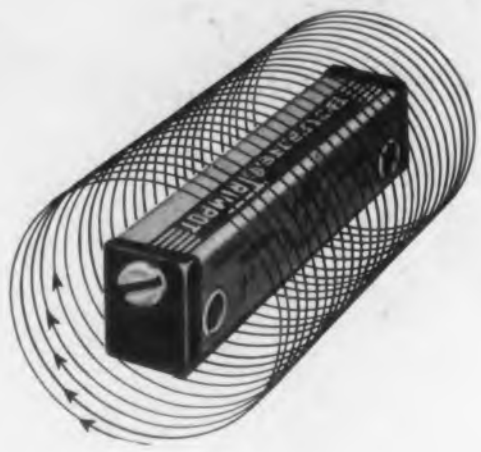
The "Poly Cap" cores are available for both stainless steel and ceramic bobbins. The rigid structure of the new cap does not distort with wide temperature changes, and thus, allows freedom of handling, and assures against damage or changes in core characteristics.

The permanent protection of these caps (unbreakable in normal use), not only lowers production costs, and assures performance stability, even after potting, but actually allows for smaller cores because the cap fits over the top of the flanges rather than requiring encapsulation.

Guaranteed Voltage Breakdown

The new finish for the aluminum boxes for tape wound cores insulates the windings from the box without taping—and over a temperature range from —70 to +450 F. By eliminating the need to tape the core box, cost and production time are knocked down. This GVB finish is compatible with any standard potting compound, and allows vacuum impregnation down to 20 mm of mercury.

For more information on these new developments, turn to the Reader Service card and circle 25.



YOU GET 33 TIMES THE ADJUSTABILITY

WITH BOURNS POTENTIOMETERS!

Compared with the conventional single-turn rotary potentiometer, the adjustability of Bourns potentiometers is a 33:1 improvement. Providing 9000° of rotation instead of 270°, Bourns potentiometers *simplify* and speed up the adjustment or balancing of circuits. You can repeat any setting quickly and easily. Settings are virtually immune to shock, vibration and acceleration. Translatory action of wiper provides inherent stability. The rigidly mounted wiper is driven by a threaded stainless steel shaft, which is actuated by your screwdriver. No need to recheck settings after a lock-nut is tightened. There *isn't* any lock-nut. Available with printed circuit pins, solder lugs, or stranded insulated leads.

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Model Summary Brochure

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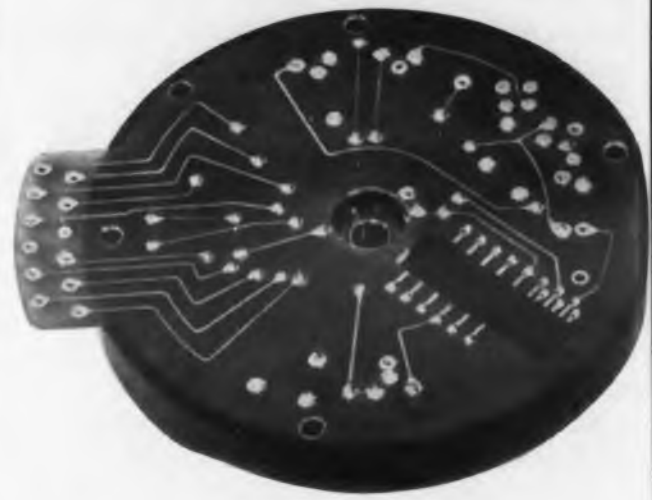
CIRCLE 27 ON READER-SERVICE CARD

Error-Free



Analog/Digital

Converter

Unbuttoned A/D converter shows staggered segments on 3-1/2 in. disc. Ten bit resolution and no ambiguity for "on the fly" reading is obtained in this way, with an unusual internal switching network.

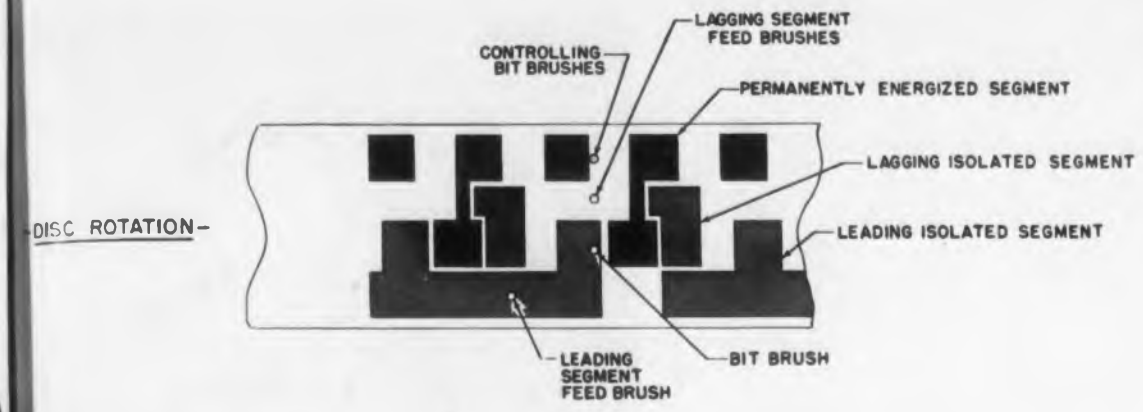


Fig. 1. Staggered pattern of disc. Black areas are permanently energized, shaded areas are the leading and lagging portions of the segments. The electrical status of the bit brush is a function of a logic circuit formed by feed brushes and conducting segments. Control of the logic circuit is by the controlling bit brushes.

UNAMBIGUOUS ten bit resolution on a 3-1/2 in. disc results from staggering bits on two concentric tracks in this new analog to digital converter. Ambiguity is controlled by preventing the transition of any of the nine most significant bits—except when they coincide with the least significant bit. An unusual combination of bit tracks and transistorized logic circuits provides the 10 bit resolution.

Designed by Librascope, Inc., Glendale, Calif., the converter uses 17 brushes —one readout brush per digit, six feed brushes, and one common brush. The disc pattern shown in Fig. 1 is designed so each normally-conducting segment has an electrically isolated leading and lagging portion (shaded areas).

The unique brush arrangement coupled with the transistor logic eliminates ambiguous outputs due to time differences in bit transition. The transition of a single brush depends on the simultaneous transition of the controlling bit.

Ambiguity in earlier disc converters usually resulted from disc misalignment. Miscounts and noise resulted. To dodge this problem, some computers operate only on information received when the converter's input shaft has been stopped and locked. This eliminates ambiguity, all right, but decreases the amount of data available to the computer during any interval.

Other converters use either special numerical codes—requiring that only one digit change at a time—or some combination of electrical and mechanical techniques to prevent errors. With these, a translator is needed for the output. The computer usually accepts only binary or binary coded decimal systems.

A double brush system, formerly used by Librascope, required that two brushes be used on the more significant track, instead of one. The angular distance between each of the double brushes and the single, least significant brush was half the angular length of the least significant segment. A switching circuit, controlled by the signal from the single brush, eliminated the transition between conductive and nonconductive segments. Need for this switching made the system more complex.

The new A/D converter can be used with conventional data logging equipment, and as a source of digital information in computer facilities. It can be used in a host of applications. Typical ones include supplying integration information for aircraft engine thrust measurements; and in recent computer work, finding the convolution integral, given a weighting function and an independent function.

In the latter application the independent function is represented by the input shaft position as a function of time, and the weighting function is approximated by adjusting the computer's sampling rate.

For further information on this error-free A/D converter, turn to the Reader-Service Card and Circle 28.

NEW PRODUCTS

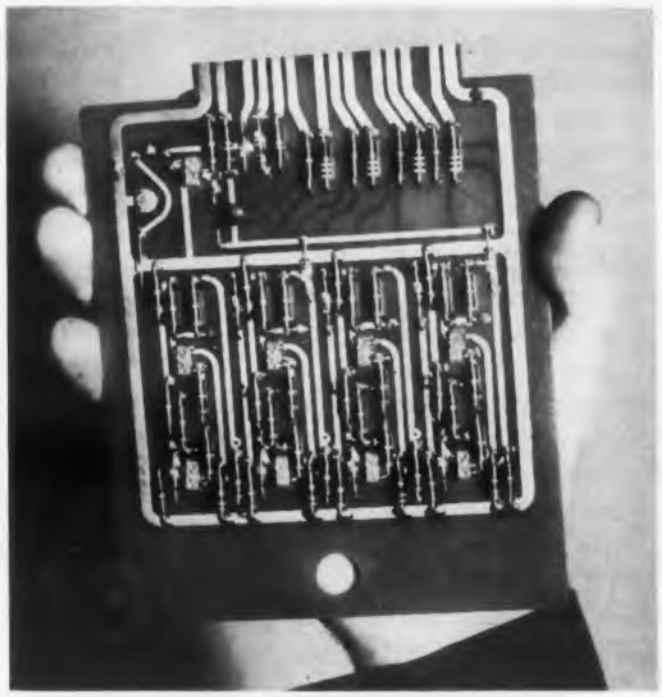
To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the largest number of items, products which are best suited to a brief description have been noted at the end of the section.

APR CAMERA

Up to 24 channels of low frequency data are stored on 16 mm film by the automatic processing and recording camera. The record is automatically developed and fixed internally by conventional processing methods. Processing is completed within 5 to 10 minutes depending upon film speed. Utilizing precision galvanometers, the APR camera has a resolution of 20 cps for a film speed of 3 cm per min, and a linearity of better than ± 1 percent.

The Geotechnical Corp., Dept. ED, 3712 Haggar Dr., Dallas 9, Tex.

CIRCLE 30 ON READER-SERVICE CARD



DECIMAL COUNTER

Providing a four line 1-2-4-8 code, with 4 ma drive available directly from each of these lines, this transistorized counter has the output amperage necessary for a variety of recording purposes. The counter is designed to operate from negative pulses of approximately 2 v amplitude and 1 to 2 μsec in duration, and at operating speeds from 0 to 150 kc.

Navigation Computer Corp., Dept. ED, 1621 Snyder Ave., Philadelphia 45, Pa.

CIRCLE 31 ON READER-SERVICE CARD

VARIABLE CAPACITOR

The Semicap, a silicon variable capacitor, has a Q of over 1000 at 1 mc, with a 10 to 1 capacity ratio well within its piv rating of —200 v dc. Applications are in automatic frequency control, frequency modulation oscillators, and bandpass and filter networks where precision capacitance control is needed.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 32 ON READER-SERVICE CARD

TOROIDAL INDUCTORS

Large inductance values, despite a relatively small size, are featured in series 781 toroidal inductors. Inductances range from 1 mh to 7 h, in a useful frequency range of 100 cps to 80 kc. Maximum Q for a typical 50 mh inductor operating at 11 kc is 130. The line is designed for printed circuit boards, or stacking on a single screw for chassis mounting.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 33 ON READER-SERVICE CARD

NEW PRODUCTS

Radar Test Set

Combination X and C band

A combination X and C band radar test s has been designed into one compact unit. Mo W 909-1C-A has all four master functions of sp trum analyzer, power monitor, signal generat and direct reading frequency meter. Identical function with standard single band models, unit has a stacking arrangement that permits dual performance check.

Kearfott Company, Inc., Microwave Di Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

CIRCLE 35 ON READER-SERVICE CARD

Phase Measuring Units

Accuracy of ±2-1/2 per cent

Type 410 phase meter features: no tubes, b tery, or power supply; no error due to harmo or noise content; no amplitude adjustment, zeroing; direct reading in degrees; no drift, warm-up period required; and accuracy ±2-1/2 per cent. Type 206 microsecond indicat measures: phase angle between two puls modulated sine waves; time interval betwe any two points of an irregular pulse; time del of a four-terminal network; and time interv between an incident and its reflected puls through a medium.

Ad-Yu Electronics Lab., Inc., Dept. ED, 2 Terhune Ave., Passaic, N.J.

CIRCLE 36 ON READER-SERVICE CARD

Synchronous Motor

Delivers 12 oz-in. torque

This hysteresis synchronous motor, size 10 with a maximum length of 1-3/16 in., will operate directly from 115 v line, 400 cps, single or three phase, delivering 12 oz-in. at 800 rpm pull out torque. The unit can be supplied with a gearhead with a maximum length of 2-1/8 in. up to a ratio of 200:1 and with a maximum length of 2-3/8 in. up to 10,500:1.

Servomechanisms, Inc., Mechatrol Div., Dept. ED, 1200 Prospect Ave., Westbury, N.Y.

CIRCLE 37 ON READER-SERVICE CARD

Filament Transformer

For transmitting tubes

Type P-6463 filament transformer has been designed especially for use with the Eimac 4CX1000A transmitting tube. The unit provides center-tapped secondaries of 6.5 or 7 v, at 13 amp. Primary is 117 v, 60 cps. The P-6463 is designed to withstand 2000 v rms.

Chicago Standard Transformer Corp., Dept. ED, 3501 Addison St., Chicago 18, Ill.

CIRCLE 38 ON READER-SERVICE CARD
CIRCLE 39 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Recorder Calibrator

Checks airborne tape recorders

A recorder calibrator, designed for checkout and calibration of airborne analog tape recorders has been developed. Voltage can be supplied to all recorder circuits from a single 28-v dc source. Voltages to supply bias current and motor drive are available. A signal current is supplied in various steps as desired to within 0.1 per cent through a Ledex type of switch. Any normal bridge type of end instrument may be calibrated.

Aerophysics Development Corp., Div. Curtiss-Wright Corp., Dept. ED, P.O. Box 689, Santa Barbara, Calif.

CIRCLE 42 ON READER-SERVICE CARD

Pressure Transducer

Has high sensitivity

Performance characteristics of pressure transducer model 22005 are: resolution 0.0002 or less, hysteresis better than ±0.3 per cent, repeatability better than 0.3 per cent, high temperature operation, low vibration, and steady state acceleration error.

Technology Instrument Corp. of California, Dept. ED, 7229 Atoll Ave., North Hollywood, Calif.

CIRCLE 43 ON READER-SERVICE CARD

◀ CIRCLE 41 ON READER-SERVICE CARD

Radar Transmitters

Available in several operating frequencies

Operating frequency of the X-band radar transmitter model is 8500-9600 mc (tunable). In other models frequency ranges are: 3030-3110 mc (fixed); 5360-5400 mc (fixed); 16,400-16,600 mc (fixed); 23,800-24,270 mc (fixed). Repetition rate can vary over the range 300 to 10,000 pps and pulse length over the range 0.25 to 2.5 μsec, within maximum duty cycle ratio (repetition rate times pulse length) of 0.001.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 44 ON READER-SERVICE CARD

Energizer

Has sandwich construction

A cut-away model of the cathodic envelope energizer construction shows the various layers of the sandwich making up this long-life high-energy battery designed specifically for transistorized equipment. Type of construction allows wide range of shapes and sizes.

National Carbon Co., Div. Union Carbide Corp., Dept. ED, 30 East 42nd St., New York 17, N.Y.

CIRCLE 45 ON READER-SERVICE CARD

CIRCLE 46 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Chargeable Dry Cell

Can be stored indefinitely

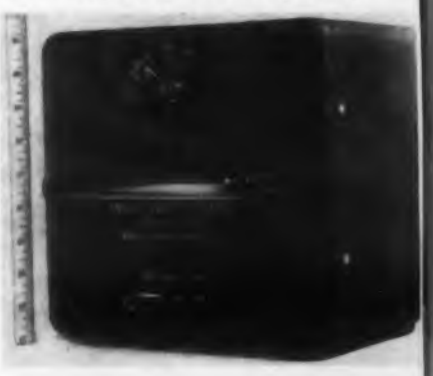
Manufactured in the uncharged state, this dry cell can be stored indefinitely at any temperature likely to be encountered, and charged when ready to use. Nominal output is 0.9 v, and average capacity 1500 ma-hr. Using an alkaline lead oxide-silver system, the cell is available in experimental production quantities.

P. R. Mallory & Company, Inc., Dept. ED, 28 S. Gray St., Indianapolis 6, Ind.

CIRCLE 48 ON READER-SERVICE CARD

Decade Inductors

High Q, low frequency



Designed for use in analog computers, network design, and general laboratory applications, these decade inductors have maximum values of Q in excess of 300 and micrometer adjustment for precise settings. Models LP 121, LP 131 and LP 141 are available in three decades (0.01 to 0.1 h; 0.1 to 1.0 h and 1 h to 10 h) which may be combined to permit switching in any value of inductance from 0.01 to 11.1 h in 0.01 h steps. Low level inductance is within 0.1 per cent of nominal value at 100 cps.

Computer Engineering Associates, Inc., Dept. ED, 350 N. Halstead Ave., Pasadena, Calif.

CIRCLE 49 ON READER-SERVICE CARD

◀ CIRCLE 47 ON READER-SERVICE CARD

Relay Sockets

For use with 6, 4 and 2 pole double throw relays

This Hi-Reli series of relay sockets features old plated over silver plate, free floating screw achine contacts in a molded body of MIL-M-4E type insulation. Contacts are available with older cup, turret or eyelet terminations. Units re for use with 6 pole, 4 pole and 2 pole double hrow relays.

Armel Electronics, Inc., Dept. ED, 840 5th Ave., Brooklyn 32, N.Y.

CIRCLE 50 ON READER-SERVICE CARD

Cooling System

Employs water boil-off method

This system, known as model RS-50, type 100, was designed to protect electronic equipment by maintaining a safe temperature within the close confines of a pressurized pod. Cooling is accomplished by circulating refrigerated air over the hot electronic components and transferring this heat to a vapor-cycle refrigeration system. This heat, plus that generated by the refrigeration compressor motor and other motors in the system, is disposed through the condenser where water carried for this purpose is boiled and exhausted overboard. Its capacity is 2500 w, with power requirements of 200 v, 400 cycle, three-phase and 28 v dc.

Eastern Industries, Inc., Dept. ED, 100 Skiff St., Hamden, Conn.

CIRCLE 51 ON READER-SERVICE CARD

Calorimeter Bridge

Measures 10 kw full scale

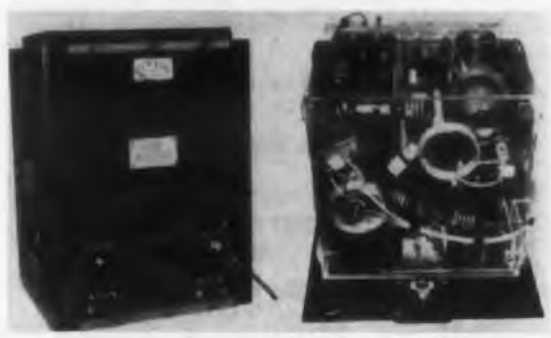
For use with any water load, this calorimeter bridge measures 10 kw full scale. Water flow is 4 gallons per minute. Accuracy of the ac wattmeter is 1 per cent. The instrument contains an ac standard load, a balancing thermopile, a galvanometer, a Variac and an ac wattmeter.

Electro Impulse Labs., Dept. ED, 208 River St., Red Bank, N.J.

CIRCLE 53 ON READER-SERVICE CARD

High Voltage Supply

0 to 90 kv regulated



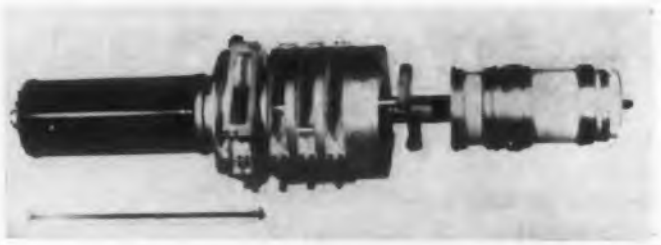
Model LAB-90 dc power supply provides voltages continuously variable from 0 to 90 kv. Output current is 1 ma at 80 kv; and 2 ma from 40 kv down. Voltage regulations are better than 1 per cent throughout the range.

Spellman Television Co., Dept. ED, 3029 Webster Ave., New York 67, N.Y.

CIRCLE 54 ON READER-SERVICE CARD

Klystron

1700 to 2400 mc range



The 4KM50, 000SG external-cavity power amplifier klystron covers the 1700 to 2400 mc range. It is rated at 10 kw cw power output with less than 1 w drive. The unit incorporates a modulat-

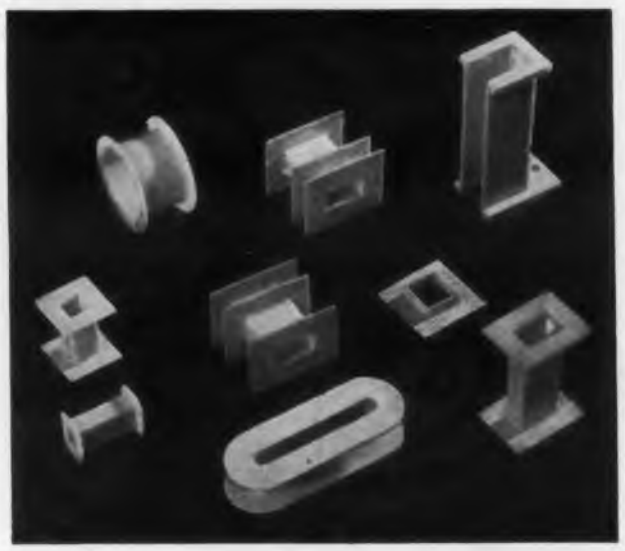
Dow Corning Silicone Dielectrics

Electronic "Package" on B-58 by Emerson Electric.

SILASTIC PROTECTS ELECTRONIC "PACKAGES"

Silastic® the Dow Corning silicone rubber, remains resilient from —70 to 250 C, has excellent dielectric strength and offers superior resistance to moisture, ozone, corona and corrosive atmospheres. Available in many forms, including molded parts, extrusions, tapes, sheets and pastes, Silastic is ideal for insulating, sealing and cushioning delicate electrical and electronic equipment.

SILICONE GLASS LAMINATES HAVE HIGH ARC RESISTANCE, STRENGTH



Silicone-glass laminates are easily molded into one-piece core and flange structures. Strong even at flange joints, they are lightweight and moisture-resistant, retain excellent physical and dielectric properties at 250 C. Finished shapes are available from leading laminators.

SILICONE VARNISH MAKES MOTORS TOUGHER, MORE DEPENDABLE

Dipped or impregnated with Dow Corning 997 Varnish, the insulating components of motors, servos, generators, transformers and other assemblies are bonded into an integrated moisture resistant insulation system with high dielectric strength. This silicone varnish combined with other silicone components permits operating temperatures up to 250 C . . . protects against moisture, many chemicals and corrosive atmospheres.

AiResearch miniature motors for B-52A Bomber.

For further information on these products, write Dept. 167

CIRCLE 55 ON READER-SERVICE CARD

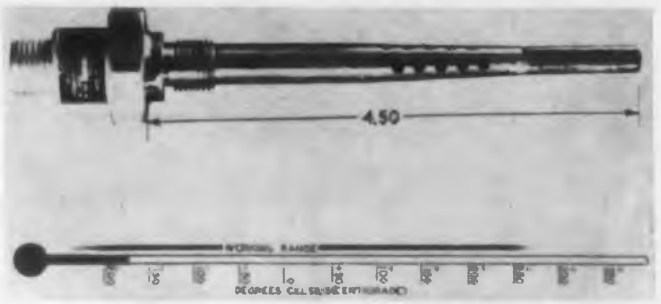
ing anode which allows simple, continuously variable control of power applied to the tube.

Eitel-McCullough, Inc., Dept. ED, San Bruno, Calif.

CIRCLE 56 ON READER-SERVICE CARD

Temperature Probe

—200 to +250 Range



Model 134 temperature probe has a temperature range from —200 C or lower to +250 C or higher. The probe provides 100 ohm variation in the range from —270 to —300 F, which corresponds to pure platinum wire having a resistance of 1380 ohms at 0 C. The high impedance level together with a capability for large power dissipation permits large voltage variations to be developed for telemetering purposes. Calibration stability is such that after 50 cycles from boiling water to LN_2, R_0 resistance drift is less than 0.1 ohm.

Rosemont Engineering Co., Dept. ED, 9424 Lyndale Ave., S., Minneapolis 20, Minn.

CIRCLE 57 ON READER-SERVICE CARD

Phase-Lock Demodulator

Boosts telemetry receiver sensitivity

Model 8-100 receiver phase-lock demodulator offers a gain in telemetry receiver sensitivity by lowering the improvement threshold by at least 6 db. This is a minimum figure realized when all rdb subcarriers are received. When fewer channels are used, the threshold is lowered even more. The demodulator is specifically designed for use with standard 1400 series receivers but may be modified for use with other models. It is installed by a simple plug-in connection and no modification to the receiver is required.

Radiation, Inc., Dept. ED, P.O. Box 37, Melbourne, Fla.

CIRCLE 391 ON READER-SERVICE CARD

NEW PRODUCTS

Amplifier

Voltage gain of 1000

Model M-10 transistorized amplifier has the following characteristics: input impedance greater than 150 K; voltage gain of 1000; power gain of 85 db and maximum output of 150 mw rms into 350 ohm.

M F Electronics Co., Dept. ED, 122 E. 25th St., New York 10, N.Y.

CIRCLE 59 ON READER-SERVICE CARD

Wide-Band Sweep Generators

Range of 4 mc to 225 mc

Two rugged, portable, wide-band sweep generators to test and align radio frequency circuits in the range from 4 mc to 225 mc are available. Models 601 and 602 have an all-electronic sweep circuit, of the saturable reactor type, with a continuously variable sweep range from a minimum of a nominal 1 per cent of center frequency to a maximum frequency deviation of approximately 5 to 1. Agc circuitry holds fundamental frequency output constant throughout the operating range.

The 601 has a frequency range of 12 mc to 225 mc divided into 11 switchable bands. Output voltage is 1 v rms with a variation at maximum sweep widths of ±0.5 db. The 602 has a frequency range of 4 to 112 mc, also divided into 11 overlapping bands. A voltage output of 2.5 v rms is maintained across any band to within ±0.5 db.

Jerrold Electronics Corp., Dept. ED, 23rd and Chestnut Sts., Philadelphia 3, Pa.

CIRCLE 60 ON READER-SERVICE CARD

Pulse Event Recorder

Recoverable type

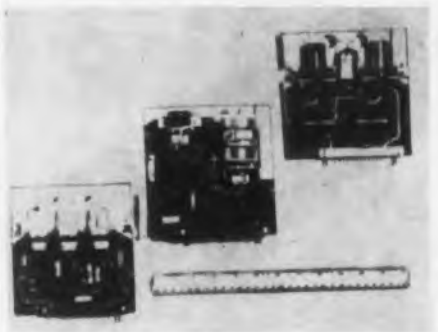
This recoverable pulse event recorder monitors accurately whether or not an event occurs in missile, sled and other applications. Designed to withstand high impact forces, the recorder has a self-contained electrical system. Weight is one pound.

Aerophysics Development Corp., Div. Curtiss-Wright Corp., Dept. ED, P.O. Box 689, Santa Barbara, Calif.

CIRCLE 61 ON READER-SERVICE CARD

Logic Units

Thirty types available



Thirty types of plug-in printed circuits in modular form are currently offered as stock items. The various types of bales currently available include: multi-vibrators, high speed binary and decimal electronic counters, stepping switches, operational amplifiers, storage devices, for both short and long-term applications; pulse-shaping circuits, timing and delay circuits, diode logic, "and," "or," and "not" circuits, gating circuits and transmission gates, relay and switching circuits, voltage regulators, pulse generators, clocks and gated oscillators, and analog to digital conversion systems and vice versa.

Skiatron Electronics & Television Corp., Dept. ED, 180 Varick St., New York 14, N.Y.

CIRCLE 62 ON READER-SERVICE CARD

CIRCLE 63 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Microsyn

3/4 in. in size

The unit shown is the T 813 microsyn, 3/4 in. in size, used with frequency from 400 to 1600 cps. The signal generator T 813 S 1 has a sensitivity of 0.3 mv/milliradian/ma excitation of 400 cps. The range is ±10 deg and the resolution is 15 sec of arc. Maximum torque of 3000 dyne-cm rated continuous torque 50 dyne-cm is a feature of the T 813 T 1 torquer. The unit has a transfer function 0.005 dyne-cm/ma^2.

Sterling Precision Corp., Instrument Div., Dept. ED, 17 Matinecock Ave., Port Washington, N.Y.

CIRCLE 64 ON READER-SERVICE CARD

Cathode Ray Indicator Tube

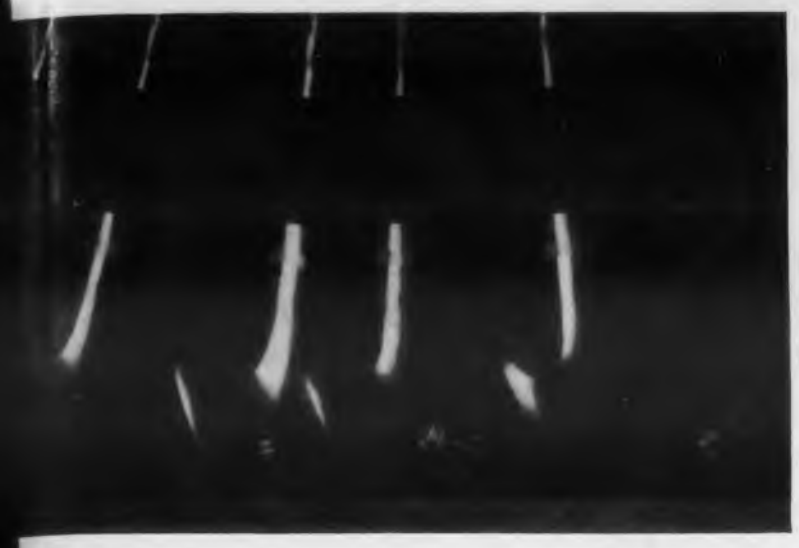
7-1/2 in. long

Operating conditions of cathode ray indicator tube model VTP-P1XP-11 are heater voltage of 6.3 v, heater current of 0.400 to 0.500 a, anode #1 from 400 to 500 v dc, anode #2 of 2000 v dc, anode #3 of 4000 v dc and grid #1 of —35 to —70 v. The undeflected spot position is within 1/8 in. radius circle with deflection factors: D_1 D_2 of 255 to 325 v per in. and D_3 D_4 of 143 to 175 v per in. Ratio of anode #3 voltage to anode #2 voltage is a maximum of 3 with optimum conditions obtained when the ratio is less than 1.5.

Vacuum Tube Products Co., Inc., Dept. ED, 2020 Short St., Oceanside, Calif.

CIRCLE 65 ON READER-SERVICE CARD

tremendous impact and vibration



"GOLF CLUB TEST" General Electric transistors with Fixed-Bed Mounting have been struck full force with a No. 2 Iron. After traveling forty yards, tests showed they still worked perfectly.

"JACKHAMMER TEST" Another G-E transistor with Fixed-Bed Mounting was taped to a pneumatic drill, which was then operated for ten minutes. When the transistor was removed, tests showed it still worked perfectly.

Ceramic disk guards against major causes of transistor failure

In General Electric's new Fixed-Bed Mounting, critical elements of the transistor are welded flat on a disk of ceramic. Thus any impact must be great enough to damage the disk itself before transistor failure can occur. In conventional methods of manufacture, impact need only penetrate the transistor's metal case in order to damage the standard upright header.

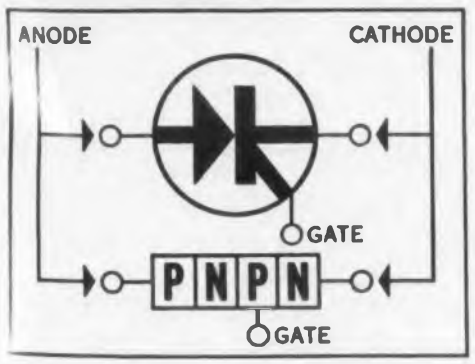
Because of their many suspended parts, standard upright headers are also subject to inertial stress at a number of points. General Electric's Fixed-Bed Mounting eliminated *all but one* of those parts—the suspended aluminum emitter lead. And this is provided with enough slack to absorb inertial stress, with connection points so securely welded that the unit withstands far more than the military centrifuge test of 20,000 G's.

To eliminate thermal stress, the coefficient of expansion of G.E.'s ceramic disk has been made equal to that of the semiconductor metal. Previously, enough "play" had to be allowed to absorb alternate expansions and contractions, thereby reducing the strength and stability of the unit.

The Fixed-Bed Mounting's electrical elements lie flat, in close contact to the transistor case, providing greater heat conduction out through the case. Therefore, the fixed-bed construction cuts down junction temperature, making it possible to double the power dissipation of the same transistor made with upright-header construction.

Fixed-Bed Mounted units have exceeded all standard shock, centrifuge and temperature-cycling tests. General Electric's unijunction transistor (see below) now has this feature.

New G-E Controlled Rectifier rectifies and controls current up to 5 amperes at 300 v.



The controlled rectifier is a four-layer silicon device with a "gate" to which a signal can be applied to control forward current. It can handle more than one kw of power.

NEED A FEW SEMICONDUCTORS IN A HURRY? Check your local G-E distributor *first*. You'll find his delivery, service facilities and prices are hard to beat.

General Electric's new silicon controlled rectifier acts like a thyratron. In the reverse direction, it's a standard rectifier. But it will also block forward current until either a critical breakover voltage is exceeded or a signal is applied to the third lead. Then it switches to a conducting state and acts as a forward-biased silicon rectifier.

The controlled rectifier can be actuated by a little as 15 mw. Breakdown occurs at speeds approaching a microsecond, after which voltage across the device is so low that current is determined by the load. This enables the user to control a large anode-to-cathode current with an extremely small amount of power, or to switch power from high impedance to low impedance in microseconds.

Applications include replacement of relays, thyratrons, magnetic amplifiers, power transistors and conventional rectifiers. Sample quantities of the controlled rectifier are now available. Prices will be sent on request.

GENERAL ELECTRIC

CIRCLE 66 ON READER-SERVICE CARD

Converter

Operates over 100 c

This transistorized high temperature dc to dc converter features: input from 12 to 30 v; output from 6 to 300 v; regulation line and load ±1 per cent; and temperature line and load ±5 per cent.

Jordan Electronics, Dept. ED, 3025 W. Mission Rd., Alhambra, Calif.

CIRCLE 67 ON READER-SERVICE CARD

Power Supply

0.03 ohm internal impedance

Model 104 transistorized has a low internal impedance of less than 0.03 ohms, dc to 10 kc. Overload protection is provided for the current meter, with automatic reset. Coarse and fine voltage controls facilitate precision settings.

Quan-Tech Lab., Dept. ED, Morristown, N.J.

CIRCLE 68 ON READER-SERVICE CARD

Illumination Control

Light level actuates relay

A new version of an illumination control instrument which monitors light levels and signals a relay to switch lights on or off automatically has been announced. Model 1099 Luminaire features operation without regard to temperature, or weather conditions.

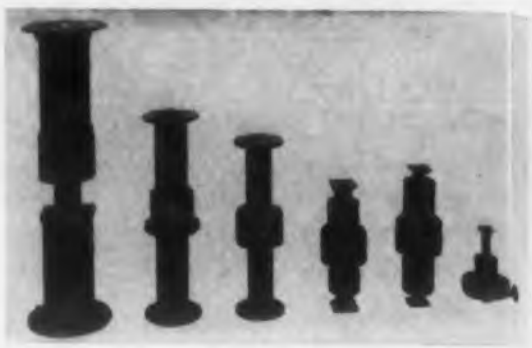
Weston Instruments, Division of Daystrom Inc., Dept. ED, Newark 12, N.J.

CIRCLE 69 ON READER-SERVICE CARD

NEW PRODUCTS

Rotary Joints

High speed, broadband



These waveguide rotary joints are of the line type and feature broadband operation high speeds. The joints employ novel transdu from rectangular to loaded circular waveg producing a pure circularly symmetric TM m Because of the purity of the mode, no dissip mode suppressors are required so that inser loss is held to a minimum, and there is no p shift with mechanical rotation. The joints c frequencies from 2.6 to 26.5 kmc. Average p handling ranges from 3 kw to 1/2 kw. Vsw less than 1.5 to 1. Insertion loss is less than 0.

Diamond Antenna & Microwave Corp., D ED, 7 North Avenue, Wakefield, Mass.

CIRCLE 71 ON READER-SERVICE CARD

Spectrum Analyzers

2400 to 9600 mc

Series 860 spectrum analyzers have a w range of performance that makes them valu for precise spectrum measurements, such as e uation of high vswr, leakage, and loss; and an sis of radar, radio relay, and other signals. F turing simplicity of operation and lower pr they offer a choice of frequency ranges from 2 to 9600 mc and have an accuracy of ±0.08 cent, or ±1 mc. The instruments are based the improved power supply and indicator u type 860-I.

Polytechnic Research & Development C pany, Inc., Dept. ED, 202 Tillary St., Brook 1, N.Y.

CIRCLE 72 ON READER-SERVICE CARD

NEW PRODUCTS

Kilomegacycle Generator

Stability Of 1 part In 10^8

Model RD-170 generates both sinusoidal frequencies of 100 mc and 1000 mc and harmonic signals covering a major portion of the microwave spectrum. Output frequency stability is governed by the stability of a 1 mc reference signal. The unit is intended for use as a precise but low cost source for reference, monitoring or calibrating purposes. Employing crystal synthesizer design techniques, the instrument essentially consists of a free running 100 mc oscillator, which is phase-locked to the 1 mc reference, and multiplier stages which raise the frequency to 1000 mc. A pencil tube in a coaxial cavity forms the final output state. Power delivered is 100 mw across 50 ohms.

Manson Laboratories, Inc., Dept. ED, 207 Greenwich Ave., Stamford, Conn.

CIRCLE 73 ON READER-SERVICE CARD

Pulse Modulator

Delivers 21 kw

USN-3D21B pulse modulator is a beam power tube capable of delivering 21 kw in 10 μsec pulses. It features an open-type plate of large area for high thermal dissipation, a non-warping cathode, and gold-plated special alloy grids with heavy side rods and oversize heat radiators. The tube is rated to withstand a plate pulse voltage of 5 kv.

CBS-Hytron Div. Columbia Broadcasting System, Inc., Dept. ED, 100 Endicott St., Danvers, Mass.

CIRCLE 74 ON READER-SERVICE CARD

Time Delay Relays

Transistorized series

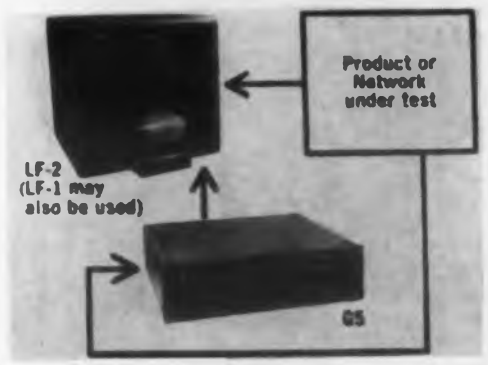
This line of time delay relays offers high temperature operation, high vibration, light weight and very short time delays. A transistorized rc time constant network is used. Two series are currently offered with time delays ranging from 50 msec to 60 sec. Operating voltage for either type will be 18 to 30 v dc, although operation on ac voltages can be offered. The 31200 series can be provided with contact arrangements up to 4 pdt. Weight is approximately 6 oz, length 2-1/4 in., and the unit will withstand vibrations up to 500 cps. The 31300 miniature series can be supplied with contact arrangements up to dpdt. This unit can withstand vibrations up to 2000 cps at 10 g. Weight of this style is approximately 3 oz.

A. W. Haydon Co., Dept. ED, Waterbury 20, Conn.

CIRCLE 75 ON READER-SERVICE CARD

Response Indicator

Range from 0.5 to 2250 cps



Model G-5 analyzes frequency response characteristics of servo amplifiers, filters, acoustic reproducers, transformers and shaker tables in the low frequency range from 0.5 to 2250 cps. It is helpful in locating resonant frequencies in mechanical structures and testing networks and devices which tend to produce distortion products, where hum and noise are present, and where measurements through large dynamic ranges are necessary.

Panoramic Radio Products, Inc., Dept. ED, 520 S. Fulton Ave., Mt. Vernon, N.Y.

CIRCLE 76 ON READER-SERVICE CARD

NEW PRODUCTS

Voltage Regulator

400 cps use

Type TM7101 voltage regulator is designed for 115 v, 400 cps ±5 per cent, single phase duty with a rating of 1 kva. The input voltage range is 95-130 v and the output voltage is adjustable from 110 to 120 v. Output voltage accuracy is constant to within a 1 v bandwidth for line voltage variations.

Superior Electric Co., Dept. ED, Bristol, Conn.

CIRCLE 77 ON READER-SERVICE CARD

Pulse Height Analyzer

Improved 256-channel unit

The improved 256-Channel Pulse Height Analyzer, Model 20609, has these advantages: 27 hours pre-set time during which background may be counted and automatically subtracted from original run data; logarithmic readout on flat-faced cathode ray tube and strip chart recorder; dual-function high voltage supply; and interpolation lights to aid in setting zero point and instrument maintenance. All channels are printed out in less than one minute.

Radiation Counter Laboratories, Inc., Dept. ED, Skokie, Ill.

CIRCLE 78 ON READER-SERVICE CARD

Packaged Amplifier

High flexibility

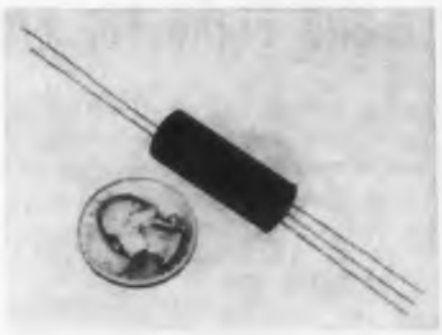
This flexible packaged amplifier, the Model UPA-2, can drive a 12,000 ohm load to 100 v in either direction, and will tolerate large values of cable capacitance. Typical operations which can be performed separately or in combination include: straight amplification and inversions; slaving or transducing voltages into currents and vice-versa; integrating and differentiating; adding and subtracting; and oscillating, bounding, clipping, multivibrating, and other nonlinear functions. For standard 3-1/2 in. rack mounting, the unit can be removed from the rack adaptor and used as a bench-top amplifier or plug-in subassembly.

George A. Philbrick Researches, Inc., Dept. ED, 230 Congress St., Boston, Mass.

CIRCLE 79 ON READER-SERVICE CARD

Chopper

Nonmechanical type



This transistorized chopper, Model 50, is a solidly encapsulated unit which can be used either as a modulator or demodulator. Unlike mechanical choppers, the Model 50 can be driven from dc to hundreds of kilocycles. The switching circuitry used operates the transistors in a manner which provides stability and freedom from drift. The unit withstands shocks of 500 g for 11 msec, vibrations of 30 g up to 2000 cps, and acceleration of 700 g.

Solid State Electronics Co., Dept. ED, 8158 Orion Ave., Van Nuys, Calif.

CIRCLE 80 ON READER-SERVICE CARD

NEW PRODUCTS

Potentiometer

For dc analog computation

Developed initially for accurate conversion of slant range to ground range and altitude in dc analog computation, model PT315 trigonometric potentiometer enables accurate triangle solution over a range of angles commonly encountered in navigational problems. These 15-turn units embody the sine or cosine function over a 100-degree range of function. Conformity is 0.02 per cent for sine or cosine less than 0.707, and 0.04 per cent for sine or cosine greater than 0.707.

Analogue Controls, Inc., Dept. ED, 39 Roselle St., Mineola, N.Y.

CIRCLE 82 ON READER-SERVICE CARD

Aircraft Blower

Delivers 175 cfm of air

The MSA 7861 aircraft blower unit delivers 175 cfm of air against an operating pressure of 16 in. of water and can be used in a temperature range from −75 to 160 F. The totally enclosed, explosion-proof 1.2 hp aircraft motor furnished with the unit operates with a 4-pin-type connector on a 200-v, 400-cps system and at speeds up to 11,000 rpm. The MSA 7861 unit weighs 8 lb and occupies a space of less than 8 x 8 x 9 in.

Torrington Manufacturing Co., Air Impeller Div., Dept. ED, Torrington, Conn.

CIRCLE 83 ON READER-SERVICE CARD

Delay Lines

Feature compactness

A standard series of delay lines features compactness and meets MIL-C-15305A, Grade 1, Class B requirements. The 1 μsec, 1000-ohm line has a delay-bandwidth product of over 7.5 per cu in. Molded in epoxy resin, units are square or tubular for printed circuit use or for stacking on common mounting screws. They can be stacked in series to give higher delays, or tap-off points can be used to give lower delays. Impedances range from 500 to 2000 ohms, with delays up to 1 μsec. Operating temperature range is −55 to +125 C. Rise times are short—0.15 μsec maximum for the longest delay.

NYT Electronics, Inc., Dept. ED, 2979 N. Ontario St., Burbank, Calif.

CIRCLE 84 ON READER-SERVICE CARD

Curve Tracer

Plots transistor characteristics

Model 341 power transistor characteristics plotter is a compact, general purpose curve tracer, designed for use with both point-contact and junction transistors. Its uses include supplying design information for transistor circuits, observing transistor anomalies, examining transistors for changes or deterioration, checking tolerance of transistors and matching or comparing transistors. Design permits circuit simplification similar to that of one-curve tracers, yet yields information equivalent to that from far more complex plotters.

Dunn Engineering Assoc., Inc., Dept. ED, 225 O'Brian Hwy., Cambridge 41, Mass.

CIRCLE 85 ON READER-SERVICE CARD

NEW PRODUCTS

Phase Meter and Phase Shifters

0.1 deg accuracy

Model 340 phase meter and phase shifter as shown provides phase measurements and a phase source having an accuracy of 0.1 deg. The phase angle is continuously adjustable from 0 to 400.0 deg. Model 440 phase shifter has an accuracy of better than 0.1 deg. The input impedance is 200 K and the output impedance is 500 ohm.

Dytronics Co., Dept. ED, P.O. Box 3676, Columbus 14, Ohio.

CIRCLE 88 ON READER-SERVICE CARD

Clutch

Has torque of 140-oz-in.

Model HCS-500 clutch has 140 oz-in. torque rating. Torque may be controlled from zero up to the maximum rating of the unit, relatively independent of slip speed characteristics, according to the clutch control current setting. The unit employs a stationary coil, eliminating frequently objectionable characteristics of slip rings.

Magtrol, Inc., Dept. ED, 240 Seneca St., Buffalo 5, N.Y.

CIRCLE 89 ON READER-SERVICE CARD

Low Pass Filters

Feature low insertion loss

Type A2 low pass filters have low insertion loss, are very compact in size and have rugged construction. Six models are available with cut-offs from 125 to 1000 cps. Specifications include an insertion loss of 0.2 to 0.5 db ripple in the

pass band; vswr of 1.5 max; power handling of 5 w, and weight of less than 3 oz.

Maury & Assoc. Electronic Research & Development, Dept. ED, 10373 Mills Ave., Pomona, Calif.

CIRCLE 90 ON READER-SERVICE CARD

Servo Amplifier

Has variable damping or feedback control

Operating from —55 to +125 C, this transistorized servo amplifier with variable damping or feedback control, has an output power of up to 10 w. Type AMP-9616 can be designed to drive a servo motor-generator with standard 115/57.5 v control phase or 40/20 v control phase without the need of an output transformer. Open loop power gain is up to 90 db.

John Oster Manufacturing Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 91 ON READER-SERVICE CARD

Timers

Intervals from 50 msec to several hours

This series of transistorized RC timers has time intervals ranging from 50 μsec to several hours and eliminates use of motor-driven and thermal elements. Voltage ranges are 14 to 32 v dc or 24 to 220 v ac. They measure as small as 3 cu in. and weigh a minimum of 3 oz. Temperature range from —55 to +71 C or —55 to +125 C.

Jordan Electronics Div. of The Victoreen Instrument Co., Dept. ED, 3025 W. Mission Rd., Alhambra, Calif.

CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

Gear-Head Motor

Withstands very high shock

Model P5B827P75 is stated to be designed to withstand 7500 g. It operates on 28.5 to 31.5 v dc developing 1000 oz-in. of torque at —65 C. The gear box is a six-stage, planetary design with a reduction ratio of 13,840:1, giving the output shaft a rotation speed of 1.3 rpm.

Western Gear Corp., Dept. ED, P.O. Box 182, Lynwood, Calif.

CIRCLE 95 ON READER-SERVICE CARD

Gas Noise Source Tube

Generates random noise of 16 ±1 db

Designed for use with the standard RG-52/U waveguide assembly, this gas noise source tube type 6357 will generate random noise at a noise level of 16 ±1 db above 290 K at frequencies in the 2.4 to 3.6 cm waveband. The use of an inert gas makes the noise output independent of the operating temperature.

Central Electronic Manufacturers, Inc., Dept. ED, 2 Richwood Pl., Denville, N.J.

CIRCLE 96 ON READER-SERVICE CARD

Magnetic Shift Register

Speeds to 500 kc

A two-cores-per-bit shift register operates at speeds up to 500 kc. The maximum shifting rate of the DK 107 is above one megacycle. All components including two cores and four gold-

bonded germanium diodes are encapsulated in epoxy. Units are provided with solder lug headers, plug in bases, and solder pins for printed circuitry.

Airtronics, Inc., Dept. ED, Bethesda, Md.

CIRCLE 97 ON READER-SERVICE CARD

Converter

Features three section tuner

Model 99R all-channel uhf converter features a three-section tuner with a dual input section. Additional features are simplified single-knob tuning of channels 14 through 83, drift-free performance, double-tuned rf section and precise 300 ohm impedance match. The unit operates on 117 v at 60 cps. It weighs 3-1/2 lb and measures 6-3/4 x 5 x 4-3/4 in.

Blonder-Tongue Labs., Inc., Dept. ED, 9-25 Alling St., Newark 2, N.J.

CIRCLE 98 ON READER-SERVICE CARD

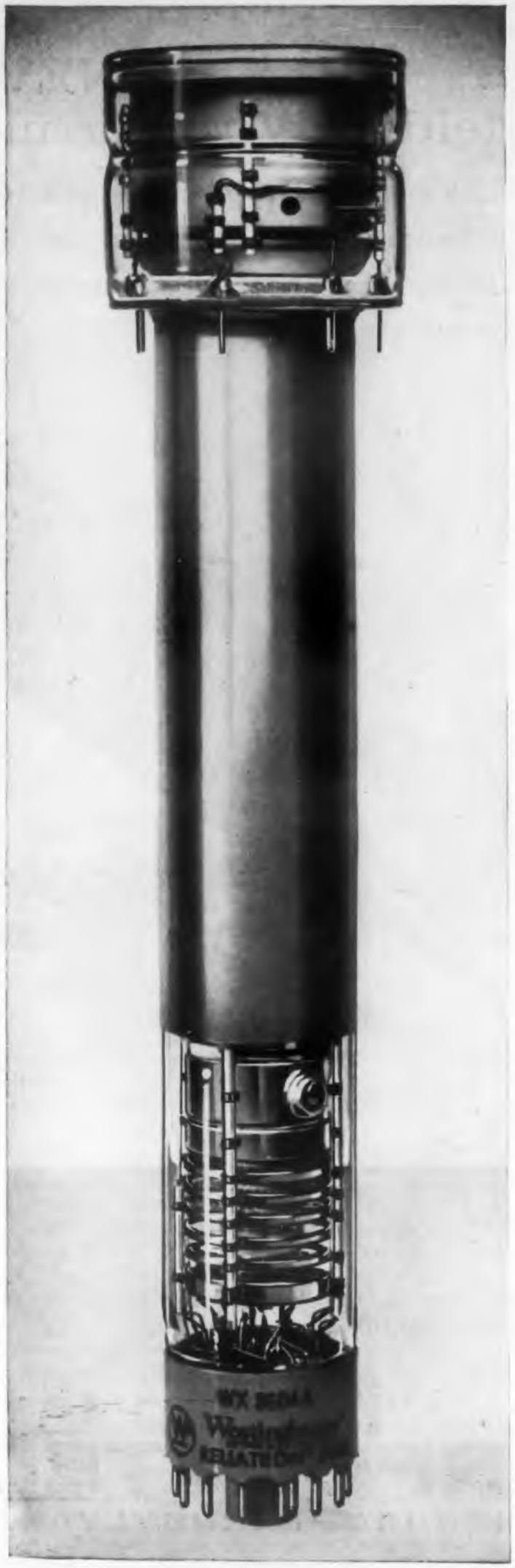
Transistor Tester

Measures transistor characteristics

Model TT-205 transistor tester measures small signal beta, collector leakage current, and collector resistance on all npn, pnp, surface barrier, grown or diffused junction transistors. Eleven operating points are provided with one selector switch. The instrument employs three transistors, one as a stable local oscillator having a nominal frequency of 1000 cps, the other two as a special purpose, low level, synchronous linear detector.

Sonex, Inc., Dept. ED, 73 S. State Rd., Upper Darby, Pa.

CIRCLE 99 ON READER-SERVICE CARD



New Ruggedized Westinghouse Image Orthicon!

DURABLE NEW WL-7198 WITHSTANDS SEVERE ENVIRONMENTAL CONDITIONS, SHOWS NO DEGRADATION AFTER 30 G'S!

Now Westinghouse has developed an image orthicon tube that's rugged enough to withstand 30 g's . . . yet sensitive enough to perform efficiently at low light levels. The new WL-7198 is ideal for military, industrial and scientific applications subject to extreme environmental conditions.

TYPICAL CHARACTERISTICS OF THE WL-7198 ARE:

Vibration: (1) Operable throughout MIL-E-5272A Procedure I (10 g's from 50 to 500 cps)
(2) 350 lines horizontal resolution at 5 g's from 50 to 500 cps with 3 x 10^{-2} foot-candles on photocathode.

Shock: No degradation after 30 g's.

Low light level performance: 250 lines minimum resolution 3 x 10^{-4} foot-candles on photocathode.

Sample quantities of the WL-7198 are available for immediate delivery.

WESTINGHOUSE ENGINEERS WILL HELP YOU SOLVE YOUR IMAGE ORTHICON PROBLEMS UPON YOUR REQUEST.

YOU CAN BE SURE...IF IT'S

Westinghouse

Electronic Tube Div. Elmira, New York

CIRCLE 105 ON READER-SERVICE CARD

NEW PRODUCTS

Patchcord System

Modular contact strips

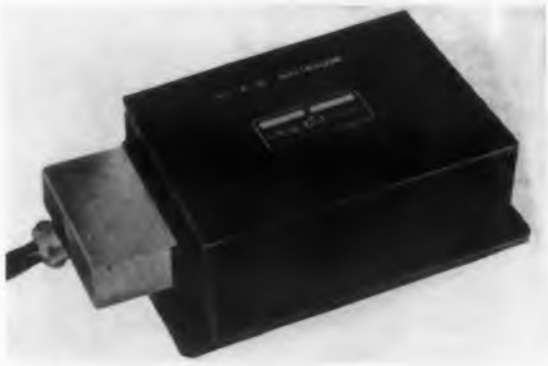
This patchcord programming system provides an uncomplicated method of programming that is both compact and flexible. Its flexibility results from the modular arrangement of contact strips and the use of either single or multiple patch cords. By altering the size of the framework any reasonable number of contacts can be provided. The compactness of the system is such that 440 contacts are contained in an area 8-3/32 in. wide by 4-1/2 in. high.

Virginia Electronics Co. Inc., Dept ED, River Rd. and B. & O. Railroad, Washington 16, D.C.

CIRCLE 106 ON READER-SERVICE CARD

Sampling Switch

45 channels



This solid state commutator has 45 non-shorting channels, sampled 20 times per second. It accepts signals ranging from 0 to +5 v dc and produces a train of noise-free pam waveforms with rise and fall times not exceeding 0.5 per cent of full scale pulse. "On" time is continuously adjustable from 100 to 0 per cent of duty cycle. Preselected repetition rates are selected by proper wiring to mating plugs. The unit weighs less than 2-1/4 lb, and requires less than 3 w of 28 v dc. With source impedances as low as 5 k conversion accuracy is ±0.5 per cent of full scale.

General Devices, Inc., Dept. ED, Princeton, N.J.

CIRCLE 107 ON READER-SERVICE CARD

Relay

For high vibration use

Type 2SM two-pole relay is available on special order to those who need vibration immunity to two or three times the normal limitation of 20 g at 2000 cps. The relay will withstand temperatures to 125 C, standard, and to 200 C, special. Contacts are rated to 5 amp resistive, and for dry circuit application.

Hi-G, Inc., Dept. ED, Bradley Field, Windsor Locks, Conn.

CIRCLE 108 ON READER-SERVICE CARD

Tape Monitor

Multi-channel

Model P-106-B Systemat multichannel tape monitor has applications in telemetering, jet engine testing and many other similar jobs. The unit includes six Panelscopes, power supply, and sweep generator for up to 14 monitors. A system of lamps is used to indicate under or over modulation. The model P-106-B is designed to indicate full scale vertically or horizontally with an input of 1 v rms with a response of dc to 300 kc within 3 db.

Waterman Products Co., Inc., Dept. ED, 2445 Emerald St., Philadelphia 25, Pa.

CIRCLE 109 ON READER-SERVICE CARD
CIRCLE 393 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Punched Card Buffer

Card-to-tape compatibility

This magnetic core memory unit, type 80-CB-7, stores up to 80 alpha-numeric characters to accommodate the full contents of a standard card. Additional applications include transfer of card data to electronic computers, digital control systems, and remote transmission equipment.

Telemeter Magnetics, Inc., Dept. ED, 2245 Pontius Ave., Los Angeles 64, Calif.

CIRCLE 394 ON READER-SERVICE CARD

Tuning Forks

Accuracies to 0.01 per cent

Series 6250 tuning forks cover a range of 300-4000 cps at accuracies to 0.01 per cent. Configurations available include thermistors for external circuit temperature compensation and heaters for extreme temperature ranges.

Varo Manufacturing Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

CIRCLE 395 ON READER-SERVICE CARD

Power Supply

Dual transistorized unit

Model TQ-36 is a twin transistorized dc power supply, with each output rated at 4-36 v, 0-1 amp. Regulation of 0.1 per cent for line or load is

afforded by a Zener diode reference. Output impedance is 0.01 ohm, dc. Typical transient response is 50 μsec and ripple is less than 3 mv.

Universal Electronics Co., Dept. ED, 1720 22nd St., Santa Monica, Calif.

CIRCLE 397 ON READER-SERVICE CARD

Constant Speed Drive

16 in.-oz at 1000 rpm

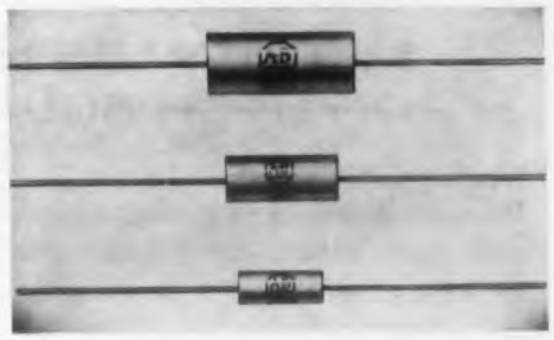
Designed for computer and control system applications, this constant speed power drive supplies 16 in.-oz at 1000 rpm. Tolerance on speed is in the order of ±0.1 per cent with an input voltage variation of ±20 per cent and an input speed of 1100 rpm ±15 per cent. A typical unit, type 041-9902, measures 4-1/4 x 2 x 2 in. and weighs in the order of 1 lb. This unit utilizes a timing motor requiring 28 v dc at 3 w.

M. Ten Bosch, Inc., Dept. ED, Pleasantville, N.Y.

CIRCLE 398 ON READER-SERVICE CARD

Resistors

Grid resistance Element



Using a specially designed metal alloy grid resistance element, these resistors are available in three types: the CAH, 0.25 w; the EAH, 0.50 w; and the GAH, 1.0 w, with full ratings at 100 C ambient. The resistors exceed Mil specifications for wirewound and metal film type precision resistors. The resistors employ a noninductive resistance element for excellent high frequency characteristics. The metal alloy grid results in a noise level comparable to that of wirewound resistors.

Allen-Bradley Co., Dept. ED, 136 W. Greenfield Ave., Milwaukee 4, Wis.

CIRCLE 399 ON READER-SERVICE CARD

NEW PRODUCTS

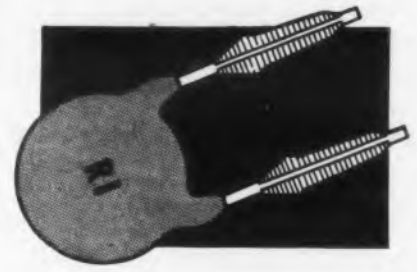
Terminals

High temperature ceramic-to-metal

These ceramic-to-metal lead-through terminals, which provide vacuum seals around conductor lead-throughs, are designed for high temperatures and high altitudes. The terminals are for use with soft solders at temperatures up to 450 F and with hard or silver solders at temperatures to 1400 F.

Thermo Materials, Inc., Dept. ED, 4040 Campbell Ave., Menlo Park, Calif.

CIRCLE 111 ON READER-SERVICE CARD



Capacitor Leads

Lock-in

Available on RI-cap printed circuit capacitors. Swedge leads lock firmly into circuit boards and prevent falling out or tipping over. A special shoulder stop keeps the leads from being pushed through the board and prevents durez pant from interfering with soldering. The leads insert easily into various size holes.

Radio Industries, Inc., Dept. ED, 5225 N. Ravenswood Ave., Chicago 40, Ill.

CIRCLE 112 ON READER-SERVICE CARD

Components

For 26 v and 115 v, 400 cps operation

This series of synchros, resolvers and linear transformers for indication and control is designed for 26 v and 115 v, 400 cps operation

Stainless steel construction with high nickel laminations provides for good corrosion resistance. Operating temperatures are from −50 to +125 C. In addition to position indicating on valves, computer shafts, and missile components, the units achieve accuracy as sensing elements and in servo mechanisms.

Induction Motors of California, Dept. ED, 6058 Walker Ave., Maywood, Calif.

CIRCLE 113 ON READER-SERVICE CARD

Cooling System

Takes large heat loads

The U-520878-1 hydraulic and electronic system has such performance characteristics as: max heat loads of 2500 w (hydraulic) and 5150 w (electronic); required air flow of only 75 lb per min; max pressure drop of 6 in. H_2O at 122 lb per min, and an operative altitude range to 70,000 ft.

United Aircraft Products, Inc., Dept. ED, 1116 Bolander Ave., Dayton, Ohio.

CIRCLE 114 ON READER-SERVICE CARD

Silicon Diodes

Rated to 500 v piv

These diodes provide dc forward currents up to 45 a with a maximum peak inverse voltage to 500 v. They are capable of operation at a junction temperature of 200 C.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 115 ON READER-SERVICE CARD

NEW PRODUCTS

Frequency Measurement

Range from 2000 to 4000 mc

Developed for the exact determination of frequencies of transmitted signals, this instrument is basically a frequency marker generator covering the range from 2000 to 4000 mc. Applications include use in counter-measures, communication systems, and telemetering.

Allen B. DuMont Labs., Inc., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

CIRCLE 117 ON READER-SERVICE CARD

Video Attenuator

Flat response to 10 mc

Model V256 video attenuator is available in 45 steps of 0.1 db per step. The attenuator has a flat frequency response from dc to 10 mc and has either a standard lug type terminal board, or UG-185/U connectors.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 118 ON READER-SERVICE CARD

Low-Noise Potentiometer

Operates from —85 to +185 F

Capable of handling up to 3 w, the model 101 low-noise precision potentiometer operates

over a temperature range from −85 to +185 F. It stands 5 g of vibration between 20 and 2000 cps and up to 30 g of shock in six directions. This 10-turn potentiometer is available in eight standard resistance values between 500 and 100,000 ohms. Standard linearity tolerance is ±0.5 per cent. Other resistance values can be provided with linearity up to ±0.05 per cent.

Hub-Pot, Inc., Dept. ED, 1242 E. Transit Ave., Pomona, Calif.

CIRCLE 119 ON READER-SERVICE CARD

Waveguide Bending

Process provides smooth interior

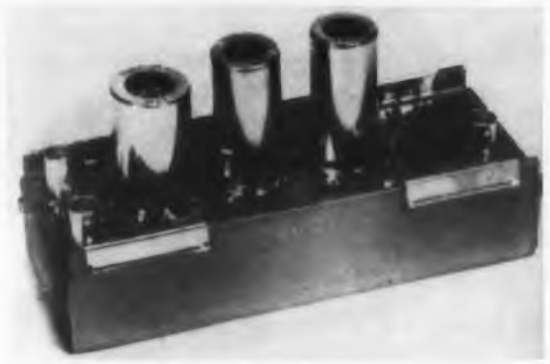
This forming process, for bending and twisting wave guides, produces a uniformly smooth interior devoid of energy absorbing hot-spots. Draw marks, creases, burrs and ripples are eliminated by the process, which is called Micro-Smooth. The method allows closer tolerances to be held on inner dimensions while bends in any plane can be combined with twists and sharp radii.

Uniwave, Inc., Dept. ED, Farmingdale, N.Y.

CIRCLE 120 ON READER-SERVICE CARD

I-F Preamplifier

20 db gain over 10 mc band



Model P205 preamplifier is designed to be fed from a crystal mixer having a 200 to 300 ohm balanced output. A variation of the P205, model P205A, is available for 200 ohm unbalanced mixers. The unit provides a gain of 20 db with a bandwidth of 10 mc. Noise figure is 2 db. Output impedance is 50 ohms, and input is either 200 to 300 ohms balanced or 200 ohms unbalanced.

Instruments For Industry, Inc., Dept. ED, 150 Glen Cove Rd., Mineola, N.Y.

CIRCLE 121 ON READER-SERVICE CARD

NEW PRODUCTS

Ignition Primer

For high altitudes

Model 1029A high-altitude ignition primer is a hermetically-sealed part designed for the ignition of propellants and powders at altitudes in excess of 100,000 ft. The unit is a standard screw-in construction having a 3/8-24 class 2A thread and a 7/16 in. hex.

Holex, Inc., Dept. ED, P.O. Box 148, Hollister, Calif.

CIRCLE 125 ON READER-SERVICE CARD

Potentiometer

2.5 w at 200 c

Designed for high temperature service, this potentiometer is for use up to 250 C, with 2.5 w rating 200 C. Sample and pilot quantities are available in linear tapers from 10 to 20,000 ohms, in standard tolerance of ±5 per cent.

P. R. Mallory & Co. Inc., Dept. ED, Indianapolis 6, Ind.

CIRCLE 124 ON READER-SERVICE CARD

Frequency Standard

Temperature shifts less than 0.01 C

The LA90 5-mc frequency standard offers long term stability to better than one-part in one b

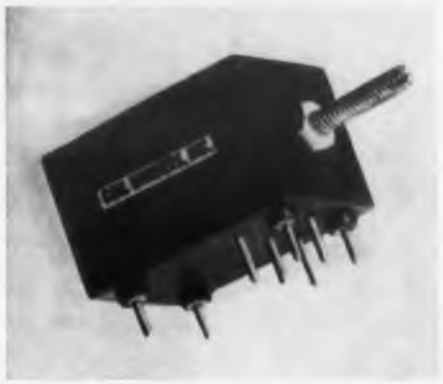
lion. Long term operation results in temperature shifts of less than 0.01 C. The environmental temperature range is 0 to 50 C. When the unit is in operation a high coefficient crystal acts as a very sensitive high Q control device which equalizes the power in the oven.

Lavoie Laboratories, Inc., Dept. ED, Matawan-Freehold Rd., Morganville, N.J.

CIRCLE 126 ON READER-SERVICE CARD

Tuneable Transformers

Plug-in PC units



This series of sealed miniature tuneable transformers and reactors for printed circuit use are plug-in types with provision for assuring clearance of body of unit from printed circuit board. This type of construction is available with 2 to 8 functional terminals. Characteristics include a frequency range of up to 70 mc, inductance to 30 mh. and Q value to 125.

Coil Winders, Inc., Dept. ED, New York Ave., Westbury, N.Y.

CIRCLE 127 ON READER-SERVICE CARD

Power Supply

For strain gages

Model 2-200 transistorized strain-gage power supply provides 0-15 v at 0-5 amp with less than 1 mv drift over a 24-hr period at constant temperature, and less than 0.001 per cent per deg F change with temperature variations. A 10 per cent change in line voltage will produce a change of less than 2 mv in output, while a 1 amp change in load current will produce less than 1 mv change in output. Ripple is less than 1 mv peak to peak under all conditions of load.

Neff Instrument Corp., Dept. ED, 2211 E. Foothill Blvd., Pasadena, Calif.

CIRCLE 128 ON READER-SERVICE CARD

NEW PRODUCTS

Tape-Programmed Tester

Improved flexibility

The new model Robotester, type LA-302, permits random selection throughout any two of 250 circuit points for measurement of resistance, polarized dc or ac voltage or insulation resistance. This improvement in flexibility increases user savings over that obtained with the original model. The unit is adaptable to automated production running 60-100 tests per minute and is able to signal wiring or assembly errors with a flashing light indicator. The range of voltage measurement is from 0.5 to 500 v and hipot is accomplished at 500 v dc with a theoretical 10,000 meg upper limit. The resistance range of the Robotester is from one ohm to 9.99 meg.

Lavoie Laboratories, Inc., Dept. ED, Matawan-Freehold Rd., Morganville, N.J.

CIRCLE 131 ON READER-SERVICE CARD

Relay

Switches radio frequencies

This relay for switching radio frequencies has applications such as antenna change-over on mobile radio. A special contact spring construction is designed to provide the lowest possible capacitance between springs. Operating voltages 6 to 110 v dc spst or spdt contacts rated 2 amp at 24 v dc or 115 v ac non-inductive load.

Magnecraft Electric Co., Dept. ED, 33500 W. Grand Ave., Chicago 51, Ill.

CIRCLE 132 ON READER-SERVICE CARD

◀ CIRCLE 130 ON READER-SERVICE CARD

1958 Transistor Data Chart

Audio and High Frequency Transistors

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)	r'_b
Amperex Electronic Corp., Hicksville, N. Y.												
2N279	p-n-p, alloy, audio pre-amp.	125	75	2.5(a)	—30	10	40	5[2]	10		0.3[3]	
2N280	p-n-p, alloy, audio driver	|	|	2.5(a)	—30	10	75	4.5	10		0.3	
2N283	p-n-p, alloy, audio gen. pur.	|	|	2.5(a)	—32	10	55	3.5	10		0.5	
2N284	p-n-p, alloy, audio output	167[1]	|	3.33(a)	—32	250	45	4.5	10		0.35	
OC65	p-n-p, alloy, hear aid, pre-amp.	50[1]	65	1.54(a)	—10	10	30	5[2]	9		0.15[3]	
OC66	p-n-p, alloy, hear aid, out.	| [1]	|	1.54(a)	—10	10	47	5[2]	9		0.1[3]	
Bendix Aviation Corp., Long Branch, N. J.												
B159	p-n-p, AJ, audio	500	95	0.20 (b)	40	300	100				10 kc	
Bogue Electric Mfg. Co., Paterson, N. J.												
2N97	n-p-n, grown, audio, if	50	75	2.0(a)	30	10	0.93	2[1]	15	14	1.0	
2N161	n-p-n, grown, Si, comp. servo	150	175	1.0(a)	40	25	30	0.5	25	10	5	
2N163A	n-p-n, grown, Si, comp. servo	|	|	|	|	|	50	0.5	|	|	6	
2N160	n-p-n, grown, Si, comp. servo	|	|	|	|	|	15	0.5	|	|	4	
2N163	n-p-n, grown, Si, comp. servo	|	|	|	|	|	50	0.5	|	|	6	
2N162A	n-p-n, grown, Si, comp. servo	|	|	|	|	|	35	0.5	|	|	8	
RD316	n-p-n, grown, Si, comp. servo	100[5]	175	1.0(a)	20	20	10	0.2[4]	25	10	0.2	
2N347	n-p-n, grown, Si, servo, sw.	750	|	3.0(a)	60	60	20		24	|	|	
2N348	n-p-n, grown, Si, servo, sw.	|	|	3.0(a)	90	50	20		|	|	|	
2N349	n-p-n, grown, Si, servo, sw.	|	|	3.0(a)	125	40	20		|	|	|	
2N332	n-p-n, grown, Si, gen. purpose	150	|	1.16(b)	45	25	0.925	4	20	7	4	
2N333	n-p-n, grown, Si, gen. purpose	150	175	1.16(b)	45	25	0.960	4	20	7	5	
2N334	n-p-n, grown, Si, gen. purpose	|	|	|	|	|	0.975	|	|	|	8	
2N335	n-p-n, grown, Si, gen. purpose	|	|	|	|	|	0.980	|	|	|	6	
General Electric Co., Syracuse, N. Y.												
3N36	n-p-n, Meltback, amp.	30	85	0.5(a)	7	20		3			50	50
3N37	n-p-n, Meltback, amp.	|	|	|	|	|		|			90	|
2N44A	p-n-p, AJ	155	100	0.25(b)	—45		30	—5	6	40	1	
2N524	p-n-p, AJ	225	|	0.27(b)	|	—500	|	|	|	25	2	
2N525	p-n-p, AJ	|	|	|	|	|	44	|	|	|	2.5	
2N526	p-n-p, AJ	|	|	|	|	|	64	|	|	|	3	
2N527	p-n-p, AJ	|	|	|	|	|	81	|	|	|	3.3	
General Transistor Corp., Jamaica, N. Y.												
GT14	p-n-p, AJ, audio	125	85	2.0(a)	—25		20-34	<10	16			
GT20	p-n-p, AJ, audio	125	|	2.0(a)	—25		35-49	<10	16			
GT34	p-n-p, AJ, audio	|	|	|	|		10-19	|	|			
GT74	p-n-p, AJ, audio	|	|	|	|		50-99	|	<12			
GT75	p-n-p, AJ, audio	125	85	2.0(a)	—25		100-199	<10	<12			
GT81	p-n-p, AJ, audio	|	|	|	|		50-99	|	16			
GT81HS	p-n-p, AJ, audio	150	|	|	|		50-99	|	|			
GT82	p-n-p, AJ, audio	125	|	|	|		100-999	|	|			
GT87	p-n-p, AJ	125	85	2.0(a)	—25		20-34	<15	<24	<50	>0.5	
GT88	p-n-p, AJ	|	|	|	|		>50	<10	16	|	>1.0	
GT109	p-n-p, AJ, audio	|	|	|	|		80-140	|	<29	|		
GT122	p-n-p, AJ	|	|	|	|		>50	<10	|	|	>1.5	
GT229	n-p-n, AJ, amateur	100	|	1.67(a)	|		>10	<20	|	|	>3	
GT34HV	p-n-p, AJ, hi-volt	125	85	2.0(a)	—50		10-34					
GT759R	p-n-p, AJ, rf-if	90	75	1.8(a)	—10		>15	6		16	0.5	90
GT760R	p-n-p, AJ, rf-if	|	|	|	|		>20	|		|	3.0	110
GT83	p-n-p, AJ	125	85	2.0(a)	—25		35-49	<10		<50	>0.7	
GT35[7]	p-n-p, AJ	100	|	1.67(a)	|		20-80	<25				

Sixth Annual

Transistor Data Chart

THIS YEAR'S data chart has been designed as a quick and comprehensive reference for the transistor circuit designer. Only the most significant characteristics have been tabulated in an effort to keep the chart within reasonable proportions. Each transistor's operating characteristics depends on a particular circuit used, the frequency of operation, the temperature and other conditions so that the operating characteristics given are typical ones, usually for the grounded emitter circuit.

Four Data Charts

Transistors are grouped into four categories according to principal use.

Audio and high frequency types—these are for the most part general purpose types.

Low level switching types—low power devices for signal circuits are included here. Currents of 1 amp or better are included under Power types. Switching characteristics such as rise time, fall time and storage time in addition to other factors which are important to switching are tabulated.

Power types—devices having a collector dissipation of one watt or greater are included here. Transistors for switching substantial currents are included in this section. Thus the compilation contains audio output, servo, and switch devices.

Special types—photo transistors, unijunction units, etc. are found in this section. Not included are controlled switching rectifiers. As three terminal devices they might be considered transistors but since operating characteristics do not fall into our chart conveniently, they are not tabulated.

Transistors made by a single manufacturer are grouped together within the main categories. The type number is generally used to classify transistors within each manufacturer's grouping. However, this did not always seem the best arrangement and if grouping by similar fabrication type, power, or rating seemed better, this scheme was followed.

A total of about 612 different types of transistors are available this year as compared to about 430 last

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year. One important development of the year has been the further trend toward coordination of types between manufacturers. Probably this trend will continue in the coming years as designs become stabilized.

We have not included foreign types this year. To date, sales of foreign transistors has been negligible. U.S.A. types are generally better for the price. (Japanese transistors are not available to American buyers.)

Footnotes are used throughout to add pertinent information or distinctions that might be of interest. Unless otherwise described, the transistor is a germanium type and classed according to the following abbreviations:

AJ = alloy junction	SBT = surface base
GJ = grown junction	PC = point contact
DJ = diffused	MAJ = micro-alloy junction
FJ = fused	Si = silicon

Not all explanatory notes are included as the chart would become too unwieldy. Manufacturers data should be consulted before selecting transistors.

Ratings depend on testing conditions. Because there are few or no standards in the industry, the reader must not assume that he can accurately compare one manufacturer's transistors with another's on the basis of published data.

For an additional copy of this chart, turn to the Reader-Service card and circle 100.

1. Collector Dissipation at 25 C
2. at I_{cbo}
3. at F_{cob}
4. μa at 25 C (v_c = 5 v)
5. Mw's at 25 C
6. Symmetry pairs (npn)
7. also 2N35
8. Military
9. at 270 cps
10. with heat sink 0.18 c/mw
11. with heat sink 0.15 c/mw
12. grounded base
13. same type flexible leads
    a. collector to base volts —12
    b. collector to base volts —25
    c. collector to base volts —30
    d. 2 transistor push-pull
14. matched pair
15. push-pull
16. maximum frequency of oscillation

Audio and High Frequency Transistors (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_c ($\mu\mu f$)	f_{co} (Mc)	r'_b
General Transistor Corp., (cont.)												
GT222	p-n-p, AJ, audio	125	85	2.0(a)			>10	<20	30			0
GT761R	p-n-p, AJ, rf-if	90	75	1.8(a)	—10		>30	6		14	>7.0	15
GT762R	p-n-p, AJ, rf-if						>60				>15	
GT792R	n-p-n, AJ, rf-if										5-7	130
GT948R	n-p-n, AJ, rf-if										3-5	120
2N43	p-n-p, AJ, audio	150	100	2.0(a)	—45		>32	1-15	11-33	30-50	0.5-2.5	
2N43A[4]	p-n-p, AJ, Ind.						30-66	<10	20	<50	>0.75	
2N44	p-n-p, AJ, audio						16-32	1-15	11-33	30-50	0.5-2.5	
2N45	p-n-p, AJ, audio						9-16	1-15	11-33	30-50	0.5-2.5	
2N529[6]	p-n-p, AJ, comp.	100	85	2.0(a)	—15			<5	14	14	2.5	
2N530	p-n-p, AJ, comp.										3.0	
2N531	p-n-p, AJ, comp.	100	85	2.0(a)	—15			<5	14	14	3.5	
2N532	p-n-p, AJ, comp.										4.0	
2N533	p-n-p, AJ, comp.										4.5	
2N563	p-n-p, AJ, audio	150		2.5(a)	—30		25		16	30		
2N564	p-n-p, AJ, audio	120		2.0(a)								
2N565	p-n-p, AJ, audio	150	85	2.5(a)	—30		55	<5	16	30		
2N566	p-n-p, AJ, audio	120		2.0(a)								
2N567	p-n-p, AJ, audio	150		2.5(a)			100					
2N568	p-n-p, AJ, audio	120		2.0(a)								
2N569	p-n-p, AJ, audio	150		2.5(a)			150					
2N570	p-n-p, AJ, audio	120	85	2.0(a)	—30		150	<5	16	30		
2N571	p-n-p, AJ, audio	150		2.5(a)			200					
2N572	p-n-p, AJ, audio	120		2.0(a)								
2N605	p-n-p, drift, amp. osc., conv.	120	85	2.0(a)	—15		40	<10	16	<7		150
2N606	p-n-p, drift, amp. osc., conv.						60					160
2N607	p-n-p, drift, amp. osc., conv.				—15		80	<10	16	<7		180
2N608	p-n-p, drift, amp. osc., conv.						120					200
Hughes Aircraft Co., Los Angeles 45, Calif.												
HA5011	n-p-n, AJ, amp.	400	70	9.0(a)	40		50	6	15	15	1	200
HA5016	n-p-n, AJ, amp.				30		40	4			0.5	
HA5002	n-p-n, AJ, amp.				20			6	16			
HA5003	n-p-n, AJ, amp.				30		50		15		1	
HA5005	n-p-n, AJ, amp.				10		20	7		20	0.5	
Industro Transistor Corp., Long Island City 6, N. Y.												
2N359	p-n-p, AJ, audio radio	150	85	0.36[11](b)	—20	150	150[9]	5	12			
2N360	p-n-p, AJ, audio radio			0.35[11](b)			100[9]					
2N361	p-n-p, AJ, audio radio			0.36[11](b)	—30		70[9]					
2N362	p-n-p, AJ, audio radio				—20		120[9]					
2N363	p-n-p, AJ, audio radio				—40		50[9]					
TR764	p-n-p, AJ, hf gen pur	150	85	0.4[10](b)	—20	150	200[9]	5		14	25	
2N413	p-n-p, AJ, hf gen pur				—18		25[9]	5		14	2.5	
2N414	p-n-p, AJ, hf gen pur				—15		40[9]	2		14	7	
2N416	p-n-p, AJ, hf gen pur				—12		60[9]	2		14	10	
2N417	p-n-p, AJ, hf gen pur				—10		80[9]	2		14	20	
2N422	p-n-p, AJ, audio	150	85	0.36(b)	—20	150	90	5	12			
2N464	p-n-p, AJ, audio			[11]	—30		22					
2N465	p-n-p, AJ, audio						45					
2N466	p-n-p, AJ, audio				—20		90					
2N467	p-n-p, AJ, audio				—15		180					

Audio and High Frequency (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_{coe} ($\mu\mu$f)	f_{co} (Mc)	r'_b
Industro Transistor Corp. (cont.)												
Long Island City, N. Y.												
2N481	p-n-p, AJ, rf radio	150	85	0.4[10](b)	—12	150		2		12	2.5	
2N482	p-n-p, AJ, rf radio										4	
2N483	p-n-p, AJ, rf radio										4	
2N485	p-n-p, AJ, rf radio										8	
2N486	p-n-p, AJ, rf radio										8	
2N519	p-n-p, AJ, hf gen pur	150	85		—15	150	25	5		14	0.5	
2N520	p-n-p, AJ, hf gen pur				—12		40				0.3	
2N521	p-n-p, AJ, hf gen pur				—10		70				0.8	
2N522	p-n-p, AJ, hf gen pur				—8		120				15	
2N523	p-n-p, AJ, hf gen pur				—6		200				21	
TR81	p-n-p, AJ, audio	150	85	0.36[11](b)	—22	150	200	5	12			
TR722	p-n-p, AJ, audio				—25		22					
Motorola, Inc., Semiconductor Prod. Div., Phoenix, Arizona												
2N464	p-n-p, AJ, audio	150	85	2.5(a)	—45	100	26[12]	6	22	20	700 kc	
2N465	p-n-p, AJ, audio						15				800 kc	
2N466	p-n-p, AJ, audio				—35		90				1	
2N467	p-n-p, AJ, audio						180				1.2	
2N650	p-n-p, AJ, audio	200	100	2.8(a)	—45	250	40	15	10		2	
2N651	p-n-p, AJ, audio	200	100	2.8(a)	—45	250	75	15	10	20	2.5	
2N652	p-n-p, AJ, audio				—45		160				3	
2N653	p-n-p, AJ, audio				—30		40				2	
2N654	p-n-p, AJ, audio						75				2.5	
2N655	p-n-p, AJ, audio						160				3	
Philco Corp., Lansdale, Pa.												
2N207	p-n-p, AJ, aud. amp.	50	65	0.8(b)	12	20	100	15			2	
2N207A	p-n-p, AJ, aud. amp.							10				
2N207B	p-n-p, AJ, aud amp.							10				
2N535	p-n-p, AJ, amp.		85		20			10				
2N223	p-n-p, AJ, audio driver	200	65	0.2(b)	18	150	95	20		90		
2N224[14]	p-n-p, AJ, audio out.	250	75		25			25		125	0.5	
2N226[14]	p-n-p, AJ, aud. out.	250	75	0.2(b)	30	150		25		140	0.4	
2N128	p-n-p, Sbt, rf, if video	25	85	0.75(b)	10	5	35	0.7	9	3	65[16]	
2N499	p-n-p, Madt, rf, osc amp.	75	85	0.8(b)	30	50		15	5	1.3	320[16]	
2N500	p-n-p, Madt, uhf osc.				20			25		1		
2N502	p-n-p, Madt, vhf amp.	60		1(b)					5		500[16]	
2N344	p-n-p, Sbt, hf	20	55	0.75(b)	5	5	22	3		3	50[16]	
2N345	p-n-p, Sbt, hf	20	55	0.75(b)	5	5	35	3		3	50[16]	
2N346	p-n-p, Sbt, hf						30	0.7			75[16]	
2N299	p-n-p, Sbt, hf tuned amp.	40	85		7	20			8		105[16]	
2N300	p-n-p, Sbt, Video amp.						16					
2N503	p-n-p, Madt, vhf amp.	60		1(b)	20	50		10	5	1		
2N504	p-n-p, Madt, if amp.	50	85		35	50	16	10		1.7	50[16]	
2N588	p-n-p, Madt, osc., vhf amp.	80			20	18		15	15		200	
RCA, Somerville, N. J.												
2N104,215[13]	p-n-p, AJ, amp.	150	85		—30	—50	41	—10[13a]	6.5	22.8	0.7	290
2N105	p-n-p, AJ, amp.	60			—25	—15	55	— 7[13a]	7.5	12.4	0.75	250
2N109,217[13]	p-n-p, AJ, lge. sig. amp.	150				—70	75	—14[13b]				
2N175,220[13]	p-n-p, AJ, amp.	50			—10	—2	65	—12[13b]	6	25	0.85	190
2N206	p-n-p, AJ, amp.	75	50		—30	—50	47	—10[13c]	9		0.78	200
2N270	p-n-p, AJ, lge. sig. amp.	250	85		—25	—150	70	—16				
2N405,406[13]	p-n-p, AJ, driv., amp.	150			—12	—70	35	—14[13a]			0.65	
2N407,408[13]	p-n-p, AJ, lge. sig. amp.				—20		65	[13a]				

Symbology of Tra

K. A. Pullen, Jr.

THE BASIC Symbols for transistor electrical quantities comprise a combination of lower-case and capital letters. For example, instantaneous signal values use lower-case symbols and lower-case subscripts, whereas the instantaneous total values use lower-case symbols and capital subscripts. Likewise, rms, limit, or effective varying component values may be identified by capitalized symbols with lower-case subscripts, and the average or dc value by capitalized symbols and subscripts.

Values at specified limiting conditions take the symbols for the corresponding rms value and add an extra subscript to identify the specific condition. For example, the negative-limit value for the base voltage is written as V_{bn}. Tables for the significant transistor voltages are included in Table I, and currents in Table II.

The symbols for the electrical parameters are made up in a somewhat similar fashion. The recognized families of parameter symbols include the hybrid, or h symbols, the admittance, or y symbols, the current gain, or α (*alpha*) symbols, and the equivalent *tee*, or R symbols. In accordance with electrical engineering practice, both the z and y parameters may be taken as phasor quantities according to the equations:

$$z = r + jx$$
$$y = g + jb$$

Because of these standard and accepted forms for impedance and admittance components, the selection of g to represent the inverse h parameters appears to be contrary to good usage. Reasons for not using g symbols to represent inverse h parameters include the use, for many years, of g parameters on transistor data sheets, notably by RCA, for conductance components, and the general use of the g symbol for conductance with such active devices as tubes.

The subscripts which indicate the specific relation, input, forward, reverse, or output immittance (an immittance may be an impedance, an admittance, or a numerical ratio of two impedances or admittances) have been changed by the IRE from the *11*, *21*, *12*, and *22* subscripts commonly used in physics for many years to the more descriptive *i*, *f*, *r*, and *o*, respectively. These

Transistors

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symbols are simpler than the old number symbols, and have proven to be entirely satisfactory. One additional specific relation is often convenient, since it helps in the removal of the differencing of two products. It is represented by the subscript c, and is defined by the relation:

$$y_i\, y_c = y_i\, y_o - y_f\, y_r$$

As a result, a simple relation exists between one of the h parameters and the y_c parameter:

$$h_o = y_c$$

The subscripts associated with small-signal parameters always use lower-case letters. The first letter indicates the specific immittance relation, and the second letter, if used, indicates the circuit configuration under which the parameter should be measured. In this application, an e subscript indicates that the grounded emitter configuration is used for measurement, b—the grounded base, and c—the grounded collector. The relations between these various parameters are indicated in the conversion tables in the list of parameter relations.

The number subscripts, *11*, *12*, *21*, and *22*, still may be used for the designation of immittances, but the use of the *i*, *f*, *r*, *o*, and *c* symbols is more practical since they convey the same information and require writing fewer symbols. In either case, a configuration subscript symbol may be required after the specific immittance symbol or symbols to make the equations clear.

Considerable confusion has arisen in the field of transistor parameters as a result of the failure to designate the configuration used for the measurement. Since the trend for several years has justifiably been toward the use of the common emitter configuration as a reference, it is suggested that the configuration symbol be omitted when the data are measured for a grounded emitter circuit, and included when the measurements are for either grounded base or grounded emitter circuits.

The following three tables show the suggested symbols for use by design engineers for voltage, current, and immittance symbols. They conform with IRE symbols insofar as possible, but provide additional symbols which have proven use-

Audio and High Frequency Transistors (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)	r'_b
RCA, Somerville, N. J. (cont.)												
2N139,218[13]	p-n-p, AJ, if amp.	80			—16	—15	48	— 6[13a]			6.8	
2N140,219[13]	p-n-p, AJ, conv.						75	[13a]			10	
2N409,410[13]	p-n-p, AJ, if amp.	80			—12	—15	48	—10[13a]			31	
2N411,412[13]	p-n-p, AJ, conv.				—13		75	[13a]			32	
2N247	p-n-p, AJ, Drift	80	85				60	—20[1]			30	
2N274	p-n-p, AJ, Drift, rf amp.	80	85		—35	—10	60	—20[1]			30	
2N370	p-n-p, AJ, Drift, rf amp.				—20							
2N371	p-n-p, AJ, Drift, rf osc.											
2N372	p-n-p, AJ, Drift, Mixer	80	85		—20	—10	60	—20			30	
2N384	p-n-p, AJ, Drift, rf amp.	120			—30			—16			100	
2N544	p-n-p, AJ, Drift	80			—18	—10	60	—4[1]			30	
Raytheon Mfg. Co., Newton, Mass.												
2N359	p-n-p, AJ, audio	165	85	0.36(b)	—45	—200	150	—10				
2N360	p-n-p, AJ, audio						100					
2N361	p-n-p, AJ, audio						70					
CK13	p-n-p, AJ, rf amp.	80	85	0.75(b)	—30		30	—2	7	12	2.5	
CK14	p-n-p, AJ, rf amp.						60		6		7	
CK16	p-n-p, AJ, rf amp.	80	85	0.75(b)	—30	—200	80	—2	4	12	10	
CK17	p-n-p, AJ, rf amp.						140				18	
CK64	p-n-p, AJ, audio				—35	—100	22.5		22		800 kc	
CK65	p-n-p, AJ, audio						45				1000 kc	
CK66	p-n-p, AJ, audio						90				1200 kc	
CK67	p-n-p, AJ, audio	80	85	0.75(b)	—35	—100	180	—2	22		1500 kc	
CK22	p-n-p, AJ, audio preamp.						190		6.5		1200 kc	
2N330A	p-n-p, AJ, Si, lo noise	380	160	0.35(b)	—50	—50	25	0.005	8	70	500 kc	
2N622	p-n-p, AJ, Si, lo noise						25					
2N362	p-n-p, AJ, audio	165	85	0.36(b)	—20	—100	100	—10				
2N363	p-n-p, AJ, audio	165	85	0.36(b)	—40	—100	50	—10				
2N481	p-n-p, AJ, portable radio	150		0.4 (b)	—12	—20		10 max				
2N482	p-n-p, AJ, portable radio						50			10-14	3.5	
2N483	p-n-p, AJ, portable radio						60				5.5	
2N484	p-n-p, AJ, portable radio						90				10	
2N485	p-n-p, AJ, portable radio					—10	50			12	7.5	
2N486	p-n-p, AJ, radio ckts.	15	85	0.4(b)	—12	—10	100	—3		12	12	
2N487	p-n-p, AJ, radio ckts.							—3			10	
2N631	p-n-p, AJ, audio	165		0.36(b)	—25	—50	150	—10			1.2	
2N632	p-n-p, AJ,AJ, audio				—30		100				1	
2N633	p-n-p, AJ, audio				—35		60				0.8	
Sprague Electric Co., North Adams, Mass.												
2N345	p-n-p, Sbt, hf	20	55	0.75(b)	—5	5	35	3		3	50	
2N346	p-n-p, Sbt, hf						30	0.7			75	
2N128	p-n-p, Sbt, rf-if video	25	85		—10		35	0.7	9	3	65	
2N344	p-n-p, Sbt, hf	20	55		—5		22	3		3	50	
Sylvania Electric Products, Inc., Woburn, Mass.												
2N233A	n-p-n, AJ, if amp.	50	75	1.0(a)	18		5	50		12	2	1250
2N515	n-p-n, AJ, hf	50	75		18	10	7.5	2.5		11	3	1250
2N516	n-p-n, AJ, hf											
2N517	n-p-n, AJ, hf											
2N214	n-p-n, AJ, audio out.	180		3.6(a)	25	100		50			10 kc	

Audio and High Frequency (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)	r'_b
Sylvania Elec. Prod., Woburn, Mass.												
2N228	n-p-n, AJ, audio out.	50	75	1(a)	40		70	50			600	
2N94	n-p-n, AJ, if amp.				20	50	7.5			11	2	1250
2N94A	n-p-n, AJ, hf				20		25				5	2000
2N193	n-p-n, AJ, osc.				18		7.5				2	1250
2N229	n-p-n, AJ, gen. pur.				6	40	15	100				
2N306	n-p-n, AJ, audio dr.	50	75	1(a)	15		75	50			600 kc	
2N34	p-n-p, AJ, audio dr.	150		3(a)	—25	100					10 kc	
2N35	n-p-n, AJ, audio dr.				25							
2N213	n-p-n, AJ, audio dr.		85	2.5(a)	25		300					
2N194	n-p-n, AJ, mixer	50	75	1(a)	18	50	8			11		2000
2N211	n-p-n, AJ, osc.	50	75	1(a)	12	50	10	20		10		1250
2N212	n-p-n, AJ, conv.				18		20	50				
2N216	n-p-n, AJ, if amp.					10	7.5			11		
2N233	n-p-n, AJ, hf				10	50	4.5					1200
2N370	p-n-p, Drift, hi-freq.	80	85		—35	—0.5	90	15		2.5		100 ohm
2N372	p-n-p, Drift, hi-freq.				—20		100					
2N247	p-n-p, Drift, hi-freq.				—35	—1.0	60	25		3.0		
2N544	p-n-p, Drift, hi-freq.				—18		90	4		2.5		
2N624	p-n-p, DJ, hi-freq.	100	100	1.3(a)	—30		25	30		3		50 ohm
Texas Instruments, Inc., Dallas, Texas												
2N185	p-n-p, AJ, audio amp.	150	75		—20	—150	70	8				
2N238	p-n-p, AJ, audio amp.	50					55					
2N291	p-n-p, AJ, audio amp.	180	85	0.25(b)	—25	—200	45	10				
2N368	p-n-p, AJ, gen. pur.	150	75	0.33(b)	—30	—50	36	7	8	33	1.0	
2N369	p-n-p, AJ, gen. pur.						55	7	7			
2N680	p-n-p, AJ, audio amp.	150	75	0.33(b)	—20	—50	35	8				
2N117	n-p-n, grown, Si, gen. pur.		175		45	25	0.925	2	20	7	4	
2N118	n-p-n, grown, Si, gen. pur.						0.96				5	
2N118A	n-p-n, grown, Si, gen. pur.						0.975				8	
2N119	n-p-n, grown, Si, gen. pur.	150	175		45	25	0.98	2	20	7	6	
2N120	n-p-n, grown, Si, gen. pur.						0.99				7	
2N248	p-n-p, Diff., hi-freq.	30	85		—25	—5	20	5		1.2	50	
3N25	p-n-p, Diff., hi-freq.	25	75		—15	—2	65	10		1.1	200	
2N145	n-p-n, grown, 455 kc if	65	75	0.7(b)	20	5	15	0.2		6		
2N146	n-p-n, grown, 455 kc if											
2N147	n-p-n, grown, 455 kc if											
2N253	n-p-n, grown, 455 kc if											
2N254	n-p-n, grown, 455 kc if											
2N172	n-p-n, grown, radio conv.	65	75	0.7(b)	16	5	15	0.2		6		
2N252	p-n-p, grown, radio conv.	30			—16	—5	20	5		6		
2N308	p-n-p, grown, 455 kc if				—20							
2N309	p-n-p, grown, 455 kc if											
2N310	p-n-p, grown, radio refl.				—30							
Transitron Electronic Corp., Wakefield, Mass.												
2N117	n-p-n, Diffused, Si	150	175		30		15	0.1	20	7	8	
2N118	n-p-n, Diffused, Si		150		30		30		20		10	
2N118A	n-p-n, Diffused, Si						50		25		11	
2N119	n-p-n, Diffused, Si						60		20			
ST903	n-p-n, Diffused, Si						16	0.1	25			
ST904	n-p-n, Diffused, Si						31					
2N332	n-p-n, Diffused, Si[2]		175		45		14	0.2	22		7	
2N333	n-p-n, Diffused, Si	150	175		45		28	0.2	20	7	9	
2N334	n-p-n, Diffused, Si						45		19		11	
2N335	n-p-n, Diffused, Si						60				10	
2N336	n-p-n, Diffused, Si						100				13	

ful to the writer. The third table may be converted from admittance to hybrid parameters by the substitution of an h for the corresponding y values.

Table I. Voltages

Conditions	Base	Collector	Emitter	In	Out
Instant. total	v_B	v_C	v_E	v_S	v_o
No signal dc	V_B	V_C	V_E	V_S	V_o
Instant. signal	v_b	v_c	v_e	v_s	v_o
Maximum value varying component	V_{BM}	V_{CM}	V_{EM}	V_{SM}	V_{om}
Rms value	V_b	V_c	V_e	V_s	V_o
Value at peak positive bias	V_{bp}	V_{cp}	V_{ep}	V_{sp}	V_{op}
Value at peak negative bias	V_{bn}	V_{cn}	V_{en}	V_{sn}	V_{on}
Value at cutoff bias	V_{bz}	V_{cz}	V_{ez}	V_{sz}	V_{oz}
Average value	V_{ba}	V_{ca}	V_{ea}	V_{sa}	V_{oa}
Total change	Δv_b	Δv_c	Δv_e	Δv_s	Δv
Max. dissipation	V_{bm}	V_{cm}	V_{em}		
Supply voltage	V_{BB}	V_{CC}	V_{EE}	V_{SS}	V_{oo}

TABLE II. Currents

Conditions	Base	Collector	Emitter	In	Out
Instant. total	i_B	i_C	i_E	i_S	i_o
No signal dc	I_B	I_C	I_E	I_S	I_o
Instant. signal	i_b	i_c	i_e	i_s	i_o
Maximum value varying component	I_{BM}	I_{CM}	I_{EM}	I_{SM}	I_{om}
Rms value	I_b	I_c	I_e	I_s	I_o
Value at peak positive bias	I_{bp}	I_{cp}	I_{ep}	I_{sp}	I_{op}
Value at peak negative bias	I_{bn}	I_{cn}	I_{en}	I_{sn}	I_{on}
Value at cutoff bias	I_{bz}	I_{cz}	I_{ez}	I_{sz}	I_{oz}
Average value	I_{ba}	I_{ca}	I_{ea}	I_{sa}	I_{oa}
Total change	Δi_b	Δi_c	Δi_e	Δi_s	Δi
Max. dissipation	I_{bm}	I_{cm}	I_{em}		

TABLE III. Conductance

Conditions	Input	Forward	Output	Modified Output	Amplification
Instant. value*	g_i	g_r	g_o	g_c	K
Static value	g_{is}	g_{fs}	g_{os}	g_{cs}	K_s
Value at peak positive bias	g_{ip}	g_{fp}	g_{op}	g_{cp}	K_p
Value at peak negative bias	g_{in}	g_{fn}	g_{on}	g_{cn}	K_n
Average value	g_{ia}	g_{fa}	g_{oa}	g_{ca}	K_a
Total change	Δg_i	Δg_f	Δg_o	Δg_c	ΔK
Conversion gain	$\Delta g_i/4$	$\Delta g_f/4$	$\Delta g_o/4$	$\Delta g_c/4$	$\Delta K/4$

* g_r = reverse

The following list is a compilation of symbols and definitions extracted from the *IRE Standard 56 IRE 28.S1*. In each definition, only the basic symbol, without a configuration subscript, is listed. Where a second symbol is required to identify an electrode which is inactive or connected in some specified manner, the electrode is identified by the symbol μ. Where several possible symbols can be used for the same parameter, only one of the group is included, since the other forms may be found by consulting the reference.

List of Terms

C_i (added symbol) = diffusion (or input) capacitance from base to emitter; the output is short-circuited to ac.

C_o = capacitance measured across the output terminals with the input open-circuited to ac.

f_α = frequency at which the magnitude of the forward-current transfer ratio (small-signal) under low impedance output is 0.707 of its low frequency value.

h_F = static value of the forward-current transfer ratio under low-impedance output conditions.

h_f = small-signal value of the forward-current transfer ratio under low-impedance output conditions.

h_I = static value of the input impedance under low-impedance output conditions.

h_i = small-signal value of the input impedance under low-impedance output conditions.

h_O = static value of the output impedance under open-circuit input conditions.

h_o = small-signal value of the output impedance under open-circuit input conditions.

(Continued on following page)

Audio and High Frequency (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)	r'_b
Transitron Electronic Corp., (cont.) Wakefield, Mass.												
2N480	n-p-n, Diffused, Si[2]	200	200		45		60	0.2	19	7	11	
2N473	n-p-n, Diffused, Si				15		30		20		10	
2N474	n-p-n, Diffused, Si				30							
2N475	n-p-n, Diffused, Si				45							
2N470	n-p-n, Diffused, Si				15		16		22		8	
2N541	n-p-n, Diffused, Si	200	200		15		130	0.02	19	7	15	
2N542	n-p-n, Diffused, Si				30							
2N543	n-p-n, Diffused, Si				45							
2N478	n-p-n, Diffused, Si				15		60				11	
2N479	n-p-n, Diffused, Si				30							
2N549	n-p-n, Diffused, Si	5w	200		60			0.04		130	4	
Tung-Sol Electric Inc., East Orange, N. J.												
2N381	p-n-p, AJ, audio out.	200	85	0.2(b)	—25	200	50	10		50	1.2	
2N382	p-n-p, AJ, audio out.						75				1.5	
2N383	p-n-p, AJ, audio out.						100				1.8	
2N460	p-n-p, AJ, audio		100		—45	400	0.960	15	9		1.2	
2N461[8]	p-n-p, AJ, audio						0.980		9			
2N413	p-n-p, AJ, rf amp.	120		0.4(b)	—30	200	30	5	7	12	3	
2N414	p-n-p, AJ, rf amp.						60		6		5	
2N416	p-n-p, AJ, rf amp.	120	85			200	80	5	4	12	10	
2N417	p-n-p, AJ, rf amp.						140		5		20	
TS627	p-n-p, AJ, driver amp.	150	85	0.33(b)	—25	200	80	20			1.5	
TS628	p-n-p, AJ, low-noise					100	0.992	10	9		1.2	
TS629	p-n-p, AJ, driver amp.						0.985	15				
Western Electric,[3] New York, N. Y.												
2N509	p-n-p, Diffused, amp.	250	100	0.35(b)	—30	40	15.5	1.2		2.5	750	55
GA53194	p-n-p, Diffused, osc.					30	14	2.5			600	80
Westinghouse Electric Corp., Youngwood, Pa.												
2N59	p-n-p, Fused, Class B audio	180	85	0.003(a)	—25	200	95	10			1.8	
2N60	p-n-p, Fused, Class B audio						65				1.5	
2N61	p-n-p, Fused, Class B audio						50				1.1	
2N402	p-n-p, Fused, Class A audio driver						20				0.6	
2N403	p-n-p, Fused, Class A audio out.						30				0.85	
2N609	p-n-p, Fused, Class B audio out.	180	85	0.003(a)	—25	200	95	20			1.8	
2N610	p-n-p, Fused, Class B audio out.						65				1.5	
2N611	p-n-p, Fused, Class B audio out.						50				1.1	
2N612	p-n-p, Fused, Class A audio driver					150	20				0.6	
2N613	p-n-p, Fused, Class A audio out.					200	30				0.85	
2N614	p-n-p, Fused, if amp.	150	85	0.0025(a)	—25	100	.97	—3		6	3.5	
2N615	p-n-p, Fused, if amp.						.98				7	
2N616	p-n-p, Fused, reflex amp.						.985				8	
2N617	p-n-p, Fused, conv. amp.						.987				9	

1. Collector Dissipation at 25 C
2. at I_{cbo}
3. at F_{coe}
4. μa at 25 C (v_c = 5 v)
5. Mw's at 25 C
6. Symmetry pairs (n-p-n)
7. also 2N35
8. Military
9. at 270 cps
10. with heat sink 0.18 c/mw
11. with heat sink 0.15 c/mw
12. grounded base
13. same type flexible leads
    a. collector to base volts —12
    b. collector to base volts —25
    c. collector to base volts —30
    d. 2 transistor push-pull
14. matched pair
15. push-pull
16. maximum frequency of oscillation

h_R = static value of the reverse voltage transfer ratio for open-circuit input conditions.

h_r = small-signal value of the reverse voltage transfer ratio for open-circuit input conditions.

$I_{b\mu_o}$ = base current when the base is biased in the high-impedance direction with respect to the given reference electrode; the remaining electrode μ is open-circuited with respect to dc.

$I_{b\mu_s}$ = base current when the base is biased in the high-impedance direction with respect to the given reference electrode; the remaining electrode μ is short-circuited with respect to dc.

$I_{c\mu_o}$ = collector current when collector is biased in the high-impedance direction with respect to the given reference electrode; the remaining electrode μ is open-circuited with respect to dc.

$I_{c\mu_s}$ = collector current when collector is biased in the high-impedance direction with respect to the given reference electrode; the remaining electrode μ is short-circuited with respect to dc.

$I_{e\mu_o}$ = emitter current when emitter is biased in the high-impedance direction with respect to the given reference electrode; the remaining electrode μ is open-circuited with respect to dc.

$I_{e\mu_s}$ = emitter current when emitter is biased in the high-impedance direction with respect to the given reference electrode; the remaining electrode μ is short-circuited with respect to dc.

r'_b = base spreading resistance—resistance between the external connection and the active area of the base region.

t_d = ohmic delay time—time interval between the rise of a pulse applied at the input terminals and the rise of the output pulse generated by minority carriers.

t_s = storage time—time interval between the start of the decay of a pulse applied at the input terminals and the start of the decay of the output pulse generated by the minority carriers.

$V_{B\mu_F}$ = floating potential; open-circuit direct voltage between base and reference electrode when the electrode μ is biased in the high-impedance direction.

$V_{C\mu_F}$ = floating potential; open-circuit direct voltage between the collector and reference electrode when the electrode μ is biased in the high-impedance direction.

$V_{E\mu_F}$ = floating potential; open-circuit dc voltage between emitter and reference

electrode when the electrode μ is biased in high-impedance direction.

$BV_{\mu o}$ = breakdown voltage between the base and reference electrode.

$BV_{\mu o}$ = breakdown voltage between the collector and the reference electrode.

$BV_{\mu o}$ = breakdown voltage between the emitter and the reference electrode.

y_c = modified output admittance with high input impedance.

y_f = forward transfer admittance with low output impedance.

y_i = input admittance with low output impedance.

y_o = output admittance with low input impedance.

y_r = reverse transfer admittance, low input impedance.

z_f = forward transfer impedance with high output impedance.

z_i = input impedance with high output impedance.

z_o = output impedance with high input impedance.

z_r = reverse transfer impedance with high input impedance.

The g components of y parameters are frequently used rather than the y parameters, since often the susceptance component may be neglected. In that case, y_c, y_f, y_i, y_o and y_r are replaced with g_c, g_f, g_i, g_o, and g_r respectively.

Parameter Conversion Tables

Literature over the years in the transistor field has been written in a mixture of early network parameters and later IRE designations. The problem is further complicated by the use of impedance, admittance, and hybrid parameters. The following tables are included in this issue to facilitate easy conversion from one system to another. See figs. 1-5.

Any of these symbols may carry an additional e, b, or c subscript to designate the configuration in which the transistor is operated. The only exceptions are h_{fb} and h_{fc}, which already have the additional subscripts.

Admittance parameters may be represented by conductance parameters at low frequencies.

All h and y parameters are grounded emitters unless otherwise noted.

The primed conductances are those which would be observed at the active region in the transistor after correction for base spreading resistance.

In all the above tables, y_i, y_f, y_c, and y_o, may be replaced by the corresponding g functions, g_i, g_f, g_c, and g_o, respectively except when capacitance effects are important.

Additional parameter relations may be found for h, z, and r parameters in the 1957 Data Chart.

(Continued on page XIII)

Switching Transistors, Low Level

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (mw)	T_j (C)	(am)w/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)	r'_b	Switching: Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Manufacturer and Type
CBS Hytron, Lowell, Mass.																			**CBS Hytron**
2N438	n-p-n, AJ	100	85	2.0 (a)	30		25	1.5		10	4	180	0.7	0.8	0.5	0.15	40	25(a)	**2N438**
2N439	n-p-n, AJ						35				8	220	0.5	0.7	0.3		60	40(a)	**2N439**
2N440	n-p-n, AJ						65				12	300	0.3	0.6	0.2		100	70(a)	**2N440**
2N356	n-p-n, AJ				20v	500		3		14	3		1	0.3	1	0.18		30(a)	**2N356**
2N357	n-p-n, AJ										6		0.6		0.6				**2N357**
2N358	n-p-n, AJ	100	85	2.0 (a)	20v	500		3		14	9		0.4	0.5	0.6	0.18		30(a)	**2N358**
2N377	n-p-n, AJ	150	100		25v	200		6		15	5		1.2	0.4	0.6			30(a)	**2N377**
2N385	n-p-n, AJ										6							40(a)	**2N385**
2N388	n-p-n, AJ									15	8		0.6	0.4	0.4			80(a)	**2N388**
General Electric Co., Syracuse, N. Y.																			**General Electric**
2N394	p-n-p, AJ, sw.	150	100	2.5(a)	—10	—200		—6		12	5.5	150	0.9	0.35	0.35	—0.1	2	20(a)	**2N394**
2N395	p-n-p, AJ, sw.				—15						7	130		0.28	0.28			25(a)	**2N395**
2N396	p-n-p, AJ, sw.				—20							140		0.35	0.25	—0.09		30(a)	**2N396**
2N397	p-n-p, AJ, sw.				—10	—250					10	160				—0.085		(a)	**2N397**
2N450	p-n-p, AJ, sw.		85		—20	—125					7					—0.2		(a)	**2N450**
2N518	p-n-p, AJ, sw.	150	85	2.5(a)	—45	—125		—6		12	10		0.8	0.9	0.5	—0.150		60(a)	**2N518**
2N332	n-p-n, GJ[5], amp, Si, sw.		200	1(a)		25	15	.04	28	7	30		0.4	0.4	.14	0.4	.04	15(a)	**2N332**
2N333	n-p-n, GJ[5], amp, Si, sw.						35		23		33		.35	.15	.16			35(a)	**2N333**
2N335	n-p-n, GJ[5], amp, Si, sw.						50		20		38		.33	.25	.17			50(a)	**2N335**
2N452	n-p-n, DJ, Si, sw.	85	150		65	5		50			400 kc							8(a)	**2N452**
2N634	n-p-n, AJ, sw.	150	85	2.5(a)	20	300		5			8							15(a)	**2N634**
2N635	n-p-n, AJ, sw.										12							25(a)	**2N635**
2N636	n-p-n, AJ, sw.										17							35(a)	**2N636**
General Transistor Corp., Jamaica, N. Y.																			**General Transistor**
2N311	p-n-p, AJ, lo-speed sw.	100	85	1.67(a)	15			<60					<1.5	<1.5	<1.5			25-75(b)	**2N311**
2N312	n-p-n, AJ, lo-speed sw.																	(b)	**2N312**
2N315	p-n-p, AJ, comp. sw.				20			<2		14	5		<1.5	<0.4	<0.8			15-30(a)	**2N315**
2N316	p-n-p, AJ, comp. sw.										12		<0.8	<0.8	<1.0			20-50(a)	**2N316**
2N317	p-n-p, AJ, comp. sw.										20		<0.6		<0.8			20-60(a)	**2N317**
2N356	n-p-n, AJ, comp. sw.	100	85	2(a)	20		30	<5		14	3		<2.0	<0.7	<2			20-50(a)	**2N356**
2N357	n-p-n, AJ, comp. sw.						45				6		<1.2		<1.2			(a)	**2N357**
2N358	n-p-n, AJ, comp. sw.										9		<0.8	<1.0	<1.2			(a)	**2N358**
2N444	n-p-n, AJ, comp. sw.			1.67(a)	15			<6	16	13	>0.5	140						>10 (b)	**2N444**
2N445	n-p-n, AJ, comp. sw.										>2	150						>20 (b)	**2N445**
2N446	n-p-n, AJ, comp. sw.	100	85	1.67(a)	15			<6	16	13	>5	180						>30 (b)	**2N446**
2N447	n-p-n, AJ, comp. sw.										>9	220						>50 (b)	**2N447**
2N519	p-n-p, AJ, comp. sw.							<2		14	>0.5	75						>15 (b)	**2N519**
2N520	p-n-p, AJ, comp. sw.										>3	100						>20 (b)	**2N520**
2N521	p-n-p, AJ, comp. sw.										>8	150						>35 (b)	**2N521**
2N522	p-n-p, AJ, comp. sw.	100	85	1.67(a)	15			<2	16	14	>15	200						>60 (b)	**2N522**
2N523	p-n-p, AJ, comp. sw.										>21	275						>80 (b)	**2N523**
2N592	p-n-p, AJ, bi-lateral, sw.	125		2 (a)	20			<5		35	0.4							>20 (a)[6]	**2N592**
2N593	p-n-p, AJ, bi-lateral, sw.			(a)	30						0.6							>50 (a)[6]	**2N593**
2N594	n-p-n, AJ, bi-lateral, sw.	100		1.67(a)	20					15	>1.5							>20 (a)[6]	**2N594**
2N595	n-p-n, AJ, bi-lateral, sw.	100	85	1.67(a)	15			<5	16	15	>3.0							>35 (a)[6]	**2N595**
2N596	n-p-n, AJ, bi-lateral, sw.				10						>5.0							>50 (a)[6]	**2N596**
GT345	p-n-p, AJ, bi-directional	125		2 (a)	40			<15	24									10-19(b)	**GT345**
GT123	p-n-p, AJ, sw.	100		1.67(a)	20			<6		15	>5		0.5	0.5	0.5			30-150(a)[6]	**GT123**
GT153	p-n-p, AJ, sw.				30			<5		<15								>20 (a)	**GT153**
2N602	p-n-p, Drift, sw. comp.	120		2.0(a)	20			3	16	<7								0.1 20-80(a)	**2N602**
2N603	p-n-p, Drift, sw. comp.			2.0(a)	30			3	16	<5								0.12 30-100(a)	**2N603**
2N604	p-n-p, Drift, sw. comp.			2.0(a)	30			4	16	<5								0.15 40-140(a)	**2N604**

Switching Transistors, Low Level (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_{coe} ($\mu\mu$f)	f_{co} (Mc)	r'_b	Switching: Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Manufacturer and Type
General Transistor Corp. (cont.)																			**General Trans. (cont.)**
GT792	n-p-n, AJ, sw.	100	85	1.67(a)	20			<6			>4.8							37-160(b)	GT792
GT903	n-p-n, AJ, sw.	|	|	|	|			<25		<20								GT903
GT904	n-p-n, AJ, sw.							|			>4								GT904
GT905	n-p-n, AJ, sw.									<20									GT905
GT947	n-p-n, AJ, sw.				15					<30									GT947
GT167	n-p-n, AJ, sw.	100	85	1.67(a)	25			<10		<15	>5							>25(b)	GT167
GT269	p-n-p, AJ, sw.	|	|	|	|			<2.5			>4							>35(a)	GT269
GT758	p-n-p, AJ, sw.							<2		16	<0.5							>10(b)	GT758
GT759	p-n-p, AJ, sw.							|		16	>0.5							>15(b)	GT759
GT760	p-n-p, AJ, sw.										>3							>20(b)	GT760
GT761	p-n-p, AJ, sw.	100	85	1.67(a)	—20			<2		16	>8							>30(b)	GT761
GT762	p-n-p, AJ, sw.	|	|	| (a)					|	>15							>60(a)	GT762
GT763	p-n-p, AJ, sw.							|	16	14	>20							>80(b)	GT763
Hughes Aircraft Co., Culver City, Calif.																			**Hughes Aircraft**
HA7501	p-n-p, FJ, Si, med. pwr.	0.5w	150	4 (a)	—60		.880	—0.1			0.5					—2	—0.1		HA7501
HA5014	n-p-n, AJ, sw.	400	70	9 (a)	40								0.9	0.7	0.8	0.15	8	80(a)	HA5014
HA5020	n-p-n, AJ, sw.	300	|	6.7(a)	20								0.9	0.7	0.8	0.25	5	70(a)	HA5020
HA5021	n-p-n, AJ, sw.	|	|	6.7(a)	|							0.6	0.5	0.4	0.30	5	70(a)	HA5021
HA5001	n-p-n, AJ, sw.	400		9 (a)	30								0.9	0.7	0.8	0.20	5		HA5001
HA5009	n-p-n, AJ, sw.	400	70	9 (a)	10						2		0.9	0.7	0.8	0.35	7	15(a)	HA5009
HA7502	p-n-p, FJ, Si, med. pwr.	0.5w	150	4 (a)	—60		.950	—0.1			0.5					—2	—0.1		HA7502
HA7506	p-n-p, FJ, Si, med. pwr.	|	|	|	—35		.930	—0.5								|	—0.5		HA7506
HA7507	p-n-p, FJ, Si, med. pwr.				—20		.930	—0.1			1.5						—0.1		HA7507
HA7510	p-n-p, FJ, Si, med. pwr.				—35		.960	—0.5			0.5						—0.5		HA7510
Industro Transistor Corp., Long Island City, N. Y.																			**Industro Transistor**
2N315	p-n-p, AJ, comp.	150	85		—15	400		1		14	5		1	0.5	0.5			20(a)	2N315
2N316	p-n-p, AJ, comp.	|	|		—10	|		|		|	12			0.4	0.4	0.6			30(a)	2N316
2N317	p-n-p, AJ, comp.				—6						20		0.3	0.4	0.3			40(a)	2N317
2N425	p-n-p, AJ, comp.				—20						4		0.5	0.3	0.45			30(a)	2N425
2N426	p-n-p, AJ, comp.				—16						6		|	|	0.3			40(a)	2N426
2N427	p-n-p, AJ, comp.	150	85		—15	400		1		14	15		0.4	0.3	0.3			60(a)	2N427
2N428	p-n-p, AJ, comp.	|	|		—12			|			20		|	|	|			80(a)	2N428
Motorola, Inc., Phoenix, Ariz.																			**Motorola**
2N425	p-n-p, AJ, sw.	150	85	2.5(a)	—30	400		2		14	4	50	0.5	0.3	.45	0.22	2	30(a)	2N425
2N426	p-n-p, AJ, sw.	|	|	|	|	|		|		|	6	55	|	|	.35	|	|	40(a)	2N426
2N427	p-n-p, AJ, sw.										11	60	0.4		.35			55(a)	2N427
2N428	p-n-p, AJ, sw.										17	70	|		0.3			80(a)	2N428
																			2N375
Philco Corp., Lansdale, Pa.																			**Philco Corp.**
2N597	p-n-p, AJ	250	100		—30	400		25		18	4.5					.085		40(a)	2N597
2N598	p-n-p, AJ	|	|		|	|		|		|	7.5					|		90(a)	2N598
2N599	p-n-p, AJ										15							100(a)	2N599
2N462	p-n-p, AJ, bi-lateral	150	75		—40	200		35		20	0.5					.085		45	2N462
2N670	p-n-p, AJ, pulse amp.	300	85		|	2 amp.		75							0.35		40-250	2N670
2N671	p-n-p, AJ, pulse amp.	1w[8]				|		|							|		|	2N671
2N240	p-n-p, Sbt	30	85	0.75(b)	—6	15	30	0.7		3	50[9]								2N240
2N501	p-n-p, Madt	50	85		—15	50		0.8		2			12	7	4	0.15		50(a)	2N501
2N393	p-n-p, MAJ, hf amp., osc.	25	85		—6	50	155	1.5		3.5	60					0.07		95(a)	2N393
2N534	p-n-p, AJ, amp.	25	65	0.7(b)	—50	25	150	15											2N534
2N536	p-n-p, AJ	50	85		—20	30					2					0.07	5	100	2N536
2N495	p-n-p, AJ, Si, amp.	150	140	0.77(b)	—25	50	18	1		7	15								2N495
2N496	p-n-p, AJ, Si	|	|	0.77(b)	—10	|		1		7	11[9]					0.08	5	10(a)	2N496

Switching Transistors, Low Level (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_{cob} ($\mu\mu$f)	f_{co} (Mc)	r'_b	Switching Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Manufacturer and Type
RCA, Somerville, N. J.																			**RCA**
2N269	p-n-p, AJ, med. sp., sw.	120	85		—20	—100	40	—2.5[7]			12							40(a)	**2N269**
2N356	n-p-n, AJ, hi-current sw.	100	|		20	500	30	5[7a]			3		1	0.3	1			30(a)	**2N356**
2N357	n-p-n, AJ, hi-current sw.	|	|		|	|	|	|			6	0.6		0.6			|	**2N357**
2N358	n-p-n, AJ, hi-current sw.	|	|		|	|	|	|			9	0.4	0.5			|	**2N358**
2N398	p-n-p, AJ, hi-volt sw.	50	|		—105	—100	60	—14[7]										60(a)	**2N398**
2N404	p-n-p, AJ, med. sp., sw.	120	85		—25	—100	40	—5[7c]			12							40(a)	**2N404**
2N578	p-n-p, AJ, hi-current sw.	|	|		—20	—400	15	|			5		0.9		0.6			15(a)	**2N578**
2N579	p-n-p, AJ, hi-current sw.	|	|		|	|	30	|			8	0.4		0.5			30(a)	**2N579**
2N580	p-n-p, AJ, hi-current sw.	|	|		|	|	45	|			15	0.2		0.4			45(a)	**2N580**
2N581	p-n-p, AJ, med. sp., sw.	80	|		—18	—100	30	—6[7b]			8							30(a)	**2N581**
2N582	p-n-p, AJ, hi-speed sw.		85				60	—5[7c]			18							60(a)	**2N582**
2N583	p-n-p, AJ, med-speed sw.		|				30	—6[7b]			8							30(a)	**2N583**
2N584	p-n-p, AJ, hi-speed sw.		|				60	—5[7c]			18							60(a)	**2N584**
2N585	n-p-n, AJ, med. sp. sw.		|				40	8[7d]			5		1.5		0.8			40(a)	**2N585**
2N586	p-n-p, AJ		|				60	—16[7e]										60(a)	**2N586**
Raytheon Mfg. Co., Newton, Mass.																			**Raytheon**
2N464	p-n-p, AJ, audio low-freq.	150	85	0.4 (b)	—45	—100	26	—6	22	12	0.7							30(a)	**2N464**
2N425	p-n-p, AJ, comp. sw., ckts.		|	|	—30	—400		—2		14	2							40(a)	**2N425**
2N426	p-n-p, AJ, sw., comp.		|	|	|	|		|		|	3						55(a)	**2N426**
2N427	p-n-p, AJ, sw., comp.		|	|	|	|		|		|	5						80(a)	**2N427**
2N428	p-n-p, AJ, sw., comp.		|	|	|	|		|		|	10							**2N428**
2N404	p-n-p, AJ, sw., comp.	120	85		—25	—100		—2		12	4								**2N404**
2N658	p-n-p, AJ, sw., comp.	170	|	0.35(b)	|	—1 amp		—2.5		|	5							50(a)	**2N658**
2N661	p-n-p, AJ, sw., comp.	|	|	|	|	|		—10		|	20							120(a)	**2N661**
2N662	p-n-p, AJ, sw., comp.	|	|	|	|	|		|		|	8						60(a)	**2N662**
CK25	p-n-p, AJ, sw., comp.	80	|	0.75(b)	—30	—400		—2		14	4							30(a)	**CK25**
CK26	p-n-p, AJ, sw., comp.	80	85	0.75(b)	—30	—400		—2		14	6							40(a)	**CK26**
CK27	p-n-p, AJ, sw., comp.	|	|	|	|	|		|		|	11						55(a)	**CK27**
2N413	p-n-p, AJ, rf, video, sw., ckts.	150	|	0.4 (b)	|	—200	30	|	7	12	2.5								**2N413**
2N414	p-n-p, AJ, rf, video, sw., ckts.	|	|	|	|	|	60	|	6	|	7								**2N414**
2N416	p-n-p, AJ, rf, video, sw., ckts.	|	|	|	|	|	80	|	4	|	10								**2N416**
2N417	p-n-p, AJ, rf, video, sw., ckts.	150	85	0.4 (b)	—30	—200	140	—2.6	4	12	20								**2N417**
CK28	p-n-p, AJ, comp., sw.	80	|	0.75(b)	|	—400		—2		14	17							80(a)	**CK28**
2N327A	p-n-p, FJ, Si, audio, dc amp.	380	160	0.35(b)	—50	—50	14	0.005	18	70	200					0.1		11(a)	**2N327A**
2N328A	p-n-p, FJ, Si, audio, dc amp.	|	|	|	|	|	28	|	|	|	300					0.2		18(a)	**2N328A**
2N329A	p-n-p, FJ, Si, audio, dc amp.	|	|	|	|	|	60	|	|	|	500					0.2		26(a)	**2N329A**
2N619	n-p-n, FJ, Si, audio, dc amp.	380	160	0.35(b)	—50	—50	14	0.005	18	70	200							15(a)	**2N619**
2N620	n-p-n, FJ, Si, audio, dc amp.	|	|	|	|	|	28	|	|	|	300							30(a)	**2N620**
2N621	n-p-n, FJ, Si, audio, dc amp.	|	|	|	|	|	60	|	|	|	500							60(a)	**2N621**
2N659	p-n-p, FJ, comp.	170	85	|	—25	— 1amp		—2.5		12	10							70(a)	**2N659**
2N660	p-n-p, FJ, comp.	|	|	|	|	|		|		|	15							90(a)	**2N660**
Sprague Electric Co., North Adams, Mass.																			**Sprague Electric**
2N393	p-n-p, Maj, hf amp., osc.	25	85		—6	50	155	1.5		3.5	60					0.07		95(a)	**2N393**
2N240	p-n-p, Sbt.	30	85	0.75(b)	—6	15	30	0.7		3	50[9]								**2N240**
Sylvania Electric Prod., Inc., Woburn, Mass.																			**Sylvania Electric**
2N356	n-p-n, AJ, sw.	100	85	0.6(b)	20	100		20		14	3		1	0.3	1	0.18		30(a)	**2N356**
2N357	n-p-n, AJ, sw.	|	|	|	|	200		|			6	0.6		0.6	|		|	**2N357**
2N358	n-p-n, AJ, sw.	|	|	|	|	300		|			9	0.4	0.5	|	|		|	**2N358**
2N377	n-p-n, AJ, sw.	150	100	2 (a)	20	200	40	200[11]		15	6		2.5	0.7	1.0				**2N377**
2N385	n-p-n, AJ, sw.	|	|	|	25	|	70	400[11]		|	4								**2N385**
2N388	n-p-n, AJ, sw.	150	100	2 (a)	20	200	120	50		15	8		1.0	0.7	0.7				**2N388**
2N625	n-p-n, AJ, sw.	2.5w	|	3.3(a)	40		500	100		60			0.5	0.5	0.5				**2N625**

Switching Transistors, Low Level (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a) mw/C (b) C/mw	V_c (volts)	I_c (ma)	Characteristics h_{fe} or h_{fb}	I_{co} (μa)	NF (db)	C_{coe} ($\mu\mu$f)	f_{co} (Mc)	r'_b	Switching Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{ie}	Manufacturer and Type
Sylvania Elec. (cont.)																			**Sylvania (cont.)**
2N679	n-p-n, AJ, sw.	150	85	2.5(a)	25		20	25											**2N679**
2N312	n-p-n, AJ, sw.	100	85	1.7(b)	15	200							1.0	1.5	1.5	0.075v	15	50(a)	**2N312**
2N576A	n-p-n, AJ, sw.	200	100	2.7(a)	40	400	40	40		15	5		1.5	0.7	0.7	0.4			**2N576A**
2N587	n-p-n, AJ, sw.	150	85	2.5(a)	"	200	25	15		25			"	15					**2N587**
Texas Instruments Inc., Dallas, Texas																			**Texas Instruments**
2N364	n-p-n, grown, hi-freq.	150	85	0.5(b)	30	50	12	1		4.5	2.5								**2N364**
2N365	n-p-n, grown, hi-freq.	"	"	"	"	"	26				3								**2N365**
2N366	n-p-n, grown, hi-freq.	"	"	"	"	"	65				3.5								**2N366**
204A	n-p-n, grown, hi-freq.	"	"	"	60	"	19				2.5								**204A**
2N623	n-p-n, DJ, hi-freq.	"	"	1 (b)	30	"	35			3.5	90	75 ohm	12		12^{10}	1		35(a)	**2N623**
Tung-Sol Electric Inc., East Orange, N. J.																			**Tung-Sol Electric**
2N579	p-n-p, AJ, comp.	120	85	0.4(b)	—20	400		5		14	8		0.4	0.3	0.25	—0.2	5	30(a)	**2N579**
2N580	p-n-p, AJ, comp.	120	85	0.4(b)	—20	400		5		14	15		0.2	0.2	0.2	—0.2	5	45(a)	**2N580**
2N581	p-n-p, AJ, comp.	"	"	"	—18	100		"		"	8					—0.2	5	30(a)	**2N581**
2N404	p-n-p, AJ, comp.	"	"	0.28(b)	—25	"		"		"	12					—0.1	5	30(a)	**2N404**
2N582	p-n-p, AJ, comp.	"	"	0.4 (b)	"	"		"		"	18					—0.2	5	60(a)	**2N582**
2N425	p-n-p, AJ, comp.	"	"	"	—30	400		"		"	4	50	0.5	0.3	0.45		5	30(a)	**2N425**
2N426	p-n-p, AJ, comp.	120	85	0.4(b)	—30	400		5		14	6	55	0.5	0.3	0.35		5	40(a)	**2N426**
2N427	p-n-p, AJ, comp.	"	"	"	"	"		"		"	11	60	0.4	"			"	55(a)	**2N427**
2N428	p-n-p, AJ, comp.	"	"	"	"	"		"		"	17	70	"	"	0.3		"	80(a)	**2N428**
2N578	p-n-p, AJ, comp.	"	"	"	"	"		"		"	5		0.9	"		—0.2	"	15(a)	**2N578**
Western Electric[10] New York, N. Y.																			**Western Electric**
2N29	n-p-n, GJ, trans.	100	85	0.5(b)	35		0.480	15		17	2								**2N29**
2N110	pc	200		0.3	50	50	3.2	1.3			5		0.09		1.7				**2N110**
GA52829	p-n-p, AJ	100		0.5	—30		0.985	1.8	11		3.3								**GA52829**
GA53104	p-n-p, AJ	"		"	—10		0.980	"	"		2.9								**GA53104**
GA53149	p-n-p, AJ	"		"	—35		0.09	"	"		3.3								**GA53149**
2N560	n-p-n, Diffused, Si		175	0.25(b)	60		0.98	0.1	35		50		0.075		0.05	0.50		68(a)	**2N560**
GA53242	p-n-p, AJ	500	85					5			4		0.37	0.080	0.28	0.25		20(a)	**GA53242**

1. Collector Dissipation at 25 C
2. at 70 C mounting base
3. at 2.0 amp.
4. at 0.5
5. diffused base
6. also h_{fe}
7. collector to base V = —2.5
   a. collector to base V = 5
   b. collector to base V = —6
7. c. collector to base V = —12
   d. collector to base V = 12
   e. collector to base V = —25
7. f. mounts flange temp of 80 C
   g. 2 transistor push-pull
8. heat sink
9. ft = frequency for beta = 1
10. Military
11. Maximum Icer shown with R_{BE}=1k and V_{CE} max.

(continued from page IX)

Typical Amplifier Equations

Grounded Emitter Amplifier

$$K = \frac{-g_f R_L}{1 + g_i R_s + g_o R_L + g_i g_c R_s R_L} \text{ (voltage)}$$

$$K_i = \frac{-g_f R_s}{1 + g_i R_s + g_o R_L + g_i g_c R_s R_L} \text{ (current)}$$

Degenerative Emitter Amplifier (Voltage)

$$K = \frac{-(g_f - g_i g_c R_e) R_L}{1 + g_i R_s + (g_i + g_f + g_o) R_e + g_o R_L + g_i g_c [R_s (R_e + R_L) + R_e R_L]}$$

(continued on page XIV)

Grounded Base Amplifier

$$K_b = (g_f + g_o)\, R_L / [1 + (g_i + g_f + g_o)\, R_s + g_o\, R_L + g_i\, g_c\, (R_s + R_L)\, R_s]$$

Grounded Collector Amplifier

$$K_c = \frac{(g_i + g_f - g_i\, g_c\, R_e)\, R_e}{1 + g_i\, R_s + (g_i + g_f + g_o)\, R_e + g_i\, g_c\, R_s\, R_e}$$

Grounded Collector Amplifier Complex

The normal R_e is replaced with a transistor T_1 having its collector connected to the emitter of the grounded emitter amplifier T_2, and with its emitter connected to the emitter return through a new R_e. The base current is fixed for the load transistor T_1.

$$K = \frac{1}{1 + \dfrac{g_{o2} + G_L}{g_{i2} + g_{f2}} + \dfrac{g_{o1} + g_{i1}\, g_{c1}\, R_e}{(g_{i2} + g_{f2})\, [1 + (g_{i1} + g_{f1} + g_{o1})\, R_e]}}$$

where the "1" refers to a value of T_1, the "2" to a value for T_2, and G_L is the load conductance.

Input and Output Conductances

Grounded Emitter

In the following equations R_s is the source resistance, R_e the emitter resistance, and R_L the collector load resistance.

$$G_{ie} = \frac{1 + g_c\, R_L}{1 + g_i\, R_s + g_o\, R_L + g_i\, g_c\, R_s\, R_L}$$

$$G_{oe} = \frac{g_o + g_i\, g_c\, R_s}{1 + g_i\, R_s + g_o\, R_L + g_i\, g_c\, R_s\, R_L}$$

Degenerative Emitter

$$G_{id} = \frac{g_i\, [1 + g_c\, (R_e + R_L)]}{1 + g_i\, R_s + (g_i + g_f + g_o)\, R_e + g_o\, R_L + g_i\, g_c\, [R_s\, (R_e + R_L) + R_e\, R_L]}$$

$$G_{od} = \frac{g_o + g_i\, g_c\, (R_e + R_s)}{1 + g_i\, R_s + (g_i + g_f + g_o)\, R_e + g_o\, R_L + g_i\, g_c\, [R_s\, (R_e + R_L) + R_e\, R_L]}$$

Grounded Base

$$G_{ib} = \frac{(g_i + g_f + g_i\, g_c\, R_L)}{1 + (g_i + g_f)\, R_s + g_o\, R_L + g_i\, g_c\, R_s\, (R_s + R_L)}$$

$$G_{ob} = \frac{(g_i\, g_c\, R_s + g_o)}{1 + (g_i + g_f)\, R_s + g_o\, R_L + g_i\, g_c\, R_s\, (R_s + R_L)}$$

Grounded Collector

$$G_{ic} = \frac{g_i\, (1 + g_c\, R_e)}{1 + g_i\, R_s + (g_i + g_f + g_o)\, R_e + g_i\, g_c\, R_s\, R_e}$$

$$G_{oc} = \frac{(g_i + g_f)}{1 + g_i\, (R_s + R_e) + g_f\, R_e}$$

These equations may be changed to the hybrid parameter form by dividing numerators and denominators both by $g_i\, R_s$, and substituting

$$h_i = \frac{1}{g_i}\,; \quad h_f = \frac{g_f}{g_i}\,; \quad h_o = g_c\,; \quad h_c = h_o - \frac{h_f\, h_r}{h_i} = g_o$$

Table I. From Network to IRE Parameters

Hybrid	Admittance	Impedance	Conductance
$h_{11} = h_i$	$y_{11} = y_i$	$z_{11} = z_i$	$g_{11} = g_i$
$h_{21} = h_f$	$y_{21} = y_f$	$z_{21} = z_f$	$g_{21} = g_f$
$h_{12} = h_r$	$y_{12} = y_r$	$z_{12} = z_r$	$g_{12} = g_r$
$h_{22} = h_o$	$y_{22} = y_o$	$z_{22} = z_o$	$g_{22} = g_o$
$\alpha = h_{fb}$	$\beta = h_{fe}$		

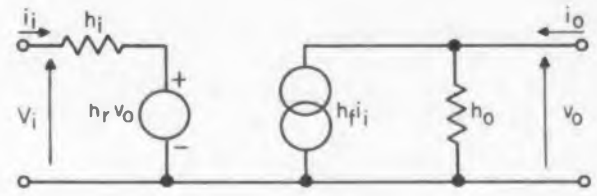

Fig. 1. Grounded base equivalent circuit using *h* parameters.

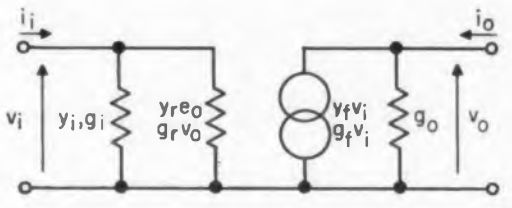

Fig. 2. Equivalent circuit using either *y* or *g* parameters.

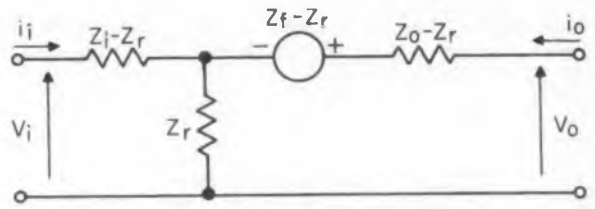

Fig. 3. Open circuit impedance equivalent circuit with one generator.

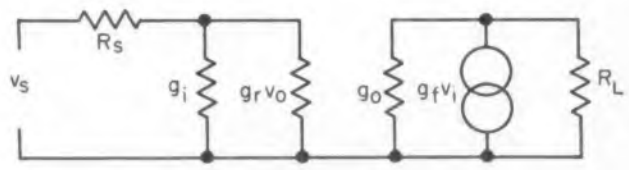

Fig. 4. Basic amplifier circuit.

Table II. Between y and z Parameters

z to y	y to z
$z_i = y_o / y_i y_c$	$y_i = z_o / D(z)$
$z_f = -y_b / y_i y_c$	$y_f = -z_f / D(z)$
$z_r = -y_r / y_i y_c$	$y_r = -z_r / D(z)$
$= (y_c - y_o) / y_f y_c$	$y_o = z_i / D(z)$
$z_o = 1 / y_c$	$y_c = 1 / z_o$
$D(z) = z_i z_o - z_f z_r$	$D(y) = y_i y_c$

Table III. Between h, y, and z Parameters

$h_i = 1 / y_i = D(z) / z_o$ $\quad h_r = (y_c - y_o)/y_f = z_r/z_o$

$h_f = y_f / y_i = -z_f / z_o$ $\quad h_o = y_c = 1 / z_o$

$D(h) = h_i h_o - h_f h_r$

Table IV. Relations for Tee Parameters

$r_d = 1 / y_c = 1 / h_o$ $\quad r_m = -y_f / y_i y_c = -h_f / h_o$

$r_b = y_o / y_i y_c = D(h) / h_o$ $\quad r_e = [(y_o/y_c) - 1]/y_f = -h_r/h_o$

$r_c = (y_i + y_f) / y_i y_c = (1 + h_f) / h_o$

Table V. Miscellaneous Relations

$\alpha = y_f / (y_i + y_f) = h_{fb}$ $\quad \beta = y_f / y_i = h_f$

$g_i' = g_i / (1 - g_i r_b')$ $\quad g_f' = g_f / (1 - g_i r'_b)$

Table VI. RCA Parameters

$g_{b'e} = g_i \approx y_i$ $\quad g_m = y_f - y_r \approx y_f \approx g_f'$

g_{ce} $\quad g_o$ $\quad g_{b'c} \approx (g_c - g_o)\, g_i / g_f$

$r_b = r_{bb}$ = base spreading resistance

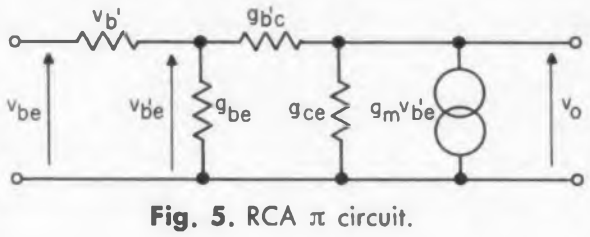

Fig. 5. RCA π circuit.

Table VII. Between y Parameters for Different Configurations

Parameters	CE	CB	CC
Input	y_i	$y_i + y_f + y_o$	y_i
Forward	y_f	$-y_f - y_o$	$-y_i - y_f$
Reverse	y_r	$y_r + y_o$	$y_i + y_r$
Output	y_o	y_o	$y_i + y_f + y_o$
Modified Output	y_c	$y_i y_c / (y_i + y_f)$	$y_i + y_f + y_o$

Table VIII. Between h Parameters for Different Configurations

Parameter	CE	CB	CC
Forward	h_i	$h_i / [1 + h_f - h_r + D(h)]$	h_i
Input	h_f	$(-h_f - D(h)) / [1 + h_f - h_r + D(h)]$	$-(1 + h_f)$
Reverse	h_r	$[D(h) - h_r] / [1 + h_f - h_r + D(h)]$	$(1 - h_r)$
Output	h_o	$h_o / [1 + h_f - h_r + D(h)]$	h_o

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Quarterly Listing of Transistor Types

Derivation and Tabulation Associates, Inc. publishes quarterly, a list of available transistor types. Complete cross indexes make the tabulation easy to use. Characteristics described are very similar to those contained in the ELECTRONIC DESIGN Data Chart. The principal difference is that D.A.T.A.'s charts are organized by increasing maximum collector dissipation. Major subdivisions are general junction transistors and power transistors. For more information on this service write to Derivation and Tabulation Associates, Inc., 67 Lawrence Ave., West Orange, N.J.

Power Transistors (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (w)	T_j (C)	(a) W/C (b) C/W	V_c (volts)	I_c (ma)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	F_{co} (Mc)	Pwr. Gain (db)	Pwr. Out. (W)	Switching: Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Manufacturer and Type
Amperex Electronic Corp., Hicksville, N. Y.																		**Amperex Electronic**
2N284A	p-n-p, alloy, hi-volt	167w[2]	75	3.33(a)	—60	250	45	4.5	0.35						0.4	200	30(a)	**2N284A**
2N115[3]	p-n-p, alloy, audio out., dc conv.	50[2]	75	1(a)	—32	3	56	20	5.5 kc		2.5				0.4	0.6	22(b)	**2N115**
OC16-G[3]	p-n-p, alloy, audio out., dc conv.	50[2]	75		—30	2	45	20	5.5 kc		2.5				0.4	0.6	22(b)	**OC16-G**
OC16-E	p-n-p, alloy, audio out., dc conv.	50[2]	75		—30	2	40	20	5.5 kc		2.5				0.4	0.6	22(b)	**OC16-E**
OC16-D	p-n-p, alloy, audio out., dc conv.	50[2]	75		—13	2	22	20	5.5 kc		2.2				0.4	0.6	22(b)	**OC16-D**
OC30[3]	p-n-p, alloy, audio output	6.67[2]	75		—32	1.4	36	12	9 kc		1.0				0.25	0.4	28(b)	**OC30**
Bendix Aviation Corp., Long Branch, N. J.																		**Bendix Aviation**
2N234A	p-n-p, AJ, audio	25w	90	2.2 (b)	—30	3	25	1	7 kc	—30	2							**2N234A**
2N235A	p-n-p, AJ, audio				—40		40	0.5		—33								**2N235A**
2N235B	p-n-p, AJ, audio		95				60			—36								**2N235B**
2N236A	p-n-p, AJ, audio			2.0 (b)			40			—33	4							**2N236A**
2N236B	p-n-p, AJ, audio						60			—36								**2N236B**
2N155	p-n-p, AJ, audio	25w	90	2.2 (b)	—40	3	40	0.5	7 kc	—33	2							**2N155**
2N176	p-n-p, AJ, audio						45			—34								**2N176**
2N242	p-n-p, AJ, audio		100				40			—33								**2N242**
2N255	p-n-p, AJ, audio		90		—30		30	1	6 kc	—30								**2N255**
2N256	p-n-p, AJ, audio	25w	90	2.2 (b)	—30	3	30	1.0	6 kc	—30	2							**2N256**
2N257	p-n-p, AJ, audio	37w			—40		40	0.5	7 kc	—33	2.5							**2N257**
2N285A	p-n-p, AJ, audio	25w	95			3	150		8 kc	—39	2							**2N258A**
2N399	p-n-p, AJ, audio[15]		90				40			—33	5[8]							**2N399**
2N400	p-n-p, AJ, audio		95				50			—36	6							**2N400**
2N268A	p-n-p, AJ	25w	100	2.2 (b)	—80	5				—31	5	15	1	30	2.0	2	25(a)	**2N268A**
2N418	p-n-p, AJ																	**2N418**
2N401	p-n-p, AJ, audio[15]	25w	90	2.2	—40	3	40	0.5	8 kc	—30	8[8]							**2N401**
2N301	p-n-p, AJ, audio	25w	90	2.2 (b)	—40	3	40	0.5	7 kc									**2N301**
2N307	p-n-p, AJ, audio				—35		25	1.0	6 kc									**2N307**
B177	p-n-p, AJ, audio				—30		150	0.5	7 kc	—38	2							**B177**
B178	p-n-p, AJ, audio						40			—33								**B178**
B179	p-n-p, AJ, audio				—40		25			—28								**B179**
2N297	p-n-p, AJ	25w	100	2.0 (b)	—70	5		0.5				15	1	30	2	2	25(a)	**2N297**
2N301A	p-n-p, AJ	25w	100	2.2 (b)	—60	2	40	0.5	7 kc									**2N301A**
B113	p-n-p, AJ	25w	100	2.0 (b)	—40	5						25	2	40	1.5	2.0	40(a)	**B113**
2N268	p-n-p, AJ	25w	100	2.2 (b)	—80	5			7 kc			15	1	30	2.0	2	25(a)	**2N268**
2N419	p-n-p, AJ	25w	95	2.2 (b)	—45	3						25	2	50	0.8	1.0		**2N419**
2N420	p-n-p, AJ		100		—40	5									1.5	0.5	50(a)	**2N420**
2N420A	p-n-p, AJ				—70													**2N420A**
2N421	p-n-p, AJ				—40													**2N421**
2N637	p-n-p, AJ			2								15	1	30	0.5	0.5	45(a)	**2N637**
2N637A	p-n-p, AJ	25w	100	2 (b)	—70	5						15	1	30	0.5	0.5	45(a)	**2N637A**
2N637B	p-n-p, AJ				—80													**2N637B**
2N638	p-n-p, AJ				—40										0.7		30(a)	**2N638**
2N638A	p-n-p, AJ				—70											2		**2N638A**
2N638B	p-n-p, AJ				—80													**2N638B**
2N639	p-n-p, AJ	25w	100	2 (b)	—40	5						15	1	30	1.1	0.5	25(a)	**2N639**
2N639A	p-n-p, AJ				—70													**2N639A**
2N639B	p-n-p, AJ				—80													**2N639B**
2N677	p-n-p, AJ	50w		1.5 (b)	—30	15									0.5	1	40(a)	**2N677**
2N677A	p-n-p, AJ				—40													**2N677A**
2N677B	p-n-p, AJ	50w	100	1.5	—70	15									0.5	2	40(a)	**2N677B**
2N677C	p-n-p, AJ				—80											1		**2N677C**
2N678	p-n-p, AJ				—30													**2N678**
2N678A	p-n-p, AJ				—40													**2N678A**
2N678B	p-n-p, AJ				—70											2		**2N678B**
2N678C	p-n-p, AJ	50	100	1.5	—80	15									0.5	2	65(a)	**2N678C**

Power Transistors (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (w)	T_j (C)	(a) W/C (b) C/W	V_c (volts)	I_c (amp)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	F_{co} (Mc)	Pwr. Gain (db)	Pwr. Out. (W)	Switching: Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Manufacturer and Type
Minneapolis-Honeywell, Minneapolis, Minn. cont.																		**Minneapolis-Honeywell**
2N539	p-n-p, AJ, dc conv., servo	10w[5]	95	2.2(a)	—80	3.5	43	100	7	31	12	40		70	0.6	2	23	2N539
2N539A	p-n-p, AJ, dc conv., servo	"	"	"	"	"	"	"	"	"	"	"		"	"	"	"	2N539A
2N540	p-n-p, AJ, dc conv., servo	"	"	"	"	"	66	"	6	34	"	45		90	"	"	48	2N540
H3A	p-n-p, AJ, servo	15w	95	14(b)	—60	0.35	20	10		21	2					0.15	15(b)	H3A
H4A	p-n-p, AJ, servo	"	"	"	"	0.5	30	"		23	3					"	22(b)	H4A
H45	p-n-p, AJ, servo	10w		2.2	—80	3.5	20	100	8.5 kc	25	12	35		60	0.6	2.0	20(b)	H45
2N539[4]	p-n-p, AJ, servo	"	"	"	"	"	43	"	7	31	"	40		70	"	"	32(b)	2N539
H200E	p-n-p, AJ	22w		1.1	—60	10	40	200	13	30	30				0.5	3.0	(b)	H200E
Motorolainc., Phoenix, Ariz.																		**Motorola**
2N178	p-n-p, AJ, 2 w pwr.	40w	90	1.6(a)	—40	3	25	1 ma	9 kc	30	2							2N178
2N176	p-n-p, AJ, 2 w pwr.	"	"	"	"	"	45	"	7	35	"							2N176
2N669	p-n-p, AJ, 2 w pwr.	"	"	"	"	"	100	"	5	40	"							2N669
2N350	p-n-p, AJ, 4 w pwr.	"	"	"	"	"	30	"	8	31	4							2N350
2N351	p-n-p, AJ, 4 w pwr.	"	"	"	"	"	45	"	7	33	"							2N351
2N376	p-n-p, AJ, 4 w pwr.	40w	90	1.6(a)	—40		60	1 ma	6 kc	35	4							2N376
2N554	p-n-p, AJ, pwr.	"	"	"	—30			3		27	2							2N554
2N555	p-n-p, AJ, pwr.	"	"	"	—40		30-100	"	8 kc									2N555
2N375	p-n-p, AJ, hv. pwr. sw.	"	"	1.5 (b)	—80	3			10 kc			10	5	50	0.6	1 ma	65(a)	2N375
2N627	p-n-p, AJ, hi-current sw.	50w	90	1.2(b)	—40	10			7.5 kc	38					0.4	1 ma	60(a)	2N627
2N628	p-n-p, AJ, hi-current sw.	"	"	"	—60	"			"	"					"	"	(a)	2N628
2N629	p-n-p, AJ, hi-v, hi-cur. sw.	"	"	"	—80	"			"	"					"	"	(a)	2N629
2N630	p-n-p, AJ, hi-v, hi-cur. sw.	"	"	"	—100	"			"	"					"	"	(a)	2N630
Nucleonic Prod. Co., Los Angeles 55, Calif.																		**Nucleonic Prod.**
2N155	power	13.5w		2.5(b)	—30	—3	—150										33(a)	2N155
Philco Corp., Lansdale, Pa.																		**Philco Corp.**
2N352	p-n-p, AJ, audio out.	25w[1]	100	3 (b)	40	2		3		0.016					0.4		65	2N352
2N353	p-n-p, AJ, audio out.	30w	"	2.5 (b)	40	2		3		.016					0.4		90(a)	2N353
2N386	p-n-p, AJ, audio out.	37.5w	"	2 (b)	60	3		5		.007					0.7		20(a)	2N386
2N387	p-n-p, AJ, audio out.	37.5w	100	2 (b)	80	3		5		.006					0.7		20(a)	2N387
2N589	p-n-p, AJ, audio out.	"	"	"	100	"		"		.006					"		(a)	2N589
RCA, Somerville, N. J.																		**RCA**
2N301	p-n-p, AJ, pwr. amp.	11w	91[7f]	1(a)	—40	—3	70	—220[7c]		33	12[7g]							2N301
2N301A	p-n-p, AJ, pwr. amp.	"	"	"	—60	"	"	"		"	"							2N301A
Sylvania Elec. Prod., Woburn, Mass.																		**Sylvania Electric**
2N301	p-n-p, AJ	12w	85	2.5(b)	—40	2A		1 ma		35	2.5							2N301
2N301A	p-n-p, AJ	"	"	"	—60	"		"		"	"							2N301A
2N307A	p-n-p, AJ		75	3.0(b)	—35			5 ma	3.5 kc	25								2N307A
2N350	p-n-p, AJ	10w	90		—30	3a	40	2 ma	5 kc	31.5	4							2N350
2N351	p-n-p, AJ	"	"		"	3A	55	"	"	33.5	"							2N351
Texas Instruments Inc., Dallas, Texas																		**Texas Instruments**
2N456	p-n-p, AJ, pwr.	50w	95	1.1(b)	—40	—5a	130	0.2 ma				26	80	0.24			30(a)	2N456
2N457	p-n-p, AJ, pwr.	"	"	"	—60	"	"	0.6				"	"	"			"	2N457
2N458	p-n-p, AJ, pwr.	"	"	"	—80	"	"	1.0				"	"	"			"	2N458
2N250	p-n-p, AJ, pwr.	25w	85		—30	—3a	90	0.3	8 kc	34								2N250
2N251	p-n-p, AJ, pwr.	"	"		—60	"	"	0.5	"	"								2N251

Power Transistors (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (w)	T_j (C)	(a) W/C (b) C/W	V_c (volts)	I_c (amp)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	F_{co} (Mc)	Pwr. Gain (db)	Pwr. Out. (W)	Switching: Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Manufacturer and Type
CBS Hytron, Lowell, Mass.																		**CBS Hytron**
2N155	p-n-p, AJ[7]	8.5w	85	0.14(a)	—30	—3	40	180	145 kc	33	2	3	8	7.5	0.5	—200	23	**2N155**
2N156	p-n-p, AJ	|	|	|	|	—3	|	|	|	|	|	|	|	|	|	|	|	**2N156**
2N157	p-n-p, AJ	|	|	|	—60	|	41	140	|	37	|	|	|	|	|	—300	20	**2N157**
2N157A	p-n-p, AJ	|	|	|	—90	|	|	|	|	|	|	|	|	|	|	|	**2N157A**
2N158	p-n-p, AJ	|	|	|	—60	|	|	|	|	|	|	|	|	|	|	|	**2N158**
2N158A	p-n-p, AJ	8.5w	85	0.14(a)	—80	—3	41	140	145 kc	37	2	3	8	7.5	0.5	—300	20	**2N158A**
2N255	p-n-p, AJ	|	|	|	|	|	30	180	|	25	1	|	|	|	|	—200	|	**2N255**
2N256	p-n-p, AJ	|	|	|	|	|	|	|	|	27	2	|	|	|	|	|	|	**2N256**
Clevite Transistor Prod., Waltham 54, Mass.																		**Clevite Transistor**
2N257	p-n-p, AJ, 12 v audio	14w	90	1.5(b)	—40	3	50	<2	7 kc	33	2.5				0.5	<2	50(a)	**2N257**
CTP1137	p-n-p, AJ, 12 v audio	|	|	|	|	|	75	|	|	36	|				|	|	75(a)	**CTP1137**
CTP1117	p-n-p, AJ, 12 v audio	|	|	|	|	6	100	|	|	36	5.0				|	|	100(a)	**CTP1117**
2N268	p-n-p, AJ, 24 v audio	|	|	|	—80	3	50	|	|	31	2.5							**2N268**
2N297[3]	p-n-p, AJ	|	|	|	—60	|									0.5	<3	50	**2N2973[3]**
CTP1512	p-n-p, AJ	20w	|	1.0(b)	—100	13									0.5	<15	90	**CTP1512**
CTP1133	p-n-p, AJ, 12 v audio	14w	90	1.5(b)	—40	30		<2	30 kc		30 kc							**CTP1133**
2N268A	p-n-p, AJ, 24 V sw.	14w[2]	90	|	—80	4									0.5	<2	40(a)[3]	**2N268A**
CTP1112	p-n-p, AJ, 30 V sw.	|	|	|	|	|									|	<3	| (a)[3]	**CTP1112**
CTP1135	p-n-p, AJ, 12 V sw.	|	|	|	—40	3						4	4	6	0.8	<2	50(a)[4]	**CTP1135**
CTP1503	p-n-p, AJ, sw.	20w	|	1.0(b)	—80	13									0.5	<15	35(a)[4]	**CTP1503**
Delco Radio, Kokomo, Ind.																		**Delco Radio**
2N173	p-n-p, AJ, pwr.	72w	95	1.0(b)	—60	13		150	10 kc	40		20		20		8 ma		**2N173**
2N174	p-n-p, AJ, pwr.	|	|	|	—80	|		|	|	38		|	|	|		12 ma		**2N174**
2N174A	p-n-p, AJ, pwr.	|	|	|	|	|		120	|	|		|	|	|	0.5	15 ma		**2N174A**
2N277	p-n-p, AJ, pwr.	52w	|	|	—40	|		150	|	40		|	|	|		8 ma		**2N277**
2N278	p-n-p, AJ, pwr.	|	|	|	—50	|		|	|	|		|	|	|		|		**2N278**
2N441	p-n-p, AJ, pwr.	52w	95	1.2(a)	—40	13		150	10 kc	38		20		20		8 ma		**2N441**
2N442	p-n-p, AJ, pwr.	|	|	|	—50	|		|	|	|		|	|	|				**2N442**
2N443	p-n-p, AJ, pwr.	|	|	|	—60	|		|	|	|		|	|	|				**2N443**
2N553	p-n-p, AJ, med. pwr.	35w	100	2.0(a)	—80	4		10	20 kc	32		5		5	0.5			**2N553**
DT80	p-n-p, AJ, pwr.	72w	95	1.0(a)	|	13		150	10 kc	40		20		20	0.5	12 ma		**DT80**
DT100	p-n-p, AJ, pwr.	|	95	1.0(a)	—100	13		150	10 kc	38		20		20		12		**DT100**
General Electric Co., Syracuse, N. Y.																		**General Electric Co.**
2N451	n-p-n, DJ, Si, amp.	85w	150	1.5(b)	65	5		20	400 kc								10(a)	**2N451**
2N453	n-p-n, DJ, Si, amp.	|	|	|	30	2		20	|								|	**2N453**
2N454	n-p-n, DJ, Si, amp.	|	|	|	65	|		20	|								|	**2N454**
Minneapolis-Honeywell Minneapolis, Minn.																		**Minneapolis-Honeywell**
H5SCL	p-n-p, AJ, dc conv., servo	10w	95	2.2(a)	—70	3.5	26	100	8.5 kc	28	12	35	60	0.6	4	23		**H5SCL**
H6SCL	p-n-p, AJ, dc conv., servo	|	|	|	|	|	41	|	7 kc	31	|	40	70	|	|	32		**H6SCL**
H7SCL	p-n-p, AJ, dc conv., servo	|	|	|	|	|	60	|	6 kc	34	|	45	90	|	|	48		**H7SCL**
SCL18[4]	p-n-p, AJ, dc conv., servo	25w	|	0.8(a)	—60	10	14	700	|	19	60	15	27	1.0	7	12		**SCL18**
SCL19[4]	p-n-p, AJ, audio dc conv., servo	|	|	|	|	|	28	|	5 kc	22	|	12	30	|	|	10		**SCL19**
2N540A	p-n-p, AJ, dc conv., servo	10[5]w	95	2.2(a)	—80	3.5	66	100	6 kc	34	12	45	90	0.6	2	48		**2N540A**
2N574	p-n-p, AJ, dv conv., servo	25w	|	0.7(a)	—60	15	14	700	|	19	60	15	27	0.5	7	12		**2N574**
2N574A	p-n-p, AJ, dc conv., servo	|	|	|	—80	|	|	|	|	|	|	|	|	|	|	|		**2N574A**
2N575	p-n-p, AJ, dc conv., servo	|	|	|	—60	30	25	|	5 kc	22	|	12	30	|	|	10		**2N575**
2N575A	p-n-p, AJ, dc conv., servo	|	|	|	—80	|	|	|	|	|	|	|	|	|	|		**2N575A**
2N538	p-n-p, AJ, dc conv., servo	10[3]w	95	2.2(a)	—80	3.5	30	100	8.5 kc	28	12	35	60	0.6	2	23		**2N538**
2N538A	p-n-p, AJ, dc conv., servo	|	|	|	|	|	|	|		|	|			|	|	|		**2N538A**

Power Transistors (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings: W_c (w)	T_j (C)	(a) W / (b) C	V_c (volts)	I_c (amp)	Characteristics: h_{fe} or h_{fb}	I_{co} (μa)	F_{co} (MC)	Pwr. Gain (db)	Pwr. Out. (W)	Switching: Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{ie}	Manufacturer and Type
Texas Instruments Inc., Dallas, Texas																		**Texas Instrument**
2N389	n-p-n, Diff., Si, pwr.	85w	200	2(b)	60	2					15	1.5	0.1	2.5	5	10 ma	10-60(a)	**2N389**
2N424	n-p-n, Diff., Si, pwr.	|	|	|	80	|								2.3	10	|		**2N424**
2N497	n-p-n, Diff., Si, med. pwr.	4w	|	22.8(a)	60	|	12-36	10				1.0	0.5	1.0	2	|	12-36	**2N497**
2N498	n-p-n, Diff., Si, med. pwr.	|	|	|	100	|	|	|									**2N498**
2N656	n-p-n, Diff., Si, med. pwr.	|	|	|	60	|	30-90	|			|	|	|	|	|	30-90	**2N656**
2N657	n-p-n, Diff., Si, med. pwr.[3]	4w	200	22.8	100	|	30-90	10				1.0	0.5	1.0	2	10	30-90	**2N657**
Transiston Electronic Corp., Wakefield, Mass.																		**Transitron Electronics**
ST400	n-p-n, Diffused, Si	85w	175		60			20 ma	6						1.5		40	**ST400**
ST401	n-p-n, Diffused, Si	|	|		30			|	|						|	50	**ST401**
ST402	n-p-n, Diffused, Si	50w	|		60			|	|					4.0		40	**ST402**
ST403	n-p-n, Diffused, Si	|	|		30			|	|					3.0		|	**ST403**
2N309	n-p-n, Diffused, Si	85w	|		60			10 ma	|									**2N309**
2N497	n-p-n, Diffused, Si	4w	|		60			0.2	4						3		20	**2N497**
2N498	n-p-n, Diffused, Si	|	|		100			|	|					|		|	**2N498**
2N550	n-p-n, Diffused, Si[2]	5w	200		30			0.4				0.7	0.2	1.0	1.5		35	**2N550**
2N551	n-p-n, Diffused, Si	|	|		60			1.2				0.12	0.3	1.3	.9		30	**2N551**
2N552	n-p-n, Diffused, Si	|	|		30			|				0.12	0.3	1.3	|	|	**2N552**
2N545	n-p-n, Diffused, Si	5w	200		60			1.2	4			0.3	0.1	0.5	3		25	**2N545**
2N546	n-p-n, Diffused, Si	|	|		30			|	|			|	|	|	2	|	**2N546**
2N547	n-p-n, Diffused, Si	|	|		60			|	|			0.7	0.2	1	3	35	**2N547**
2N548	n-p-n, Diffused, Si	|	|		30			0.5	|			|	|	|	2	|	**2N548**
Tung-Sol Electric Inc., East Orange, N. J.																		**Tung-Sol Electric, Inc.**
2N242	p-n-p, AJ, audio out.	15w	|	3 (c/w)	—45	2 amp.	50	0.3	5 kc									**2N242**
2N378	p-n-p, AJ, pwr.	50w	85	1.2 c/w	—40	3 amp.		0.5	7			25		40			50(a)	**2N378**
2N379	p-n-p, AJ, pwr.	|	|	|	—80	|	|	|	|			25		|		|	**2N379**
2N380	p-n-p, AJ, pwr.	|	|	|	—60	|	|	|	|			|		|		70(a)	**2N380**
2N459	p-n-p, AJ, pwr.	|	|	|	—105	|	|	|	|			25		40		50(a)	**2N459**
Western Electric,[3] New York, N. Y.																		**Western Electric**
2N436	p-n-p, AJ	35w	100	2 c/w	—60	5	83	59	5.5 kc			0.37	0.80	0.28	0.25		20(a)	**2N436**

Special

General Electric Co., Syracuse, N. Y.												
2N489-94	Unijunction, Si	250mw	150	2 (a)			These 6 types are specified in three ranges of stand-off ratio (.56, .62, .68) and two ranges of interbase resistance (5.6 and 7.5 K).					
General Transistor Corp., Jamaica 35, N. Y.												
2N318	p-n-p, AJ, sideview, photo	50	85	0.001(a)				<15	0.75			
2N469	p-n-p, AJ, endview, photo		75	0.001	—6			<15	10			
GT34N	p-n-p, AJ, neon light	125	85	0.002	—100							
Texas Instrumental, Inc. Dallas, Texas												
800	n-p-n, Grown, photo	65	75		—20	5						
Western Electric, New York, N. Y.												
IN85	p-n-p, GJ, photo	50	85		—90	1						

Power Transistor

Footnotes:

1. Matched pairs for Class B push-pull
2. Collection dissipation at 25 C
3. Military
4. Also under 7002
5. sink at 70 C
6. 2 transistor push-pull
7. sink at 25 C
8. Class B push-pull output

Cross-index to transistor types at the end of this section.

Choosing the Proper Transistor Circuit Battery

DESIGNING a power supply for portable transistorized equipment requires the proper choice of batteries. The basic criteria must be long periods of uniform sustained voltage and low drain under proper loads. Some of the questions that must be asked when determining the proper transistor circuit battery are:

- How do environmental factors affect the operation of the battery?
- What are the discharge characteristics under loads?
- What are the relative advantages and disadvantages of different battery constructions?

These and other useful questions will be answered as to how to make the operation of the transistor circuit battery more efficient and more reliable. A designers' check list is furnished in Table 1, enumerating the points that must be considered before the electronic circuit and physical package are finalized. A cross reference chart relating the types of batteries available is presented in Table 2.

The Effects of Temperature

Temperature is the most serious of the environmental factors that affect the life and operation of a battery. Batteries operate very efficiently at a temperature range of 60 to 90 F. But for typical batteries higher temperatures are apt to be detrimental when the batteries are stored for months at these higher temperatures. Three months at 115 F reduces the capacity of the battery from 10 to 50 per cent. It also produces occasional duds. Much higher temperatures can be withstood for shorter periods, but temperatures above 160 F are very damaging even for short periods. The chemical action which takes place on discharge within a dry cell

Vital information on the factors affecting the choice and operation of transistor batteries were obtained in an interview with J. J. Coleman, Vice President, Engineering, and R. C. Clock, Battery Design Chief, Burgess Battery Co. The article concludes with a handy designer's check list and with a cross reference chart.

is improved by higher temperatures. So long as something serious such as a blown seal does not develop, the higher the temperature, the greater the power and energy output.

On the other hand, the lower the storage temperature, the better. The shelf life of batteries is greatly prolonged at storage temperatures near 0 F. The life of even very tiny batteries can be extended by many years at temperatures of —40 F. The performance of the battery is greatly reduced at near 0 F unless special low temperature batteries are employed. In the latter case, one can get some performance down to —40 F. Below this temperature, little or no performance can be obtained.

Batteries are not much affected even by extremes of humidity. If moisture condenses, leakage currents can develop, as in the case of any electrical device. At extremely low humidities, there may be an increased tendency for batteries to dry out. The water contained in dry batteries is very vital to their operation.

Discharge Characteristics Under Load

Dry batteries ordinarily have a quick drop in their potential at the start of the discharge period. Then they discharge at a rather uniform potential down to 1 v per cell. See Fig. 1. Higher end points such as 1.2 v per cell are very common but they mean a substantial loss of performance. At end points much higher than 1.2 v per cell, the performance is likely to be inadequate. There is no sudden drop off in potential and the life is steadily increased as the end point is decreased beyond 1 v per cell. Frequently this gradual decrease is beneficial since it warns the user that a new battery is required long before the point is reached at which no operation of the

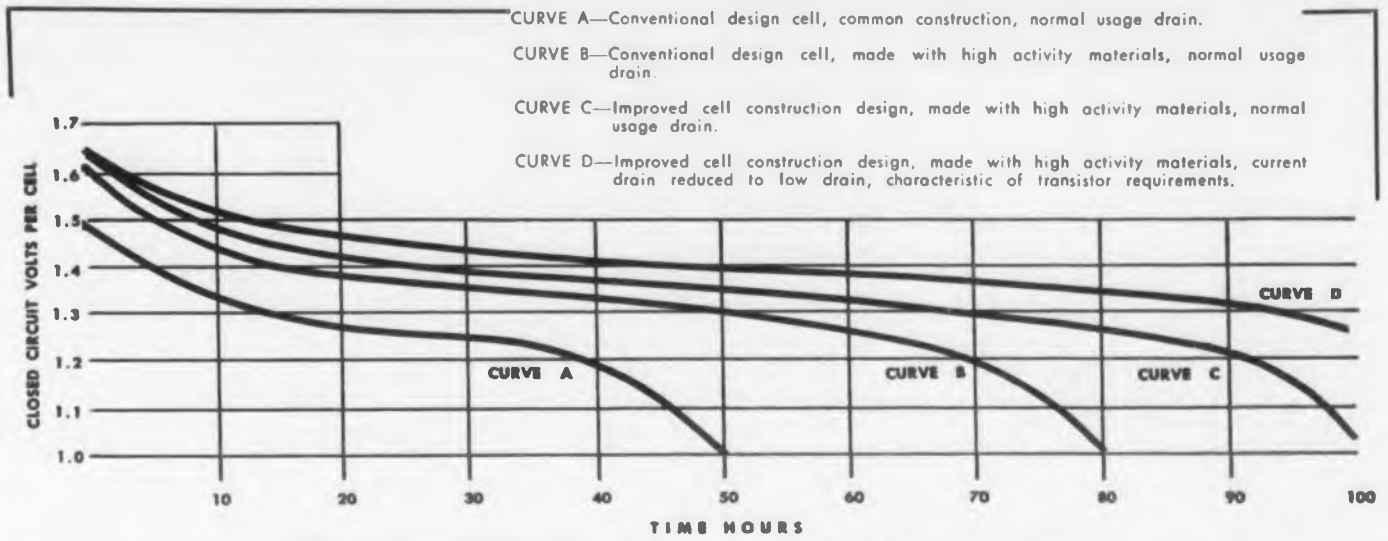


Fig. 1. Various types of cells showing voltage vs time characteristics.

Table 1. Designer's Check List

☐ **BATTERY VOLTAGE—(Nominal)**

This is normally dictated by the using equipment. The equipment will frequently operate satisfactorily over a moderately wide volt range. The designer should keep this in mind and select a standard battery if possible.

☐ **BATTERY END VOLTAGE**

This again is governed by the using equipment. For best battery efficiency the circuit should be designed to allow the widest possible range between nominal battery voltage (1-1/2 volts per cell) and end voltage.

☐ **BATTERY SIZE**

Normally batteries of the same voltage are available in several different physical sizes. Most economical service will usually be obtained by selecting the largest battery size that can be tolerated.

☐ **BATTERY COMPARTMENT**

This should be free from all sharp projections that might puncture the battery or ground to a metal battery case. Some batteries are made with rounded corners or with corners beveled at 45 deg. Where space permits, it is desirable to leave the battery compartment so that it could accommodate the full rectangular cross section without the round or beveled corners. This allows later increase in battery service by design change to utilize these corners.

The battery should fit freely into the compartment with allowance for minor size variations. This can frequently be accomplished by sponge rubber pads or light leaf springs. These also serve to prevent the battery from moving.

☐ **TERMINALS**

The using equipment should be provided with proper connections such as plugs or snap fasteners to mate with the battery terminals. Battery terminals are made to conform to RMA standards. The mating terminal should also conform to these standards. The location should be such that neither the battery nor the equipment will be damaged in the process of connecting or disconnecting the battery.

☐ **BATTERY LOCATION IN EQUIPMENT**

Battery should be located away from any sources of excessive heat. Ideal battery operating temperature is in the range of 60-90 deg. F. Weight balance is frequently a factor. Battery location should be considered with this in mind.

☐ **BATTERY DISCONNECT SWITCH**

This should provide a positive means for disconnecting the battery when the equipment is idle. An indicator to show "Off" and "On" positions is desirable to prevent the power being left on accidentally when the equipment is put away. In many instances a battery is blamed for giving poor service when in fact the power switch has been left "On" while the equipment was idle.

device is possible. Decreasing the load on a dry battery greatly increases not only the life in hours but also the life in ampere hours. A simple formula gives a fair approximation of the increase to be expected:

log of output (ma-hr) = constant — log of load current (ma)

As an example of the application of this formula, reducing the load to one-half increases the ma-hr output 20 per cent, an increase in life by a factor of 2.40.

Different Types of Construction

Commercial dry batteries are differentiated by the following characteristics: their chemical components; form; and envelope. There has been a growing use of more active chemical components. The increased activity has sometimes led to unreliable performance. Hence there has been a great deal of work done toward the control of the new materials. An example is manganese dioxide. A crystal structure which is suitable for some types of dry batteries is not at all suitable for other types.

Most multi-cell batteries are now made with cells of a rectangular shape which efficiently use the space available. The early B batteries were simply flashlight cells soldered in series. Their cylindrical shape resulted in a waste of space. One approach to the problem has been a return to something like the original voltaic pile. A duplex electrode is employed. Zinc plates are coated with carbon paint and they are assembled with other components into units which are not individual cells but which, when stacked one on another, form a pile of cells connected in series. Ordinarily the unit is enclosed in a plastic sheath or envelope. This method employs the space efficiently but presents other problems.

Since individual cells are not made, the 100 per cent testing and inspection of individual cells is no longer possible. The lower potential

Table 2. Cross Reference Chart

Burgess	NEDA	General Dry	Mercury	National Carbon	RCA	Ray-O-Vac
2N6	1602	178	—	246	VS305	1602
D6	1603	88	—	276	VS306	1603
D6S	1608	—	—	2761	—	—
D6PI	1601	89	—	2506	VS301	1601
C6X	—	86	—	2356	—	—
P6M	1600	—	—	226	VS300	1600
2U6	1604	—	—	216	—	1604
XX9	1900	177	—	239	VS304	1900
NE	910	913	G401	W468	VS073	716
930	—	—	G502	1015E	—	—
130	—	—	—	635	—	—
230	—	—	—	A100	—	—
4D4	1400	—	—	274	—	—
A4	—	—	—	—	—	—

of a weak cell is masked by the other cells in a series assembly. It is likely to escape detection in the inspection process. Moreover, these units are not themselves sealed against loss of moisture. It is only the finished stack of cells which is sealed by dipping in wax.

The wafer cell meets both of these problems. It has a complete cell, sealed against moisture loss, which can be individually tested. The cell is so strong that a stack of cells can be molded into a smooth form, leaving no wasted voids of space. One of the problems of forming such a stack of cells has always been that of making an electrical connection. This problem led to the use of duplex electrodes in the older type of dry battery.

One of the electrodes in the wafer cell is a thin sheet of plastic made conductive by loading it with graphite. It is not possible to solder to such a material nor to make any of the usual mechanical connections. A conductive wax has been developed which is rendered conductive by silver plated copper particles. This material is extremely conductive and at the same time has the soft adhesive properties of wax. Two small buttons of this wax serve as the terminals on the wafer cell.

When these cells are piled one on the other, a strong electrical bond is formed from terminal to terminal, which is very resistent to vibration because of the lack of rigidity. Each wafer cell is sealed in a plastic envelope which has a low moisture vapor permeability. The entire stack is wrapped once again with a sheet of mylar to which another plastic has been bonded to form an additional moisture vapor barrier. Finally the entire assembly is dipped in a special type of wax solution.

Cost Considerations

The following factors increase cost unnecessarily. Some types of sockets need to extend down into the battery a great distance. This not only wastes space that could be better used but also requires considerable padding. While the cost of this is not large, it is sometimes entirely unnecessary. The voltage of dry batteries declines when discharged and for efficient use a rather wide variation is required. When cost is extremely important, the batteries should be contained in simple, rectangular paper boxes. Metal containers are quite common. Both aluminum and steel are used. They can improve the quality of the battery—for example, making it more rugged and greatly enhancing its appearance. When these containers are used, the batteries usually have rounded corners. However, when possible the designers should provide a rectangular compartment for the battery so that the battery manufacturer can use this shape if he finds it desirable.

CROSS INDEX

Amperex	Am	Motorola	Mo
Bendix	Be	Nucleonics	Nu
Bogue	Bo	Philco	Ph
CBS-Hytron	CBS	RCA	RCA
Clevite	C	Raytheon	Ra
Delco	De	Sprague	Sp
General Electric	GE	Sylvania	Sy
General Transistor	GT	Texas Instruments	TI
Hughes	Hu	Transitron	Tr
Industro-Transistor	Ind	Tung-Sol	TS
Minneapolis-Honeywell	MH	Western Electric	WE
		Westinghouse	Wh

1N85	WE	2N223	Ph
2N29	WE	2N224	Ph
2N34	Sy	2N226	Ph
2N35	Sy	2N228	Sy
2N43	GT	2N229	Sy
2N43A	GT	2N233	Sy
2N44	GT	2N233A	Sy
2N44A	GE	2N234A	Be
2N45	GT	2N235A	Be
2N59	Wh	2N235B	Be
2N60	Wh	2N236A	Be
2N61	Wh	2N236B	Be
2N94	Sy	2N238	TI
2N94A	Sy	2N240	Ph, Sp
2N97	Bo	2N242	Be, TS
2N104	RCA	2N247	RCA, Sy
2N105	RCA	2N248	TI
2N109	RCA	2N250	TI
2N110	WE	2N251	TI
2N115	Am	2N252	TI
2N117	TI, Tr	2N253	TI
2N118	TI, Tr	2N254	TI
2N118A	TI, Tr	2N255	Be, CBS
2N119	TI, Tr	2N256	Be, CBS
2N120	TI	2N257	Be, C
2N128	Ph, Sp	2N268	Be, C
2N129	Sp	2N268A	Be, C
2N139	RCA	2N269	RCA
2N140	RCA	2N270	RCA
2N145	TI	2N274	RCA
2N146	TI	2N277	De
2N147	TI	2N278	De
2N155	Be, CBS, Nu	2N279	Am
2N156	CBS	2N280	Am
2N157	CBS	2N283	Am
2N157A	CBS	2N284	Am
2N158	CBS	2N284A	Am
2N158A	CBS	2N285A	Be
2N160	Bo	2N291	TI
2N160A	Bo	2N297	Be, C
2N161	Bo	2N299	Ph
2N161A	Bo	2N300	Ph
2N162	Bo	2N301	Be, RCA, Sy
2N162A	Bo	2N301A	Be, RCA, Sy
2N163	Bo	2N306	Sy
2N163A	Bo	2N307	Be
2N172	TI	2N307A	Sy
2N173	De	2N308	TI
2N174	De	2N309	TI, Tr
2N174A	De	2N310	TI
2N175	RCA	2N311	GT
2N176	Be, Mo	2N312	GT, Sy
2N178	Mo	2N313	GT
2N185	TI	2N315	GT, Ind
2N193	Sy	2N316	GT, Ind
2N194	Sy	2N317	GT, Ind
2N206	RCA	2N327A	Ra
2N207	Ph	2N328A	Ra
2N207A	Ph	2N329A	Ra
2N207B	Ph	2N330A	Ra
2N211	Sy	2N332	Bo, GE, Tr
2N212	Sy	2N333	Bo, GE, Tr
2N213	Sy	2N334	Bo, Tr
2N214	Sy	2N335	Bo, GE, Tr
2N215	RCA	2N336	Tr
2N216	Sy	2N344	Ph, Sp
2N217	RCA	2N345	Ph, Sp
2N218	RCA	2N346	Ph, Sp
2N219	RCA	2N347	Bo
2N220	RCA	2N348	Bo

2N349	Bo	2N460	TS
2N350	Mo, Sy	2N461	TS
2N351	Mo, Sy	2N462	Ph
2N352	Ph	2N463	WE
2N353	Ph	2N464	Ind, Mo, Ra
2N356	CBS, GT, RCA, Sy	2N465	Ind, Mo, Ra
2N357	CBS, GT, RCA, Sy	2N466	Ind, Mo
2N358	CBS, GT, RCA, Sy	2N467	Ind, Mo
2N359	Ind, RCA	2N469	GT
2N360	Ind, RCA	2N470	Tr
2N361	Ind, RCA	2N471	Tr
2N362	Ind, RCA	2N472	Tr
2N363	Ind, RCA	2N473	Tr
2N364	TI	2N474	Tr
2N365	TI	2N475	Tr
2N366	TI	2N476	Tr
2N368	TI	2N477	Tr
2N369	TI	2N478	Tr
2N370	RCA, Sy	2N479	Tr
2N371	RCA	2N480	Tr
2N372	RCA, Sy	2N481	Ind, Ra
2N375	Mo	2N482	Ind, Ra
2N376	Mo	2N483	Ind, Ra
2N377	CBS, Sy	2N484	Ra
2N378	TS	2N485	Ind, Ra
2N379	TS	2N486	Ind, Ra
2N380	TS	2N487	Ra
2N381	TS	2N495	Ph
2N382	TS	2N496	Ph
2N383	TS	2N497	TI, Tr
2N384	RCA	2N498	TI, Tr
2N385	CBS, Sy	2N499	Ph
2N386	Ph	2N500	Ph
2N387	Ph	2N501	Ph
2N388	CBS, Sy	2N502	Ph
2N389	TI	2N503	Ph
2N393	Ph, Sp	2N504	Ph
2N394	GE	2N508	GE
2N395	GE	2N509	WE
2N396	GE	2N515	Sy
2N397	GE	2N516	Sy
2N398	RCA	2N517	Sy
2N399	Be	2N518	GE
2N400	Be	2N519	GT, Ind
2N401	Be	2N520	GT, Ind
2N402	Wh	2N521	GT, Ind
2N403	Wh	2N522	GT, Ind
2N404	RCA, Ra, TS	2N523	GT, Ind
2N405	RCA	2N524	GE
2N406	RCA	2N525	GE
2N407	RCA	2N526	GE
2N408	RCA	2N527	GE
2N409	RCA	2N529	GT
2N410	RCA	2N530	GT
2N411	RCA	2N531	GT
2N412	RCA	2N532	GT
2N413	Ind, Ra, TS	2N533	GT
2N414	Ind, Ra, TS	2N534	Ph
2N416	Ind, Ra, TS	2N535	Ph
2N417	Ind, Ra, TS	2N536	Ph
2N418	Be	2N538	MH
2N419	Be	2N538A	MH
2N420	Be	2N539	MH
2N420A	Be	2N539A	MH
2N421	Be	2N540	MH
2N422	Ind	2N540A	MH
2N424	TI	2N541	Tr
2N425	Ind, Mo, Ra, TS	2N542	Tr
2N426	Ind, Mo, Ra, TS	2N543	Tr
2N427	Ind, Mo, Ra, TS	2N544	RCA, Sy
2N428	Ind, Mo, Ra, TS	2N545	Tr
2N438	CBS	2N546	Tr
2N439	CBS	2N547	Tr
2N440	CBS	2N548	Tr
2N441	De	2N549	Tr
2N442	De	2N550	Tr
2N443	De	2N551	Tr
2N444	GT	2N552	Tr
2N445	GT	2N553	De
2N446	GT	2N554	Mo
2N447	GT	2N555	Mo
2N450	GE	2N560	We
2N451	GE	2N563	GT
2N452	GE	2N564	GT
2N453	GE	2N565	GT
2N454	GE	2N566	GT
2N456	TI	2N567	GT
2N457	TI	2N568	GT
2N458	TI	2N569	GT
2N459	TS	2N570	GT

CROSS INDEX cont.

Amperex	Am	Motorola	Mo
Bendix	Be	Nucleonics	Nu
Bogue	Bo	Philco	Ph
CBS-Hytron	CBS	RCA	RC
Clevite	C	Raytheon	Ra
Delco	De	Sprague	Sp
General Electric	GE	Sylvania	Sy
General Transistor	GT	Texas Instruments	TI
Hughes	Hu	Transitron	Tr
Industro-Transistor	Ind	Tung-Sol	TS
Minneapolis-Honeywell	MH	Western Electric	WE
		Westinghouse	Wh

2N571	GT	2N652	Mo	GT83	GT
2N572	GT	2N653	Mo	GT87	GT
2N574	MH	2N654	Mo	GT88	GT
2N574A	MH	2N655	Mo	GT109	GT
2N575	MH	2N656	TI	GT122	GT
2N575A	MH	2N657	TI	GT123	GT
2N576A	Sy	2N658	Ra	GT153	GT
2N578	RCA, TS	2N659	Ra	GT167	GT
2N579	RCA, TS	2N660	Ra	GT222	GT
2N580	RCA, TS	2N661	Ra	GT229	GT
2N581	RCA, TS	2N662	Ra	GT269	GT
2N582	RCA, TS	2N669	Mo	GT758	GT
2N583	RCA	2N670	Ph	GT759	GT
2N584	RCA	2N671	Ph	GT759R	GT
2N585	RCA	2N677	Be	GT760	GT
2N586	RCA	2N677A	Be	GT760R	GT
2N587	Sy	2N677B	Be	GT761	GT
2N588	Ph	2N677C	Be	GT761R	GT
2N589	Ph	2N678	Be	GT762	GT
2N592	GT	2N678A	Be	GT762R	GT
2N593	GT	2N678B	Be	GT763	GT
2N594	GT	2N678C	Be	GT792	GT
2N595	GT	2N679	Sy	GT792R	GT
2N596	GT	2N680	TI	GT903	GT
2N597	Ph	3N25	TI	GT904	GT
2N598	Ph	3N36	GE	GT905	GT
2N599	Ph	3N37	GE	GT947	GT
2N602	GT	204A	TI	GT948R	GT
2N603	GT	800	TI	H3A	MH
2N604	GT	B113	Be	H4A	MH
2N605	GT	B159	Be	H5SCL	MH
2N606	GT	B177	Be	H6SCL	MH
2N607	GT	B178	Be	H7SCL	MH
2N608	GT	B179	Be	H45	MH
2N609	Wh	CK13	Ra	H200E	MH
2N610	Wh	CK14	Ra	HA5001	Hu
2N611	Wh	CK16	Ra	HA5002	Hu
2N612	Wh	CK17	Ra	HA5003	Hu
2N613	Wh	CK22	Ra	HA5005	Hu
2N614	Wh	CK25	Ra	HA5009	Hu
2N615	Wh	CK26	Ra	HA5011	Hu
2N616	Wh	CK27	Ra	HA5014	Hu
2N617	Wh	CK28	Ra	HA5016	Hu
2N618	Mo	CK64	Ra	HA5020	Hu
2N619	Ra	CK65	Ra	HA5021	Hu
2N620	Ra	CK66	Ra	HA7501	Hu
2N621	Ra	CK67	Ra	HA7502	Hu
2N622	Ra	CTP1112	C	HA7506	Hu
2N623	TI	CTP1117	C	HA7507	Hu
2N624	Sy	CTP1135	C	HA7510	Hu
2N625	Sy	CTP1137	C	MIL-T19 500	MH
2N627	Mo	CTP1503	C	OC16D	Am
2N628	Mo	CTP1512	C	OC16E	Am
2N629	Mo	DT80	De	OC16G	Am
2N630	Mo	DT100	De	OC30	Am
2N631	Ra	GA52829	WE	OC65	Am
2N632	Ra	GA53104	WE	OC66	Am
2N633	Ra	GA53149	WE	RD316	Bo
2N634	GE	GA53194	WE	SCL7002/18	MH
2N635	GE	GA53242	WE	SCL7002/19	MH
2N636	GE	GT14	GT	ST400	Tr
2N637	Be	GT20	GT	ST401	Tr
2N637A	Be	GT34	GT	ST402	Tr
2N637B	Be	GT34HV	GT	ST403	Tr
2N638	Be	GT34N	GT	ST903	Tr
2N638A	Be	GT34S	GT	ST904	Tr
2N639	Be	GT35/2N35	GT	TR81	Ind
2N639A	Be	GT74	GT	TR722	Ind
2N639B	Be	GT75	GT	TR764	Ind
2N650	Mo	GT81	GT	TS627	TS
2N651	Mo	GT81HS	GT	TS628	TS
		GT82	GT	TS629	TS

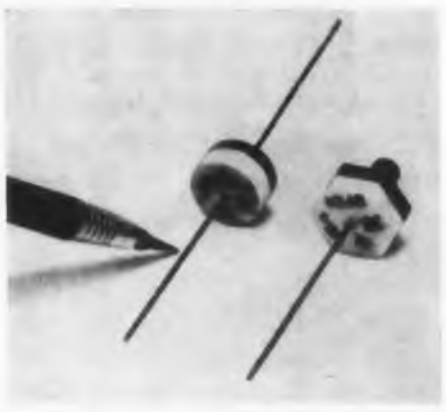
Core Plane Tester
Programmed outputs

This unit is a transistorized core tester that can be used for automatic core plane testing. It is also useful for magnetic research or individual core testing. The current outputs can be programmed to give various combinations of full or half currents. The currents are adjustable from zero to 1.5 amp. Rise time adjustments from 0.3 μsec to 1 μsec are provided. Current widths are also controllable. Accurate current control is provided and maximum reliability is achieved with the use of transistors and printed circuit assemblies throughout.

Transistor Applications, Inc., Dept. ED, 50 Broad St., Boston, Mass.

CIRCLE 402 ON READER-SERVICE CARD

Silicon Rectifiers
1250 w of rectified power



Peak inverse voltage ratings for the series J silicon rectifiers are 100, 200, 300, and 400 v. The J units are rated at 1.5 amp dc at a temperature of 100 C. They feature low forward drop, low current density, and axial leads. Type J-2 rectifiers are rated at 10 amp dc to 100 C. They require a cooling fin or heat sink to limit temperature rise. Mounting is by means of a #10-32 stud.

Sarkes Tarzian, Inc., Rectifier Div., Dept. ED, 415 N. College Ave., Bloomington, Ind.

CIRCLE 403 ON READER-SERVICE CARD

NEW PRODUCTS

Transformers

Wide band

Designed for operation from 100 kc to 100 m with minimum insertion loss, type 1210 tra formers may be used for step-up or step-do The impedance ratio is 600 ohms; 75 ohms. Go balance, low cross talk, and minimum capacit coupling are achieved.

North Hills Electric Co., Inc., Dept. E Mineola, N.Y.

CIRCLE 134 ON READER-SERVICE CARD

Three-Phase Oscillator

Facilitates component testing

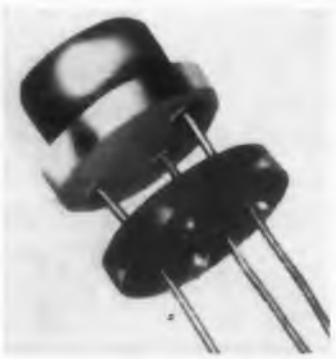
Model 603 three-phase oscillator provides wide range, variable-frequency three-phase si nal source. Coupled with three amplifiers, it ca be used for variable speed-control of synchr nous or induction motors; the testing of syste or components required to operate over a ran of frequencies varying from the normal; and f testing gyros.

Genisco, Inc., Dept. ED, 2233 Federal Ave Los Angeles 64, Calif.

CIRCLE 135 ON READER-SERVICE CARD

Transistor Mounting

For P-C boards



The Transipad, a glass filled Diallyl Phthl wafer with three holes and three hemispheri

feet, permits easier installation and more reliable mounting for transistors on printed circuit boards. Designed especially for Jetec 30 transistors, the device eliminates the need to use leads as supports and permits lower, more stable mounting with positive insulation between the transistor case and the printed circuit conductors. The Transipad is approved under MIL-M-18794 SDG.

Milton Ross Metals Co., Dept. ED, Davisville Rd., Bucks County, Southampton, Pa.

CIRCLE 136 ON READER-SERVICE CARD

Recorder

Sensitivity of 2 mv/mm

For recording electrical data from dc to 100 cps, the ER-20 direct-writing strip chart recorder features direct-coupled amplifiers which give a sensitivity of 2 mv/mm. Stylus deflection on each channel is 40 mm, with an accuracy of 2 per cent.

Mandrel Industrial Instruments, Dept. ED, 5134 Glenmont Dr., Houston, Tex.

CIRCLE 137 ON READER-SERVICE CARD

Decade Delay Line

High Impedance Output

This lumped-constant decade delay line features high impedance output. The following inputs are available: 500 ohms, 1000 ohms, 2000 ohms. Variable from 0 to 11 μsec, in increments of 0.1 μsec, with rise times of 0.25 microsecond. Units are provided with coaxial input and output connectors.

Epsco Inc., Components Div., Dept. ED, Cummington St., Boston, Mass.

CIRCLE 138 ON READER-SERVICE CARD

NEW PRODUCTS

Trimmer

2 w at 85 C

The RVG-8T trimmer potentiometers are stocked in resistance ranges of 20 to 50,000 ohms and are available to 100,000 ohms. The standard unit has a rating of 2 w at 85 C derated to zero at 150 C. Resistance tolerance of ±5 and linearity of ±3 are produced with windings on both cards and mandrels.

Gamewell Co., Dept. ED, Newton Upper Falls, Mass.

CIRCLE 141 ON READER-SERVICE CARD

Retaining Rings

Easily identified

A complete series of retaining rings are available for instrument use. Ring size is engraved on each piece for size identification. The rings are available stacked on rods for automatic assembly operations.

Rotor Clip Co., Dept. ED, 114 Allen Blvd., Farmingdale, N.Y.

CIRCLE 142 ON READER-SERVICE CARD

I-F Amplifier

With detector and cathode follower

This modified version of the M-200 Series of

amplifiers includes two models which are known as the M-230A and M-235A. A built-in detector and cathode follower is featured. Center frequency for both units is 30 mc. Bandwidths are 2 mc and 10 mc respectively.

Instruments for Industry, Inc., Dept. ED, 150 Glen Cove Rd., Mineola, N.Y.

CIRCLE 143 ON READER-SERVICE CARD

Servo Breadboard

Provides accurate test results

This apparatus consists of stocked components which may be assembled quickly into a variety of 2-7/8 in. diam mechanisms. As many as six synchro style components of any pilot diameter may be mounted. Standard gear ratios range from 1:1 to 78,125:1. Antibacklash gearing is available in all ratios. The fixed gear center mechanisms provide test results which truly represent the behavior of a correctly designed production unit.

Precision Mechanisms Corp., Dept. ED, 577 Newbridge Ave., East Meadow, N.Y.

CIRCLE 144 ON READER-SERVICE CARD

Power Supplies

Short-circuit proof

These transistorized power supplies feature three-way short circuit protection, including a high-speed circuit breaker. Regulation is 0.1 or 0.01 v for extremes of line and load. Ripple is less than 0.001 v. Wide range models start at 0 to 5 v up to 0 to 36 v. Current ratings are up to 5 amp.

Electronic Measurements Co., Inc., Dept. ED, Eatontown, N.J.

CIRCLE 145 ON READER-SERVICE CARD

FOTOCERAM circuit board blanks are made photographically. All holes and shapes are produced by simple exposure to light, heat, and an etching operation.

This is a FOTOCERAM printed circuit

. . . an unusual new type of printed circuit board

Reliable through-plate holes • The good adhesion of the circuit runs applies also to the through-plate holes because both are produced with one plating operation.

Excellent resolderability • We have removed and resoldered components over twenty times on a FOTOCERAM board without damage to circuit runs or through-plate holes. And this is *without* using adhesives to bond the copper to the board.

Dimensional stability • Rigid structure of FOTOCERAM prevents unusual design considerations—eliminates problem of warp and twist.

Good adhesion • It takes 12-25 pounds to peel a one-inch copper strip from a FOTOCERAM board.

Exceptional pull strength • 1400 pounds per square inch.

No water absorption • FOTOCERAM'S nonporous—zero water absorption.

Non-flammable

No blisters • FOTOCERAM never blisters. We put it through repeated 15-second cycles of copper metallizing at 500°F. and could not find a single blister or sign of peeling or failure.

Other properties:

Dissipation factor	1mc	@ 20°C.	0.006
		@ 200°C.	0.014
Dielectric constant	1 mc	@ 20°C.	5.6
		@ 200°C.	6.3
Loss factor	1mc	@ 20°C.	0.034
		@ 200°C.	0.088

For more information, write for our Data Sheet on FOTOCERAM.

Corning means research in Glass

CORNING GLASS WORKS, Bradford, Pa.

Electronic Components Sales Department

CIRCLE 147 ON READER-SERVICE CARD

NEW PRODUCTS

Toroidal Transformers

For dc to dc converters

A standard line of toroidal transformers f dc to dc or ac transistorized converter appli tions is available. Dual purpose transformers f switching power transistors and supplying va ous output voltages have power ratings to 1 w, inputs of 6, 12, and 24 v dc, and outputs to 6 v. Basic power transistor switching transform for use with other multiple tap power tra formers are available for use with transistors different power ratings. Units are uncased, e capsulated, or hermetically sealed.

Polyphase Instrument Co., Dept. ED, E. 4 St., Bridgeport, Pa.

CIRCLE 148 ON READER-SERVICE CARD

Force Transducer

1.68 v output

A differential transformer type force tra ducer, the model 9-1 features a high output 1.68 v full scale with input of 115 v ac at 60 c into a 5000 ohm resistive load. An efficient m netic circuit makes the output possible. Temp ature drift and sensitivity at zero are maximu of 2 per cent at full scale per 100 F. Units ha 75-lb or 240-lb capacity with a ring element d sign. Maximum linearity is 0.5 per cent, a hysteresis does not exceed 0.09 per cent. U meet or exceed MIL-E-005272B environmen requirements.

Edcliff Instruments, Dept. ED, P.O. Box 5 Monrovia, Calif.

CIRCLE 149 ON READER-SERVICE CARD

Shock Tester

Provides 77 g on 400 lb units

Model 30 K drop test machine provides shock forces in excess of 77 g on specimens weighing up to 400 lb. The machine consists of a piston type platform on which the equipment to be tested is mounted. The platform is then subjected to a free fall into a cylinder of air pressure. The advantages offered are repeatability of acceleration waveforms and simplicity of operation.

Aeroflex Corp., Aeroflex Laboratories Div., Dept. ED, 34-06 Skillman Ave., Long Island City 1, N.Y.

CIRCLE 150 ON READER-SERVICE CARD

Dual-Beam Oscilloscope

DC to 25 mc

Type 551 is a dc-to-25 mc dual-beam oscilloscope with the company's plug-in feature. All type 53/54 plug-in units can be used in both vertical channels, providing a high degree of signal-handling versatility. Risetime of the two main vertical amplifiers is 0.012 μsec, and both have 0.2-μsec signal-delay networks. The type 551 sweep is common to both beams. Twenty-two calibrated direct-reading sweep rates from 0.1 μsec/cm to 5 sec/cm are provided, with a vernier (uncalibrated) control for continuous adjustment from 0.1 μsec/cm to 12 sec/cm.

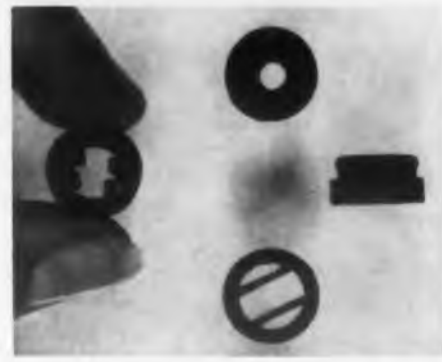
Tektronix, Inc., Dept. ED, P.O. Box 831, Portland 7, Ore.

CIRCLE 407 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Mounts

Shock, vibration resistant



These transistor mounts provide standardized mounting for all transistors regardless of size or shape. They offer shock resistance and prevent movement under severe vibration. Temperature range is from −60 to +99 C. The mounts have a low dissipation factor, low conductivity, and low dielectric constant.

Delbert Blinn Co., Dept. ED, P.O. Box 75, Pomona, Calif.

CIRCLE 152 ON READER-SERVICE CARD

Headers

One-piece construction

Square and rectangular headers of one-piece construction headers eliminate assembly operation. They are available in nearly every standard size and include moat, square flange, and insert type constructions.

Glasseal Products Co. Inc., Dept. ED, 1111 Elizabeth Ave., Linden, N.J.

CIRCLE 153 ON READER-SERVICE CARD

Frequency Indicator

Meter and converter in one package

Model FR 305 frequency indicator combines an indicating meter with the manufacturer's transistorized frequency-to-voltage converter in a single package. Accurate indication of flow rate, frequency or rpm is provided.

Waugh Engineering Co., Dept. ED, 75 Burnet Ave., Van Nuys, Calif.

CIRCLE 406 ON READER-SERVICE CARD

Diode Function Generator

Punched card memory

The Model 100 may be used to generate either n-linear functions of an independent input tage, or of any parameter which may be con- ted to a voltage, or it may be used to gener- non-linear functions of time by using either internal or an external time base. A com- te library of non-linear functions may be ated for future use.

Electrol, Inc., Dept. ED, P.O. Box 1152, Bev- Hills, Calif.

CIRCLE 154 ON READER-SERVICE CARD

Phase Meter

10 cps to 50 kc range

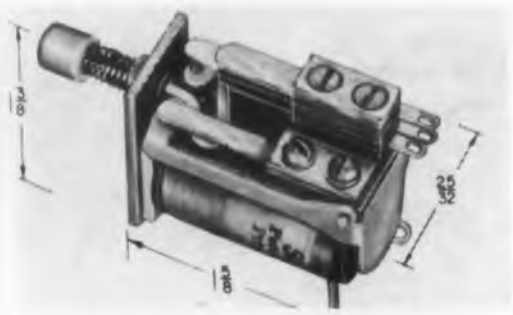
Type 328-A transistorized phase meter meas- s the phase angle in degrees between two usoidal or non-sinusoidal voltages within a quency range from 10 cps to 50 kc. It is a ect reading electronic instrument which fea- es broad frequency coverage, wide input namic range, accuracy and excellent stability.

Acton Laboratories, Inc., Dept. ED, 533 Main Acton, Mass.

CIRCLE 155 ON READER-SERVICE CARD

Relay

With reset lever



Model MA telephone-type relay has a push-to- ease reset lever. The relay operates on 2.4 w, m sec pulses and has contact arrangements up 4 p dt. When the relay operates, a latch lever ks the armature in position so that the con- cts remain transferred when power is removed m the coil.

Potter & Brumfield, Inc., Dept. ED, Princeton, d.

CIRCLE 156 ON READER-SERVICE CARD

NEW PRODUCTS

Heater Element

Total thickness of 0.02 in.

This metal film resistance element is sandwiched between rubber, fibreglass or other insulator as the particular application requires, to a total thickness of 0.02 in. This insures rapid transfer of heat and maximum efficiency. The unit is capable of continuous operation at 500 F, with power densities as high as 60 w per sq in.

Thermatic Co., Dept. ED, P.O. Box 585, Great Neck, N.Y.

CIRCLE 158 ON READER-SERVICE CARD

Switchable Tuning Unit

Requires one subcarrier discriminator

Requiring only one subcarrier discriminator this switchable tuning unit provides regular data reduction quality on all standard telemetry channels. It incorporates the company's bandpass and low pass output filters and provides a single installation available with 8, 16, or 24 channels.

Data-Control Systems, Inc., Dept. ED, Danbury, Conn.

CIRCLE 159 ON READER-SERVICE CARD

Isolator

Frequency range of 3.5 to 9.6 kmc

Model W668-1A-2-0 transverse field isolator has a frequency range of 8.5 to 9.6 kmc with isolation at 10 db min and insertion loss of

max. Other features include an input vswr 1.10 max with peak power at 300 kw nominal d ambient temperature of —65 to +125 C. Kearfott Co., Microwave Div., Dept. ED, 844 Oxnard St., Van Nuys, Calif.

CIRCLE 160 ON READER-SERVICE CARD

Spectrum Analyzers

100 and 30 channel types

This 100-channel analyzer model 100 analyzes cps bandwidths in the 50-10,500 cps range in ree bands. The 30 channel analyzer model 30 lates a single amplitude to frequency, making instant graphic display of complex audio aveforms. It is a heterodyne-type analyzer hich separates 4-kc wide bandwidths up to 20 into 29 equal frequency bands. A 30th chan- l is provided for reference.

Kay Electric Co., Dept. ED, Maple Ave., Pine rook, N.J.

CIRCLE 161 ON READER-SERVICE CARD

Waveguide Switch

Range from 4.7 to 11.0 kmc

Technical characteristics of double ridged aveguide switch model H14A2AA are: fre- ency range from 4.7 to 11.0 kmc; vswr under 5 to 1; insertion loss of 0.5 db max; crosstalk 40 db; 1P2T positions; actuator operating volt- e from 18 to 30 v dc; switching time of 1.5 sec ax; and life of 100,000 actuations.

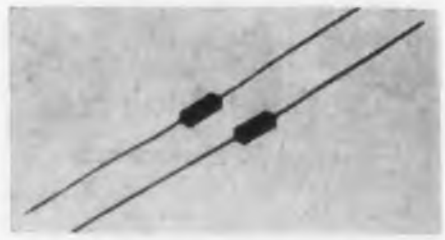
Thompson Products, Inc., Electronics Div., pt. ED, 2196 Clarkwood Rd., Cleveland 3, hio.

CIRCLE 162 ON READER-SERVICE CARD

NEW PRODUCTS

Encapsulated Resistors

Operate at 125 C



These encapsulated axial or lug-type wi wound resistors operate effectively at 125 C full rated load, derated to 0 at 145 C. Standa miniature in size, they have maximum resista values and a low inductance factor. The units a shock and humidity resistant.

General Resistance, Inc., Dept. ED, 577 E 156th St., New York 55, N.Y.

CIRCLE 164 ON READER-SERVICE CARD

Filter

Highpass-lowpass

A dual unit, this direct coupled highpass/l pass filter is an addition to the company's lin analog filters. Model LH-24D has two indivi filter units which are identical and may be c verted from highpass to lowpass by a selec switch.

Spectrum Instruments, Inc., Dept. ED, Box Steinway Station, L.I.C., N.Y.

CIRCLE 165 ON READER-SERVICE CARD

Decade Amplifier

Low phase shift

Model 12-D decade amplifier features pr sion gain and low phase-shift. Gain is down than 3 db at 3 cps and 500 kc. Phase shift nominally zero, and less than 10 deg at 20 c There is less than 3 per cent change in gain, F to 120 F. Input impedance is greater t 100,000 ohm.

Microdynamics Div., Plas-Kem Electron Corp., Dept. ED, 100 W. Alameda Ave., B bank, Calif.

CIRCLE 166 ON READER-SERVICE CARD

Switch

Designed for high voltage use

This hermetically sealed rotary selector switch ated at 1650 v dc and 20 ma. Other character- cs are: 28 v dc operating voltage; 2.3 amp coil rent at rated voltage; hi-pot rating of 2000 v with maximum leakage of 1 μa.
G. H. Leland, Inc., Dept. ED, 123 Webster Dayton 2, Ohio.

CIRCLE 167 ON READER-SERVICE CARD

Precision Potentiometer

Linearity of 0.015 per cent

Model MST-150 single turn potentiometer is a cision unit with linearities to 0.015 and reso- ion compatible with linearity. Dissipation at C is 8 w. Temperature range is 125 C con- ious and 160 C short periods.
Analogue Controls, Inc., Dept. ED, 39 Roselle Mineola, N.Y.

CIRCLE 168 ON READER-SERVICE CARD

Radar Picture Tube

High resolution

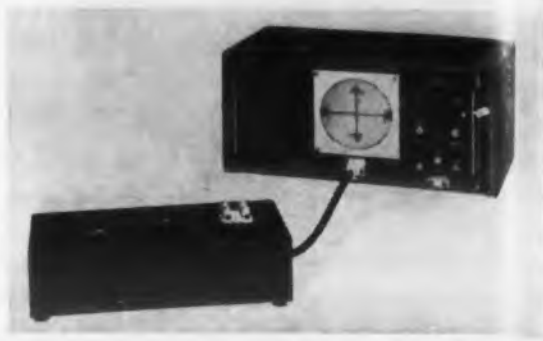
The WX3751 high resolution radar picture e produces 667 lines to the inch or a scanning e 0.0015 in. wide across the 5-in. faceplate. tically flat, the faceplate is gray glass to in- ase contrast. The tube has a modified P-11 e phosphor and a metal-backed screen to ob- maximum light output. An electrostatic us, magnetic-deflection type, the tube is 13 in. g.
Westinghouse Electric Corp., Electronic Tube ., Dept. ED, P.O. Box 284, Elmira, N.Y.

CIRCLE 169 ON READER-SERVICE CARD

NEW PRODUCTS

Comparator

Permits fast production testing



Type 265-A Q is available for fast productio testing of coils, capacitors, and resistors. T comparator provides comparison measureme of relative Q, inductance and capacitance wi ease and accuracy. No operator tuning or adj ment is necessary. Measurement is by means a dot in the center of the crt. Any dot which d not appear at the center of the crt indicates th the component under test is different than t standard. Deviation along the vertical axis sho a change in Q, and deviation along the horizon axis shows a change in L or C.

Boonton Radio Corp., Dept. ED, Boonton, N

CIRCLE 172 ON READER-SERVICE CARD

Linear Actuator

860-lb normal load

Adaptable for a wide range of aircraft, missil ordnance, and industrial applications, the Mod D-1890 linear actuator operates under a norm load of 860 lb at a rate of 0.28 ips. The maximu operating load is 1800 lb. The basic stroke 2.50 in. can be lengthened or shortened to su requirements. The unit features a radio noi filter, adjustable travel limit switches, integ thermal overload protection, an electromecha cal clutch brake for low overtravel and in versibility, and positive nonjamming mechani stops.

Hoover Electric Co., Dept. ED, 2100 S. Sto Ave., Los Angeles 25, Calif.

CIRCLE 173 ON READER-SERVICE CARD

Miniature Relay

Weighs less than 1/2 oz.

easuring less than 1 in. long and weighing than 1/2 oz, type S-M relay is designed for tinuous use in a −65 to +125 C temperature ge. Life expectancy is 100,000 operations imum, at rated load. Specifications include: hinal coil voltage 26.5 v dc; contact arrange-t, 2 pdt; contact rating, 2 amp at 28 v dc re-ive; maximum operate time 4 msec; maximum ase time 3 msec; maximum contact bounce sec operating shock 50 g for 11 msec; vibra-, 20 g to 2000 cps. The unit meets MIL-R-18 and MIL-R-5757C.

omar Electric Co., Dept. ED, 3349 W. Addi-St., Chicago 18, Ill.

CIRCLE 174 ON READER-SERVICE CARD

Pulse Transformers

Plug-in types with four windings

ypes PT-82 and PT-91 pulse transformers are igned to plug into standard noval sockets. e units may be used for isolation, coupling or cking oscillator circuits. The four windings y be connected in various ways for impedance tching.

erkshire Laboratories, Dept. ED, 964 Bank lage, Greenville, N.H.

CIRCLE 175 ON READER-SERVICE CARD

Resistance Averaging Unit

Independent of number of resistors

his system for averaging resistors in parallel esigned for applications where it is necessary continue averaging as individual resistors are in or out of the circuit (e.g. resistance ther-meters). The basic principle of operation is ase angle measurement and the unit does not orporate any relays or other moving parts. Ac-acies obtained are within ±3 when as many 50 of the resistors are cut out of the circuit. eral designs have been developed whereby er magnetic amplifiers, vacuum tubes, or sistors are utilized.

he B.G. Corporation, Dept. ED, 321 Broad e., Ridgefield, N.J.

CIRCLE 176 ON READER-SERVICE CARD

NEW PRODUCTS

DC Voltage Regulator

Provides 20 v dc power

Model PR-10 is a completely transistorized dual dc voltage regulator capable of operation under extremes of shock and vibration. It is designed to provide a stable positive and negative 20 v dc power source for as many as 30 TSO-200B voltage-controlled sub-carrier oscillators. The unit is sealed against fungus and humidity.

United Electrodynamics, Dept. ED, 1200 S. Marengo Ave., Pasadena, Calif.

CIRCLE 179 ON READER-SERVICE CARD

Voltmeters

Accuracy ±3 per cent

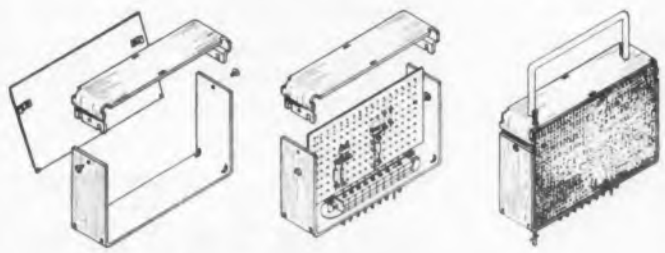
The dc voltmeters offer seven discrete voltage ranges from 1 to 1000 v. Accuracy is ±3 per cent. The ac voltmeter has broad frequency response, from 20 cps to 100 kc. Full-scale ranges are provided in 10 db steps from 10 mv to 300 v.

Metronix, Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 180 ON READER-SERVICE CARD

Plug-in Case

Metal enclosure simplifies design



A small metal enclosure, called a Frame-Loc, has recently been made available. All sides are flush and the case is provided with snap-out side

making the case particularly suitable for tor circuitry in small pluggable units. The is made in a wide variety of sizes and fin-s. Internal terminal structures may be printed uit panels or the company's wall, decks, or et posts can be supplied. Where ventilation ssential, the side panels can be omitted, or orations can be used. A variety of plug types ptional.

ector Electronic Co., Dept. ED, 1100 Flower Glendale 1, Calif.

CIRCLE 182 ON READER-SERVICE CARD

Multicoder

Accepts up to 88 mv inputs

his transistorized pulse duration multicoder epts up to 88 ten mv full scale differential in-s. The unit, termed model MC-G90X10, pro-es any of the standard PDM frame and com-tation rates of 30 x 30, 45 x 20, or 90 x 10 at turn of a selector switch. Input full scale ges of 10, 20, 50, 100, and 500 mv are select-by means of a front panel switch.

auke & Co., Dept. ED, 1632 Pico Blvd., Santa nica, Calif.

CIRCLE 183 ON READER-SERVICE CARD

Magnetic Tape Transport

Speeds of 7.5 and 3.75 in. per sec

quipped for automatic or manual operation, magnetic tape transport is designed for for-d and reverse operation at speeds of 7.5 and in. per sec. The Series 610 is provided with forward and rewind speeds of 2400 ft in two

merican Electronics, Inc., Data-Tronics Div., t. ED, 655 W. Washington Blvd., Los An-s 15, Calif.

CIRCLE 184 ON READER-SERVICE CARD

NEW PRODUCTS

Bourdon-Tube Transducer

High resolution

With the Model 461227 Bourdon-tube pressure transducer resolution of up to 400 wires is obtained. Covering pressure ranges from 200 to 10,000 psi, the unit is suitable for measuring noncorrosive liquid or gas pressure in airborne applications.

G. M. Giannini & Co., Inc., Dept. ED, 918 E. Green St., Pasadena 1, Calif.

CIRCLE 187 ON READER-SERVICE CARD

Relay Meter

Controlled by true rms

Model 1094 Sensitrol relay deflects in proportion to the true rms of the impressed current or voltage. Offered with either one or two preset contacts and in current or voltage ranges, the unit is designed for applications in over and/or under current or voltage control and alarm.

Weston Instrumens Div., Daystrom, Inc., Dept. ED, Newark 12, N.J.

CIRCLE 188 ON READER-SERVICE CARD

Pulse Sorter

Controls random inputs

Although the reversible counting of the model 111A binary counter is automatic, the feedback

pulses may occur at random or coincidental with the command pulses. The pulse sorter 136A is the answer to this problem. It is connected in series with both the forward and reverse inputs to the counter and blanks both pulses, should they occur within 5 μsec of each other.

Navigation Computer Corp., Dept. ED, 1621 Snyder Ave., Philadelphia 45, Pa.

CIRCLE 191 ON READER-SERVICE CARD

Power Supply

For strain gage excitation

Model SR-200A power supply is designed especially for strain gage excitation. The unit features floating output, less than 10 μv of noise from the dc output to ground when used with a grounded strain gage, and 0.1 per cent regulation for line voltage changes from 95 to 135 v. The dc output is continuously variable from 5 to 12. Maximum output current is 200 ma.

Video Instruments Co., Inc., Dept. ED, 3002 Pennsylvania Ave., Santa Monica, Calif.

CIRCLE 192 ON READER-SERVICE CARD

Delay Line

High delay-rise time ratio

Model 1D1 lumped constant ferrite delay line provides a high ratio of delay/rise time/number of sections through elimination of the leakage flux linkages in the cup cores. Whereas formerly a twelve section line had a delay/rise time ratio of 8, the new line has a ratio of 9.3 for twelve sections. Temperature coefficient is 25 ppm per deg C. Normal production tolerances on delay are 1 and 2 per cent on characteristic impedance.

Digitronics Corp., Dept. ED, Albertson Ave., Albertson, N.Y.

CIRCLE 193 ON READER-SERVICE CARD

NEW PRODUCTS

Signal-Noise Correlator

Takes dynamic measurements

Model I-101 signal-noise correlator can be used to make dynamic signal-to-noise measurements at the outputs of various types of communications equipment such as receivers, amplifiers, magnetic tape systems, etc. The signal-to-noise ratio can be measured without removing either the signal or the noise.

General Electronic Laboratories, Inc., Dept. ED, 18 Ames St., Cambridge, Mass.

CIRCLE 196 ON READER-SERVICE CARD

Encapsulation Cups

For cores and laminations

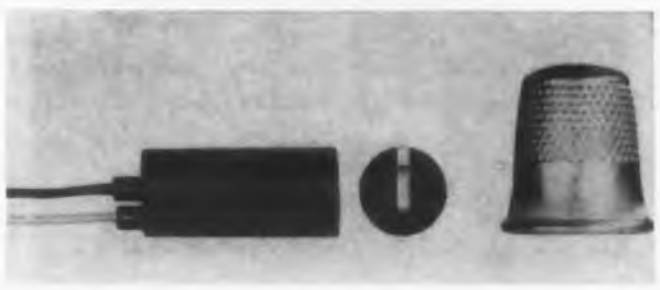
Designed to fit standard cores and laminations, these encapsulation cups permit the component to be placed closer to the container wall due to their arc resistance. The cups are made of glass-filled diallyl phthalate.

Electronic Production & Development, Inc., Dept. ED, 138 Nevada St., El Segundo, Calif.

CIRCLE 197 ON READER-SERVICE CARD

Moving Coil Indicator

Measures 7/16 in. diameter



Model HCM 7/16 core magnet moving coil indicator measures 7/16 in., permitting it to be in-

corporated within other meters to indicate such information as alarm, position, or malfunction. Hermetically sealed, the indicator is available with either flag or pointer display, and in a variety of electrical sensitivities and functions.

Marion Electrical Instrument Co., Dept. ED, Grenier Field, Manchester, N.H.

CIRCLE 418 ON READER-SERVICE CARD

Audio Response Plotter

Direct-reading indication

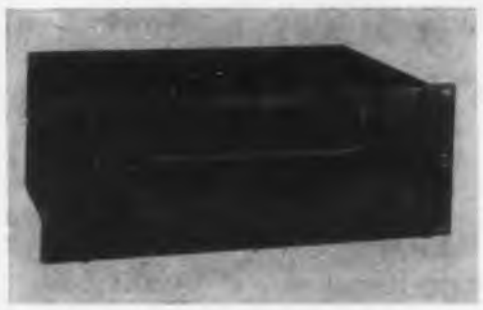
The ARP-1 audio response plotter gives immediate visual proof of performance of any audio system or component, by indicating whether the system provides equal amount of acoustical energy per octave. Records are plotted on a 40 db-range logarithmic chart by a high-torque, dry-writing, servo-controlled pen.

Southwestern Industrial Electronics, Dept. ED, 2831 S. Post Oak Rd., Houston, Tex.

CIRCLE 419 ON READER-SERVICE CARD

DC Digital Voltmeter

Includes 5 digit display



Model DVA-500 dc digital voltmeter consists of a DVX-500 switch module and a DXA-000 power module. The power module is transistorized and features internal modular construction. Specifications of the new instrument include a 5 digit display, automatic ranging and polarity, 0.0001-999.99 range and 0.01 per cent accuracy, ± one digit. Stability is better than 0.01 per cent.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

CIRCLE 420 ON READER-SERVICE CARD

NEW PRODUCTS

Piston Potentiometer

Noise-free at 40 g vibration

This self-aligning linear motion potentiometer is capable of noise-free operation at 40 g, 10-2000 cps. The floating shaft of Model 157 permits free lateral movement of an actuator without side-load effect on the instrument. Error is less than 1/2 per cent when tested under the above vibration.

Bourns Laboratories, Inc., Dept. ED, Riverside, Calif.

CIRCLE 199 ON READER-SERVICE CARD

Modulator Monitor

Frequency range from 20 to 100 mc

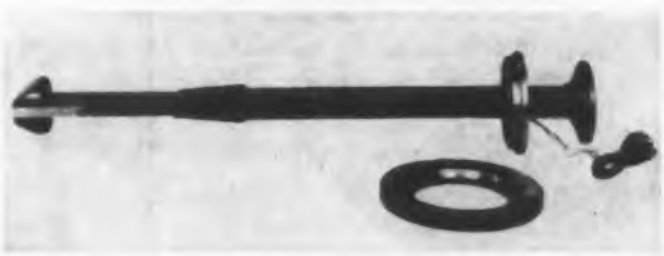
Modulation monitor model 257B. measures total deviation of the carrier of fm transmitters when modulated by multiple sub-carrier oscillators. Frequency range is 20 to 100 mc and deviation measurements can be made from 0 to 1000 kc. The audio frequency range is flat within ±1.0 db from 50 cps to 200 kc.

New London Instrument Co., Inc., Dept. ED, 82 Union St., New London, Conn.

CIRCLE 200 ON READER-SERVICE CARD

Flange Feed

Adjustable through 360 degrees



With 360 deg adjustable flange feed, this mounting flange adjusts polarization during in-

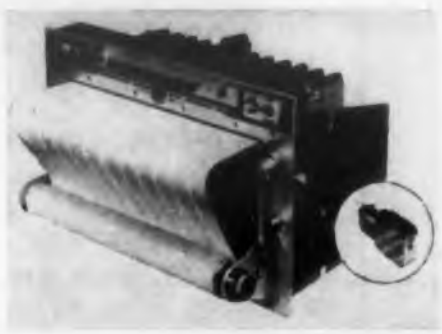
stallation or for alignment of center-fed, 7000 mc, Series B parabolic antennas. Insertable from the rear, it fits standard GED feed mounting bolts. The unit can be adjusted without removing nuts or bolts. Close tolerances permit accurate seating and positive clamping action, and there is no loss in rigidity over standard mounting flanges.

Gabriel Electronics Div., Dept. ED, Needham Heights, Mass.

CIRCLE 204 ON READER-SERVICE CARD

Rectilinear Recorder

12-channel



True rectilinear motion and good transient response are features of this 12-channel rectilinear recorder. Free of resonant peaks, overshoot, and ringing, the Model RE-12 has a frequency range from dc to 200 cps. Push button selection permits 18 chart speeds from 1/2 cm/hr to 200 mm/sec.

Massa Labs., Inc., Dept. ED, 5 Fottler Rd., Hingham, Mass.

CIRCLE 205 ON READER-SERVICE CARD

Memory Amplifier

Low standby current

Type 19 memory amplifier consists of an amplifier and bistable circuit. A relay load or any other may be connected from the output to ground. Upon application of a 50 mv trigger, full supply is applied to the load. The power continues to be applied until a reset pulse is connected to the reset line, when the power is removed from the load. A very low standby current allows the device to be connected for relatively long periods of time.

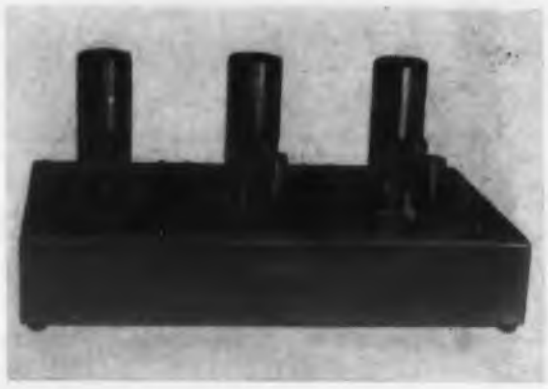
MF Electronics Co., Dept. ED, 122 E. 25 St., New York 10, N.Y.

CIRCLE 206 ON READER-SERVICE CARD

NEW PRODUCTS

Frequency Standards

Have cathode follower output



This line of frequency standards features a cathode follower output for long-term stability. Modules are available for any set frequency from 240 to 4000 cps, with accuracies up to ±0.001 per cent. Output is 5 v rms, variable from 0 to 5 rms with external control.

The Gyrex Corp., 3003 Pennsylvania St., Dept. ED, Santa Monica, Calif.

CIRCLE 209 ON READER-SERVICE CARD

FERRITE ISOLATOR.—Model IXL10, for the frequency range of 9 to 10 kmc, is added to a line of X-band isolators. Length is 1.04 in.

Raytheon Mfg. Co., Dept. ED, Waltham 54, Mass.

CIRCLE 210 ON READER-SERVICE CARD

AC ACCELEROMETER.—The model GAH ac accelerometer is available in ranges from ±0.1 to ±20 g. Output is as high as 3 v per volt input.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

CIRCLE 211 ON READER-SERVICE CARD

ANECHOIC TEST CHAMBER.—A portable test chamber used for determining acoustical characteristics of miniature radio and audio equipment.

Industrial Acoustics Co., Inc., Dept. ED, 341 Jackson Ave., New York 54, N.Y.

CIRCLE 212 ON READER-SERVICE CARD

POSITION LIGHT FLASHER.—Model AFS-125 is designed to replace the C-2 flasher.

P. R. Mallory & Co., Inc., Dept. ED, 28 S. Gray St., Indianapolis 6, Ind.

CIRCLE 213 ON READER-SERVICE CARD

COAXIAL ATTENUATORS.—Models are available for 1000 to 11,000 mc, at 3, 6, and 10 db attenuation. 20 db models are available for 2000 to 11,000 mc. All have an impedance of 50 ohm.

Narda Corp., Dept. ED, Mineola, N.Y.

CIRCLE 214 ON READER-SERVICE CARD

POWER SUPPLIES.—Magnetic Rangers, models MR36-15 and MR36-30 are tubeless continuously-variable regulated 5 to 36 v dc power supplies. They have outputs of 0 to 15 amp and 0 to 30 amp respectively.

Sorensen & Co., Inc., Dept. ED, Richards Ave., S. Norwalk, Conn.

CIRCLE 217 ON READER-SERVICE CARD

SNAP ACTION SWITCH.—Has exact repeatability and stability in temperature and humidity conditions. Conforms to dimensional requirements of MS 25026.

Meletron Corp., Dept. ED, 950 N. Highland Ave., Los Angeles 38, Calif.

CIRCLE 218 ON READER-SERVICE CARD

NIOBIUM STRIP.—Rolled in thicknesses as low as 0.0005 in. to tolerances as close as 0.0001 in.

American Silver Co., Inc., Dept. ED, 36-07 Prince St, Flushing 54, N.Y.

CIRCLE 219 ON READER-SERVICE CARD

50-WATT TOROIDAL TRANSFORMER.—Input voltage is 115 v, 400 cps, single phase. Output voltage can be any from 1 to 1000 v. Standard units supplied for filament use, for synchro drive, isolation voltage, and plate voltage. Temperature is from —55 to +100 C.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 409 ON READER-SERVICE CARD

SERVOMOTOR.—Size 8 model 8 SM 420 has rotor inertia of 0.1 gm cm^2 and stall torque of 0.25 oz in. to offer acceleration at stall of 170,000 rad/sec^2.

Helipot Corp., Dept. ED, Newport Beach, Calif.

CIRCLE 410 ON READER-SERVICE CARD

DIRECT-READING MICRODIALS.—1300 series has 3, 4, and 5 digit dials for 10-, 100-, and 1000-turn applications.

The George W. Borg Equipment Div., Dept. ED, 120 S. Main St., Janesville, Wisc.

CIRCLE 411 ON READER-SERVICE CARD

TRANSISTORIZED COUNTING PACKAGE.—Added to model C, the Count-Pak series now has model N-1 which counts at speeds up to 30,000 counts per min for more than 1 billion counts.

Veeder-Root Inc., Dept. ED, 70 Sargeant St., Hartford 2, Conn.

CIRCLE 412 ON READER-SERVICE CARD

RECYCLING TIMERS AND TIMING KITS.—In single, double, and three gang assemblies. Speeds vary from 50 cps to 1 cy per hr.

Herbach & Rademan, Inc., Dept. ED, 1204 Arch St., Philadelphia 7, Pa.

CIRCLE 413 ON READER-SERVICE CARD

TRANSISTORIZED POWER INVERTER.—Model PS-3001 provides 115 v ac at 400 cps and up to 750 ma load current. Input is 26 v dc ± 5 per cent.

Power Sources, Inc., Dept. ED, Burlington, Mass.

CIRCLE 414 ON READER-SERVICE CARD

NEW LITERATURE

Pressure Comparator 221

Catalog Sheet 32CA110 explains operation and construction of a pressure comparator. Unit gives precise service as high as 300 psi and 300 F, has about 50 times the life expectancy of other commercially-available pressure switches. Fischer & Porter Co., 496 Jacksonville Rd., Hatboro, Pa.

Special Metal Stampings 222

Services in the fabrication and production of stampings from rare and specialized metals are discussed in a 4-page illustrated folder. A quick reference chart lists the properties and typical uses of 20 types of rare or special metals. These metals include beryllium copper, K-Monel, molybdenum, tantalum, phosphor bronze, rodar, titanium, and silicon bronze. The Staver Co., 47 N. Saxon Ave., Bay Shore, N.Y.

Hermetic Seals 223

A brochure discusses the services offered by this manufacturer of hermetic seals and terminals. A consulting engineering service provides engineers for visiting customer plants to develop required components on the spot. A method for testing and inspecting finished parts is described which duplicates the testing procedures used by the customer. Glass-Tite Industries, Inc., 88 Spectacle St., Cranston 10, R.I.

Temperature Instruments 224

Having nearly 70 photographs, a 30-page booklet outlines facilities for the design and manufacture of temperature controls, detectors, and indicators. The brochure covers research, engineering, production, quality control, products, affiliated companies, and customer services. Fenwal Inc., Ashland, Mass.

Regulators 226

A 4-page illustrated brochure furnishes complete technical data on magnetic voltage regulators and also serves as a technical manual. It covers detailed product description, principles of operation, operating instructions, and maintenance. Illustrated with dimensional diagrams, response curves, schematics, and vector diagrams, the brochure answers most questions about their operating capabilities. Sorensen & Co., Inc., Richards Ave., S. Norwalk, Conn.

Creativity

Deutsch and Shea, Inc., technical manpower consultants, have compiled a bibliography on creativity and its role in technology, industry, and business. The references include books, articles, and studies encompassing science, engineering, business, and other fields. The bibliography is intended as a help to better understanding of techniques for stimulating and developing creative abilities. *Copies are $2.00 and may be obtained from Industrial Relations News, Dept. ED, 230 W. 41st St., New York 36, N.Y.*

Delay Lines 227

A 4-page catalog describes special and standard lumped constant delay lines. It lists over 275 different units covering standard impedance ranges from 50 to 10,000 ohms and delays from 0.25 to 5000 μsec. Control Electronics Co., Inc., Huntington Station, N.Y.

Connectors 228

Catalog MS-E-3, containing 16 illustrated pages, covers all type E plugs. These plugs conform to the provisions of Military Standard MIL-C-5015. Also available is bulletin EX-1, describing the company's four basic EX types. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Society of Plastics 229

This society prospectus summarizes all the activities and benefits of the organization. It contains 16 illustrated pages and includes instructions on how to join the organization. Society of Plastics Engineers, Inc., 34 E. Putnam Ave., Greenwich, Conn.

NEW LITERATURE

Connector Soldering 233

A 10-page report giving a step by step procedure for the soldering of miniature electrical connectors is available. The illustrated report is entitled "Electrical Connector Soldering Techniques." Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.

Conductive Gasketing 234

A data sheet which describes a company's electrically conductive gasketing is available. The company also provides samples with each data sheet. Connecticut Hard Rubber Co., 407 East St., New Haven, Conn.

RF Connectors 235

Rf connectors are covered in an 84-page loose-leaf catalog. The catalog contains illustrated descriptions, charts, cross indexes, assembly instructions, and technical data. Kings Electronics Co., Inc., 40 Marbledale Rd., Tuckahoe, N.Y.

Filter Capacitors 236

Bulletin GEA-6819, six pages, describes dc aluminum electrolytic filter capacitors for computer circuits. It discusses the materials and construction of the units and also their operation and uses. Specifications cover case sizes, ratings, performance, and characteristics. Pictures, charts, dimensional drawings, and tables fill out the text. General Electric Co., Schenectady 5, N.Y.

Switching Reactors 237

Catalog S-10 shows a complete line of standard switching reactors for one-step, low-cost static control. Adaptable for ac or dc use, the units perform all logic functions and are applicable to switching and sequencing installations. The 16-page catalog describes the units, their applications and dimensions. It contains tables of electrical characteristics and several typical application circuits. Control, Div. of Magnetics, Inc., Butler, Pa.

Instrument Bearings 239

Details on a miniature line of instrument bearings, including dimensions, tolerances, torque values, static and dynamic capacities and limiting speeds are covered in a 6-page catalog supplement M1. The illustrated catalog has fold-out pages. Barden Corp., Danbury, Conn.

Conduit Fittings 240

A 28-page color catalog illustrates and describes a full line of conduit fittings and accessories. The units are for rigid conduit, electric metallic tubing, armored cable flexible metallic tubing, and non-metallic cable. Conduit Fittings Corp., 6400 W. 66th St., Chicago 38, Ill.

Control Reactors 241

A catalog containing graphs and specifications for 48 standard control reactors covers 15 to 450 w type. Four series covering sensitivity range from 1.5 to 3 amp-turns. The series meets all MIL-T-27-81 specifications and stands 2000 G shock tests. Four standard windings are provided or units can be delivered with any number of windings up to eight to specifications. Chicago Magnetic Control, 1616 N. Damen Ave, Chicago 47, Ill.

Delay Lines 242

Bulletin 510 outlines performance characteristics and design considerations for ultrasonic delay lines. The 4-page data bulletin covers such subjects as: delay medium material, transducers, bonding medium, casing and packaging. Three pages are devoted to the performance characteristics of five different ultrasonic delay lines. Bliley Electric Co., Union Station, Erie, Pa.

Egghead Manual 243

An invaluable guide to aspiring eggheads is now in its second printing. Entitled "On Being An Egghead, or Engineermanship for the Shell of It," it contains a complete set of rules for egghead behavior. The booklet is fully illustrated. Benson-Lehner Corp., 11930 W. Olympic Blvd., Los Angeles 64, Calif.

NEW LITERATURE

Computer Design Techniques 248

New design techniques to accomplish substantial savings throughout engineering development programs for electronic digital computers are described in a booklet just published.

The well-illustrated booklet describes use of a family of general-purpose digital building blocks. It also explains the application of advanced computer-aided design methods, beginning with the checking of logical equations for systems definition through to the preparation of component lists and wiring tabulations. Control Data Corp., 501 Park Ave., Minneapolis, Minn.

High Speed Switching 249

"High Speed Zener Switching Circuits," an application bulletin giving detailed information on high speed electronic switching necessary for missile computers, ground control computers and industrial computers has been published. The bulletin describes the operation of silicon junction diodes about the zener or avalanche breakdown region. This permits diode switching at speeds of many magnitudes greater than those obtainable with zero bias point switching. The high speed limitation can be circumvented in this way to permit a reversal time, theoretically as short as one one-billionth of a second. Hoffman Electronics Corp., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

Data Display Indicators 250

Catalog 1015 has 12 pages of technical data on plug-in indicators for data display, storage, and transfer. It describes the construction, operation, specifications, and typical applications of the units. Union Switch & Signal, Div. of Westinghouse Air Brake Co., Pittsburgh 18, Pa.

Platinum-Clad Metals 251

Bulletin PLA-5 is a 2-page, illustrated discussion of platinum-clad metals as a low-cost substitute for solid platinum. A table lists the physical properties of platinum-group metals, while the text points out their advantages and applications. Metals & Controls Corp., General Plate Div., Attleboro, Mass.

Photoelectric Catalog 252

With pictures and descriptions, Catalog 58 lists 24 pages of photoelectric and other electronic controls. It covers high speed, ultra sensitive, and impulse actuated photoelectric timing controls; a complete series of light sources; normal, small, and miniature phototube and light source heads; electronic timers; and controls operated by current surge and impact. Autotron, Inc., Box 722 HA, Danville, Ill.

Relays 255

Six subminiature relays for critical airborne applications are described in this product engineering bulletin. Characteristics and detail specifications for the DC 31, 32, and 33-AC, 34, and 36 subminiatures are furnished along with circuit diagrams and detail drawings of each. Features and technical data involving the production of these subminiature relays are included. The bulletin contains 4 pages plus a panel fold-in. Phillips Control Corp., 59 W. Washington St., Joliet, Ill.

Thermistor Probes 256

Nine specially designed thermistor probe assemblies are described in detail in a 4-page brochure. Each assembly is identified by its most common application, and has complete dimensions and mounting arrangements. Applications of the probes include air, oil, and fuel temperature measurement; surface temperature measurement; and liquid level indication and control. The probes are widely used in missile telemetering circuits and other places where precise and accurate control is demanded. Fenwal Electronics, Inc., Mellen St., Framingham, Mass.

Waveguide Components 426

Duplexers, horns, bends, straight sections, and other components for large size waveguides are described in a short form catalog. The components are especially suited to frequencies favored for tropospheric scatter propagation. D. S. Kennedy & Co., Cohasset, Mass.

Pulse Height Analyzer 257

This literature is an 8-page pamphlet listing specifications and operating characteristics of a company's 256-channel pulse height analyzer, model 20609. The pamphlet also describes quality control tests which finished instruments undergo before shipment. Radiation Counter Laboratories, Inc., 5121 W. Grove St., Skokie, Ill.

Power Supplies 258

Catalog No. E-58 illustrates and describes a line of dc power supplies, ac line regulators, and static inverters. The catalog contains six illustrated pages. Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

Wire and Cable 259

A six page illustrated brochure, TWC 57, presents descriptive information, including operating specifications for a wire and cable line. A special section of the brochure outlines the various multiconductor cables now offered by the company. William Brand & Co., Inc., Willimantic, Conn.

NEW LITERATURE

Teflon Terminals 26

Dimensions and performance data on over 2 types of subminiature Teflon terminals are give in an 8-page catalog. The illustrated booklet d scribes subminiature stand-offs, feed-through plugs, jacks, and special terminal fabricatio Straight-pin, hollow, and threaded pin termina are included. Data is also given on tin, gold-o silver, and other pin platings available for read to-solder use. Trinseel, Inc., Div. of Tri-Po Plastics, Inc., 177 I.U. Willets Rd., Albertso N.Y.

Magnetic Core Testing 26

Bulletin 57-G describes a modular magne core tester which delivers programmed pul chains in a periodically repeated, basic 8-st pattern. The 4-page illustrated folder discuss the features of the instrument and the versatil of pulse programming through the repetition any one or more steps or step-pairs. It also has detailed explanation of the programming meth a block diagram, complete specifications, a brief descriptions of optional equipment. Re Engineering, Inc., 731 Arch St., Philadelphia Pa.

Microwave Test Equipment 26

An 86-page catalog has been released to d scribe a full line of precision microwave te equipment. Charts illustrate the complete tec nical data, and photographs show all instrumen There are tables covering measurement formula waveguides, and waveguide connectors. T catalog also contains technical reports. Two them are "Noise Measurement Techniques" a "Summary of Design for Aluminum Flux-D Brazing." Waveline, Inc., Caldwell, N.J.

Epoxy Resin Systems 26

This brochure outlines the physical and ele trical properties of a company's epoxy resin s tems. It covers twenty-five of the systems offere Included in the brochure are room-temperatur moderate-temperature, and moderate-high-te perature curing systems. For each system ava able, a chart gives the average pot life, viscosi in centipoises, recommended cure condition flexural deformation temperature, and maximu exothermic temperature. Also listed in each cha are physical properties of cured samples of t systems, heat resistance, thermal shock, volu resistivity, dielectric constant, and dissipati factors. The brochure also contains a list of d finitions of terms used in connection with epo resin systems. Permacel-Lepage's, Inc., Ne Brunswick, N.J.

Waveguide Bends 267

A 12-page Catalog No. C-158 just released, provides an up-to-date guide for the selection of precision cast bends and formed waveguide bends. The catalog covers the wide variety of bends offered and provides simplified ordering information. Microwave Development Labs., Inc., 92 Broad St., Babson Park 57, Wellesley, Mass.

Precision Springs 268

Catalog No. 10 covers compression springs, flat springs, strip springs, contact rings, contact strips, and screw machine products. The catalog includes complete engineering data on the greatly expanded line of standard products and describes design engineering service available, tool making facilities, and lists various finishes available. Instrument Specialties Co., Inc., 244 Bergen Blvd., West Paterson, N.J.

Rotary Electrical Equipment 269

Bulletin 258 contains information on a company that produces miniature motors, generators, hand driven generators, and rotary converters. The company specializes in design and development work required in the electrical rotary field for specialized applications. Heinz Mueller Engineering Co., Inc., 1906 N. Cicero Ave., Chicago 39, Ill.

Pulse Generators 270

Model 3450B two megacycle pulse generator is covered in a 3-page booklet. Specifications, large instrument photo, and typical applications, are provided. Also available is a similar description of the model 3460A megacycle double pulse generator. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Thermistors and Varistors 271

Over 250 standard thermistors and varistors are listed with pertinent engineering data in a recent catalog. The applications and characteristics of the units are noted, and curves and drawings are used for illustration. Other products mentioned include experimenters' kits, gas analysis equipment, and hypsometers. Victory Engineering Corp., 519 Springfield Rd., Union, N.J.

Hardware 272

Catalog 30, 24 pages, features complete lines of molded and standard terminals, diode clips, taper pins, plubs and receptacles, handles, quintlock nuts, terminal boards, swaging tools, and other hardware. Among the items new to the catalog is a snap-lock teflon-insulated terminal line. Facilities for custom design and manufacture are described. Lerco Electronics, Inc., 501 S. Varney St., Burbank, Calif.

NEW LITERATURE

Shock Mounting 275

Four-page Bulletin FlA deals with engineered vibration and shock mounting systems for airborne electronic equipment. It illustrates and describes variable-damped engineered mounting systems, and discusses the design and selection of the component parts of these systems. A section covers problems involved in vibration isolation mountings for gyroscopic instruments. Another describes test facilities. Mounting bases are illustrated along with special, standard, miniature, and subminiature unit mounts. Federal Shock Mount Corp., 1060 Washington Ave., New York 56, N.Y.

Solid Film Lubricants 276

Eight solid film lubricants and their applications are the subject of Catalog LB-6-1157. Included are coatings for high temperature (to 1500 F), low temperature (−300 F), corrosion resistance, high loads (225,000 psi), and high speeds (to 30,000 rpm). The 16-page illustrated booklet gives a brief description of each type with graphs to show its performance. It contains processing recommendations for various metals and a table of physical properties. Research facilities are also covered. Electrofilm, Inc., P.O. Box 106, North Hollywood, Calif.

Snap Switches 277

Catalog 0158 has 28 pages on snap-acting switches. General-purpose, high-sensitivity, environment-free, immersion-proof, metal-cased, AN and JAN, direct-current, reset, appliance, miniature, and subminiature units are listed. A pictorial index tells where to find drawings, descriptions, force and movement specification tables, and electrical ratings. Data on bases and terminals, actuator types, circuit arrangements, and NEMA sensitive-switch terms are included. Unimax Switch Div., The W. L. Maxson Corp., Ives Rd., Wallingford, Conn.

Power Oscillators 278

This literature is a technical information and product brochure on precision power oscillators offering an ultra-stable voltage source for use in a wide variety of electronic systems. The brochure is clearly illustrated and folds in a manner to provide quick identification in notebook or reference files. Photographs and descriptive material on the instrumenation line are presented with technical information prepared in text and graphs which explain ultra-stable power source characteristics, test results, etc. Electronics International Co., 145 W. Magnolia Blvd., Burbank, Calif.

Harmonic Generation 282

"PRD Reports," Vol. 5, No. 4, discusses the frequency resolution obtainable from a noise-jittered harmonic generation system. The case analyzed in the 4-page is that of a noiseless oscillator whose frequency is to be adjusted to zero beat with some harmonic of a frequency standard which is likewise immersed in noise. Polytechnic Research & Development Company, Inc., 202 Tillary St., Brooklyn, N.Y.

Multicoder 283

A company's G series multicoder and associated commutator sampling switches for low-level data acquisition are described in this set of three catalog bulletin sheets. The bulletin sheets give features and specifications of console units which operate directly from strain gages, thermocouples and similar transducers which provide outputs in the low millivolt range. Applied Science Corporation of Princeton, P.O. Box 44, Princeton, N.J.

Metal Strip 284

"Electronics Precision Strip Selector" is a pamphlet to help engineers pick the right precision-rolled metal strip for miniature applications. The strips are rolled as thin as 0.0005 in. with tolerances as close as ±0.0001 in. The pamphlet lists electronic parts and components alphabetically, showing the precision-rolled metals used in the manufacture of each. Applications are given for rarer metals such as niobium, zirconium, tantalum. and titanium. American Silver Co., 36-07 Prince St., Flushing 54, N.Y.

Heat Dissipating Shields 285

"Heat-Dissipating Electron Tube Shields and Their Relation to Tube Life and Equipment Reliability" is available in a new 28-page edition illustrated with charts, graphs, photographs, and cutaway drawings. The text is a speech that Harvey Riggs read to the U. K. Inter-Services Committee for the Coordination of Valve Development in London. International Electronic Research Corp., 145 W. Magnolia Blvd., Burbank, Calif.

Russian Research Contents

With May, 1958, a monthly guide to current Soviet research begins. Each issue will contain English titles of all papers being translated into English from 39 Soviet journals. Called "Express Contents of Soviet Journals," the guide will give the contents of Soviet periodicals two months after they are published and two to six months before translations are ready. *An annual subscription is $25.00 and may be ordered from Consultants Bureau, Inc., 227 W. 17th St., New York 11, N.Y.*

IDEAS FOR DESIGN

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Have you thought of using

The PNN and NPP

You can eliminate the inverter in a push-pull circuit with npp and pnn type transistors. They can be assembled from ordinary npn and pnp units. Some types are expected to be available commercially from Advanced Research Associates.

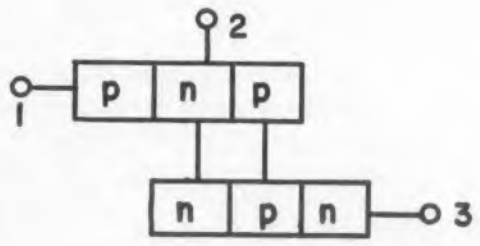
MULTI-ELECTRODE devices of npp or pnn configurations can be built that are capable of handling 10 w with good frequency response. They are built up from typical npn and pnp transistors, each selected for its individual characteristics. Essentially, the operation is based upon the stable properties of a hook connection. In this article the important design features are presented along with a simplified procedure of assigning symbols. An interesting circuit application of these devices is included where they are coupled with high-powered pnp or npn transistors in push-pull circuits.

Designing PNN and NPP Devices

In the past, pnpn structures have been built and used in a variety of ways. Many designers took advantage of the positive feedback properties a hook connection exhibits. However, no commercial units have been designed to be used in the stable configuration. On reason for this is that the floating region should have good collector characteristics and at the same time be a good base. A compromise has to be made between the two with the result that the frequency response and power handling capabilities of the device are limited when used as a pnn or npp.

By using available npn and pnp transistors each selected for its individual properties, practical pnn or npp devices can be made. A typical pnn connection is shown in Fig. 1. Units have been built that are capable of handling 10 w with good frequency response and α°'s of 5 x 10. Here the current gain of the npp or pnn transistor has been designated α°. This is approximately equal to α of a common base stage times β of the transistor used as the output stage when direct coupled. Fig. 2 is typical characteristic curve of one such pnn device. Block and schematic diagrams of the junction structure of a conventional transistor and the hook collector junction transistor are shown in Figs. 3 and 4.

The assignment of symbols differs with conventional methods. Current distribution in the npn or pnp device is related to transistor action, and standard transistor terminology has been derived from consideration of this action in devices which have been available hitherto. In the standard transistor the base lead, which carries the control signal only, is connected to the base re-



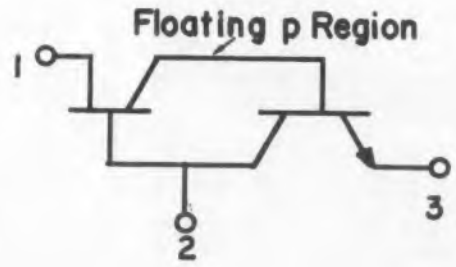


Fig. 1. A typical pnn connection built up from pnp and npn units.

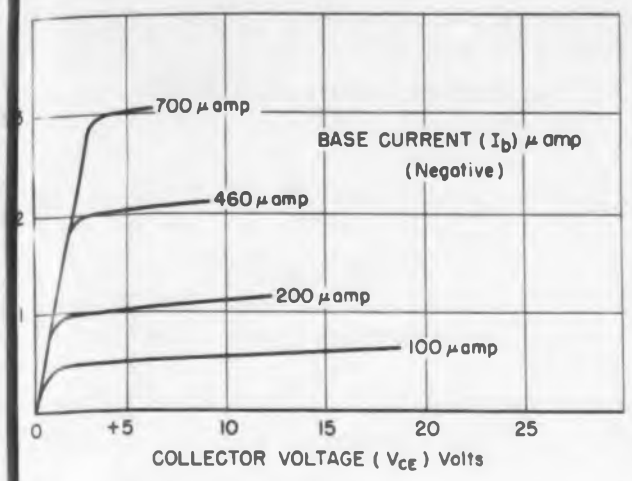


Fig. 2. Collector characteristics of pnn type transistor.

…n, which is physically situated between the …er regions and hence is common to both junc…ns. In the more complicated hook connection …th one additional junction the control current …ws through the region attached to one end of …e array, and the connection attached to the …ntral or base region carries both signal and out…t currents. In the standard texts describing the …ok connection, the leads are still designated by …e regions to which they connect, so the base …nnection carries both the control and output …rrents and the emitter connection carries only …e control current.

This terminology appears to be particularly fortunate from the point of view of the circuit signer who is only interested in the perform-

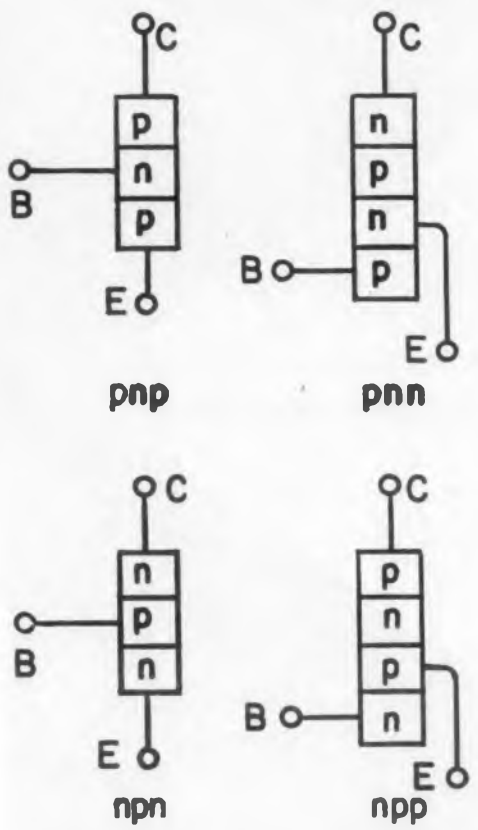


Fig. 3. Block diagrams of conventional and the hook collector junction transistors.

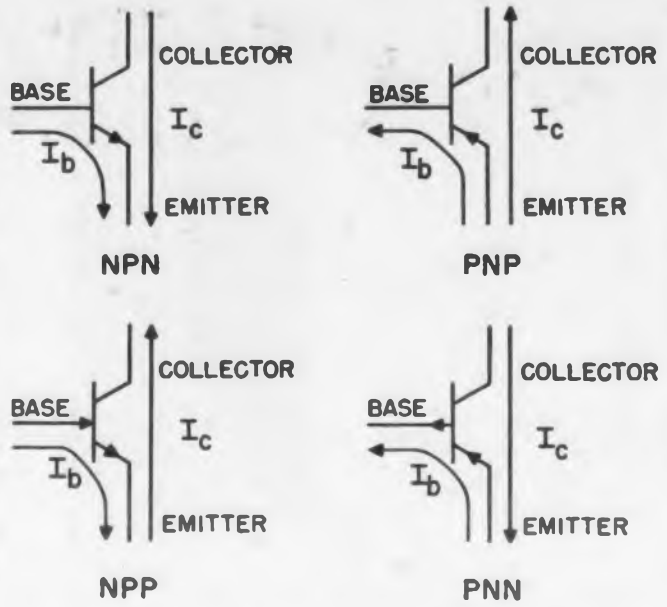


Fig. 4. Schematic diagrams of conventional and the hook collector junction transistors.

ance of the transistor as a black box.

Practical terminology of transistors will be adhered to, namely that the base connection is that which carries the control signal, the emitter connection is that which carries both control and output currents. The only adverse result of this convention is that as the control and output currents are of opposite sign, the actual emitter current is less than the actual collector current. If leads are connected to the semiconductor sections that are to be used in the circuit, one section floats. By naming the device for the sections connected, we have an npp or a pnn transistor. In Fig. 4, the four units are shown with the direction and distribution of currents.

Push-Pull Circuit Applications

One of the most interesting circuit applications of these devices is when they are coupled with existing high-powered pnp or npn transistors in

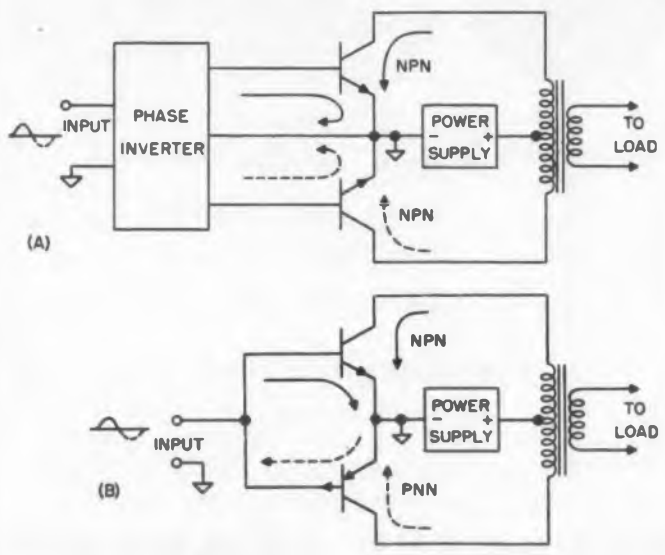


Fig. 5. (a) Typical push-pull amplifier circuit. (b) Replacing one of the npn's eliminates the need for a phase inverter.

push-pull circuits. Consider the usual push-pull amplifier circuit shown in Fig. 5a. When using two npn transistors in a push-pull amplifier, the need for a phase inverter at the input arises in order to cancel the phase inversion in one of the npn's. If one of the npn's is replaced with a npp a phase inverter is no longer needed, as shown in Fig. 5b.

In addition to push-pull applications, there are many other circuits in which these devices will provide greater efficiency. When composite units such as the npp and pnn are available to the design engineer, much of the detail circuit design can be eliminated.

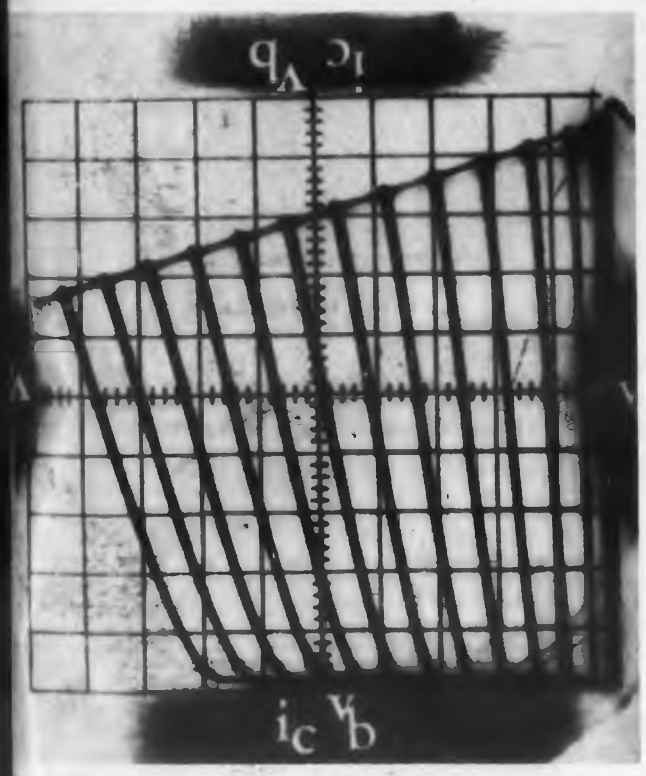
Henri H. Hoge, General Manager, Semiconductor Div., Advanced Research Associates, Inc., Kensington, Maryland.

Identifying Scope Displays

Especially when using a transistor curve tracer with a scope, it's handy to be able to identify the variables on the scope screen. An easy way to do this is to rough out a small area on the back surface of the plastic coordinate screen near the edge of the viewing area. A small piece of emery paper does this quickly. Then, one can apply decal letters on the front surface of the coordinate screen. (Decals with transparent backing are commercially available.)

The scope's scale illumination lights both the coordinates and the variable designations and simplifies the identification of curves.

Keats A. Pullen, Jr., Ballistic Research Labs., Aberdeen Proving Ground, Md.



Roughing the back of a scope's scale plate makes it easy to identify variables.

IDEAS FOR DESIGN

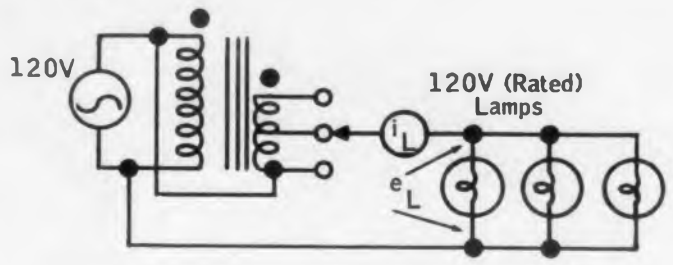
Low Cost—High Intensity Lighting

High intensity lighting is often required for printed-wiring exposure techniques. It is desirable to avoid arc lamps and photo-floods.

Ordinary 120 v light bulbs can be used if they are operated with higher voltage across them. They can burn much brighter and still last for many hours. For example, with 180 v across them they burn three times as bright, and can be used for many hours.

A simple method uses any transformer, connected as an autotransformer. The secondary winding must be able to deliver the required load current, I_L.

James L. Holcomb, Electronic Eng., Forney Mfg. Co., Fort Collins, Colo.



Connected as an autotransformer, any transformer with adequate secondary windings can supply higher voltage to intensify illumination of ordinary light bulbs.

Elliptical Spot Smothers TV Line Structure

Visible scanning lines on TV viewing screens are undesirable, particularly on large screens and studio monitors. The latter are usually viewed at close range. Most schemes to reduce the visibility of these lines added a small amplitude high frequency signal. Thus the sweep trace was changed from a line

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to a wiggly pattern.

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This scheme requires many more components and adds an rf interference problem.

The ideal solution would use a scanning spot whose horizontal dimension is minimized, but whose vertical size is equal to the distance between adjacent sweeps. An approximation is easily achieved by introducing astigmatism.

By distorting the beam focus field, an elliptical spot can be made whose major axis is in the vertical plane. Though this is a compromise with picture definition, it can reduce the visibility of the line structure.

It is an attractive solution because it can be incorporated into the electron gun design on new tubes, or added to older tubes by proper placement of external magnets.

E. R. Gunny, Hughes Aircraft Co., Culver City, Calif.
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REPORT BRIEFS

Backward-Wave Amplifier

This study was undertaken in an effort to explain gains which were measured in some early two-helix traveling-wave tubes when they were operated with one helix on the fundamental and other helix on the minus one space harmonic. A series of measurements and calculations was carried out to determine whether asymmetries in the tube could be a cause of this apparent coupling between the two space harmonics. In the study of a circumferential non-uniformity, measurements were made using a tube with a shuttered electron gun so that a portion of the electron beam could be removed. Also gain expressions were derived and calculations were made for a tube with a portion of the beam removed. On the basis of these measurements and calculations, it is concluded that the interspace harmonic gains measured in these earlier tubes were principally due to a small misalignment of the electron beam and the helix. It was found that a misalignment of one or two thousandths of an in. in a tube with helices of one-half in. diameter, could produce positive gains because of the resultant coupling between the forward and backward space harmonics. *Study of the Effect Produced by Asymmetries in the Two-Helix Backward-Wave Amplifier, Wilbur H. Watson, Calif. University, Div. of Electrical Engineering, Electronics Research Lab., Berkely, Calif. July 1957, 50 pp, photos, drawings, diagrams, graphs, $1.25. Order PB 131412 from Office of Technical Service, U. S. Department of Commerce, Washington 25, D.C.*

New Endfire Antenna

A new endfire element, the dielectric plate, has been experimentally investigated. Endfire arrays of these plates have been found to yield gains and beamwidths otherwise unattainable in a given volume as well as a measure of sidelobe control. The plate arrays have the property that whatever the broadside aperture available it may be used to advantage. In this respect they combine the characteristics of endfire and of aperture antennas. Beamwidths have, in fact, been empirically related to the volume occupied by the array. Patterns calculated by conventional means have shown good agreement with the experimental data. *Dielectric Plate Array, A New Endfire Antenna, by J. O. Pullman, U.S. Naval Research Lab., Jan. 1958, 22 pp, photos, diagrams, graphs, $0.75. Order PB 131473 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Electron Tubes in Military Equipment

This technical report presents tube information primarily from the point of view of the electronic designer as a guide in the application of electron tubes. In Part I tube properties are discussed. These are grouped according to ratings, characteristics essential in circuit operation, and properties detrimental to circuit operation. Part II discusses the tube properties in relation to circuit design. It includes a check list for use of the circuit designer to insure coverage of all important design factors. Part III contains numerical data and special design considerations for specific tube types. Part IV presents product distribution curves derived from life test records where available. The concepts of specification control, operation within ratings, and tolerance of characteristics are emphasized throughout. Supersedes earlier editions (PB 111644 and PB 111644 r). *Techniques for Application of Electron Tubes in Military Equipment, Rex S. Whitlock, U. S. Air Force, Air Research and Development Command, Wright Air Development Center, Electronic Components Lab., Wright-Patterson Air Force Base, Dayton, Ohio. Oct. 1957, 558 pp, drawings, diagrams, graphs, tables, $7.00. Order PB 111644r2 from Office of Technical Service, U. S. Department of Commerce, Washington 25, D.C.*

New Approaches to Printed Circuitry

Operative capacitors, resistors, and connective circuit patterns have been made by vacuum evaporation. Improvement of the elements by various changes in techniques and materials has constituted the principal effort. Mechanical and temperature characteristics of electroplated ceramic circuit patterns have been studied. Samples withstood severe abrasion, temperatures as high as 500 C and high electric currents without detriment other than normal oxidation. All metal screen type stencils were formed by a hot dip process and subsequent selective etching. Results show that a stencil of long life, high temperature resistance, and special versatility suitable for printing electronic circuits can be made. Trials of usual xerographic techniques in the direct formation of metal patterns were unsuccessful. An investigation of special surface films produced by chemical treatment was begun. *Performing Research on New Approaches to Printed Circuitry. Scientific Report No. 2, by John H. Dessauer, Frederick A. Schwertz and others, Haloid Co., Rochester, N.Y. Sept. 1956, 32 pp, photos, graphs, tables, microfilm $3.00, photocopy $6.30. Order PB 126412 from Library of Congress, Washington 25, D.C.*

REPORT BRIEFS

New Microwave Receiver

A new receiver has been investigated and described in some detail in this report. The principal advantage is the elimination of the l-f noise which is generated by the input tubes of a video amplifier at low modulation frequencies. With these same modulation demands, which are essentially aimed at pulse fidelity in microwave pulse reception, the new receiver should give a 12 db increase in sensitivity over a crystal video type. An important step toward receiver miniaturization has been indicated, and additional work leading to the design of an optimum r-f system is contemplated. *Some Aspects of Crystal Performance in a New Microwave Receiver, George E. Hambleton, U. S. Signal Corps Engineering Labs., Fort Monmouth, N.J. June 1956, 37 pp, photos, diagrams, graphs, table, $1.00. Order PB 131335 from Office of Technical Service, U. S. Department of Commerce, Washington 25, D.C.*

Calibrations at Microwave Frequencies

Discusses receiver noise factor, principles employed in noise source calibrations, critical parameters and errors, and hot-body noise sources and their use as standards. *Fundamentals in Noise Source Calibrations at Microwave Frequencies by J. Edwin Sees, U. S. Naval Research Lab., Jan 1958, 24 pp, diagrams, graphs, $0.75 Order PB 131367 from OTS, U. S. Dept. of Commerce, Washington 25, D. C.*

Electromagnetic Waves

Preliminary, and promising, results are given on a new, smaller bolometer made from 10 μ in. wire in .022 x .045 guide. The three-dimensional physical calculation of diffraction from an echelette grating is presented, the result at present being exact but difficult to apply. Further results are also given for the calculations being done on a UNIVAC of the optical constants of simple crystals. A new method for determining the complex index of refraction of solids is also included. For 1st-5th reports under this Contract see PB 116645, 116990, 117767, 119237, 123401. *Study of the Generation and Detection of Electromagnetic Waves in the Millimeter Wave Region, Scientific Report No. 6 by J. H. Rohrbaugh, New York University, Washington Square College of Arts and Science, Physics Dept., Dec. 1956, 26 pp, microfilm $2.70, photocopy $4.80. Order PB 126373 from Library of Congress, Washington 25, D.C.*

Maximally Flat Amplifiers

This approach to network synthesis offers a relatively simple geometric situation in which synthesis is accomplished by arranging points on a plane. The two main techniques to be developed are: the explicit visual handling on the complex frequency plane of poles and zeroes of the network transfer function; and the application of this visualization to network synthesis through mappings of function theory, in conjunction with a striking potential analogy. This method is applied to a class of bandpass amplifier interstage networks. *Maximally Flat Amplifiers of Arbitrary Bandwith and Coupling by DeForest L. Trautman, Stanford University, Electronics Research Lab., Stanford, Calif. Feb. 1952, 145 pp, diagrams, graphs, table, microfilm $7.20, photocopy $22.80. Order PB 126300 from Library of Congress, Washington 25, D.C.*

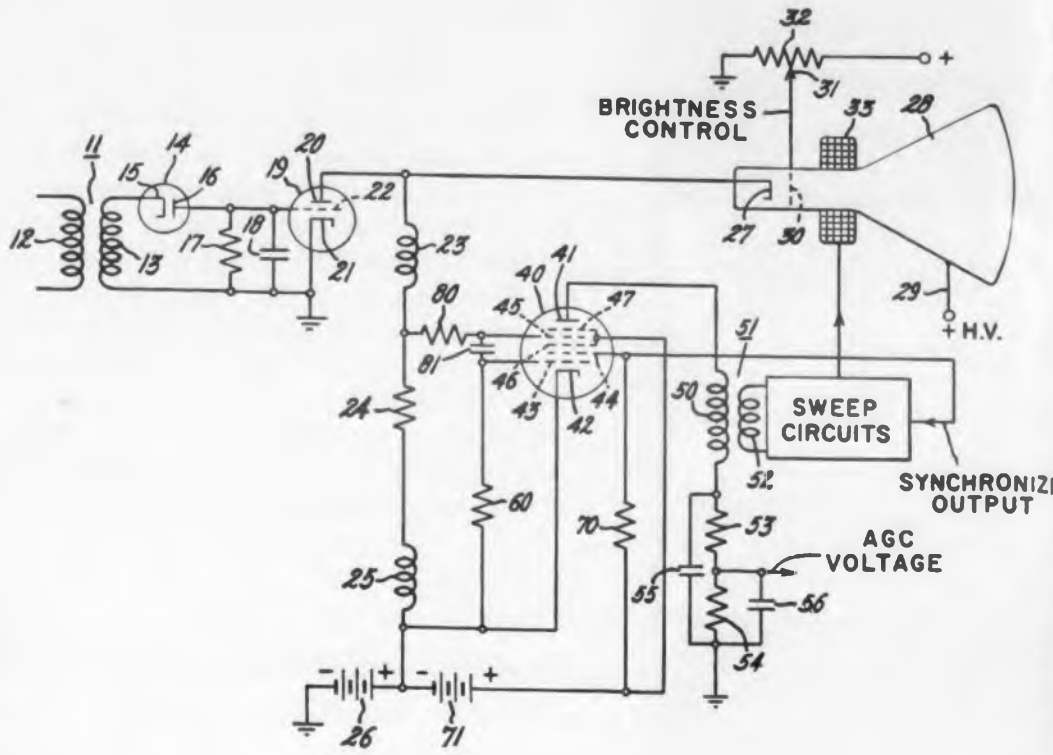
Grounded-Grid Amplifier Transfer Function

Contents: **I**—Introduction; **II**—The analysis of grounded-grid amplifiers; **III**—The synthesis of grounded-grid amplifier transfer functions; **IV**—Design equations and alignment procedure; **V**—The design and performance of a grounded-grid amplifier; **VI**—Conclusions. *Analysis and Synthesis of Grounded-Grid Amplifier Transfer Functions by Warren A. Christopherson, Stanford University, Electronics Research Lab., Stanford, Calif. May 1952, 135 pp. diagrams, graphs, tables, microfilm $6.90, photocopy $21.30. Order PB 126343 from Library of Congress, Washington 25, D.C.*

Radioactive Energy

Newly developed techniques of preparation of relatively large area electrode couple sheets from the point of view of cleaning the stainless steel base, anodizing, and evaporating magnesium on one side are described. The advantages of couples made in this manner over welded couples are given and a comparison of CPD measurements on both types is presented and analyzed. A new program of investigating promising insulators is discussed in detail. The importance of this program is reinforced by experimental evidence that the high voltage terminal of battery models must be potted. *Investigations on Utilization of Radioactive Energy as A Source of Battery Power, by Alexander Thomas, Tracerlab, Inc., Boston, Mass. October 1954, 41 pp, photos, graphs, tables, microfilm $3.30, photocopy $7.80. Order PB 130243 from Library of Congress, Washington 25, D.C.*

PATENTS



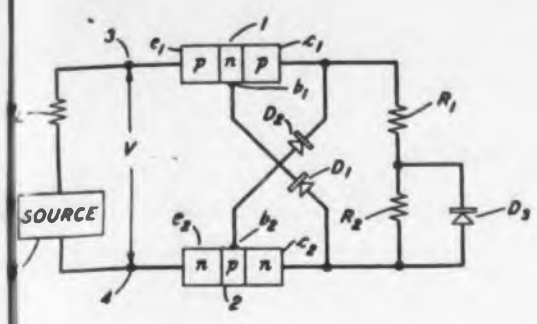
Combined Automatic Gain Control and Synchronizing Signal Separation Circuits

Patent No. 2,810,783. W. J. Gruen. (Assigned to General Electric Company)

A circuit for securing both automatic gain control and separation of the synchronizing signal from the composite signal is shown. Circuits commonly used for performing these functions have been subject to interference from noise transients. The circuit described makes use of this form of keyed A.G.C. systems having substantially greater immunity from noise. The coupling transformer 11 feeds the input signal, as from the if stage of a television receiver, to the circuit. Diode 14 detects the signal. The synchronizing signal developed across resistor 17 and condenser 18 is negative, requiring phase inversion so that the blanking pulse applied to the cathode 27 of the picture tube 28 is a positive signal which will black out the tube. The triode 19 is used for this purpose.

Substantially the entire signal of amplifier 19 will appear across resistor 24 and inductor 25. This signal is coupled to a second control grid 45 of tube 40 through a resistor 80 which provides a dc connection. Condenser 81 offers ac coupling of the amplifier signal to control grid 43 of tube 40. To obtain a keyed signal pulses are applied to the anode as from the sweep circuit genera which is coupled into the plate cir through transformer 51. A low pass fi is provided in series with second winding 50 of transformer 51 for g erating a negative agc voltage across sistor 54 and condenser 56. This sig is fed to a stage which controls am fication through the receiver circuit. signal applied to control grid 45 g erates a current through the plate circ the magnitude of which is fixed by peak value of the video signal. The t normally is in a non-conducting con tion until the signal on the second c trol grid approximates the potential positive source 26. This potential is abo at the cut-off potential of amplifier Conduction through the tube genera a control voltage which is sufficient provide the agc potential.

By proper selection of resistor 60 in circuit of control grid 43 the tri formed by the cathode, first control g and second grid 44 serves as a clip since it transmits the synch pulse o The second grid 44 which is connec with potential source 71 functions as anode for the triode. The clipped s chronizing pulse of the input signal pears across the resistor 70 and is fed the sweep circuit generator.



Negative Impedance Bistable Signal-Operated Switch

Patent No. 2,820,155. John G. Linvill. (Assigned to Bell Telephone Labs., Inc.)

The two terminal signal-operated apparatus is designed to connect the signal source, or a related source, and a load for signals in excess of a specified threshold. When the signal source is connected to the load, the circuit includes a negative impedance adjusted to be less than the positive resistance of the associated circuit so that the switch and its load together are stable when the switch is closed. At the same time the switch furnishes a substantial amount of effective gain thereby reducing the amount of gain which might otherwise be required. Negative impedance converters using vacuum tubes are known to the art and prior patents have developed the theory of transistorized negative converters.

As shown, the source 5 connects to the load R_L through n-type transistor 1 and p-type transistor 2 interconnected through "Zener" diodes D_1 and D_2, poled in opposite senses with respect to the transistor electrodes. The operation of the circuit is as follows:

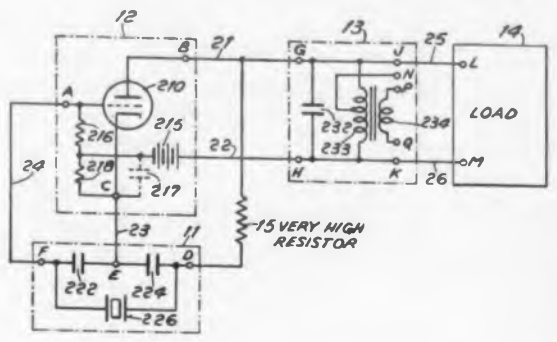
For small applied voltages, the input resistance is very high. The transistors are prevented from carrying current because each of them has in series with it a breakdown diode biased in its reverse direction. When the threshhold voltage, equal to the sum of the breakdown voltages of diodes D_1 and D_2, is exceeded, the diodes D_1 and D_2 bearkdown and negligible resistance is present in the cross-coupling paths. The transistors and the low impedance cross-coupling constitute a negative impedance converter. The magnitude of the negative impedance seen at the input terminals of converter is a direct function of the magnitude of resistances R_1 and R_2 in series. One resistor R_2 is shorted out when diode D_3 breaks down and the transient response and stability of the switch improves.

Oscillator

Patent No. 2,829,256. Joseph Kalish. (Assigned to International Telephone & Telegraph Corp.)

A triode produces ac at useful power level by means of a miniature crystal in an oscillating circuit, which is independent of variations in the other circuit elements, supply voltages and output characteristics.

In the circuit are shown amplifier tube 210 connected to the Colpitts-type oscillatory circuit 11 through the very high resistor 11. Crystal 226 operating in the



parallel mode forms the inductive branch in shunt with condensers 222 and 224 connected in series.

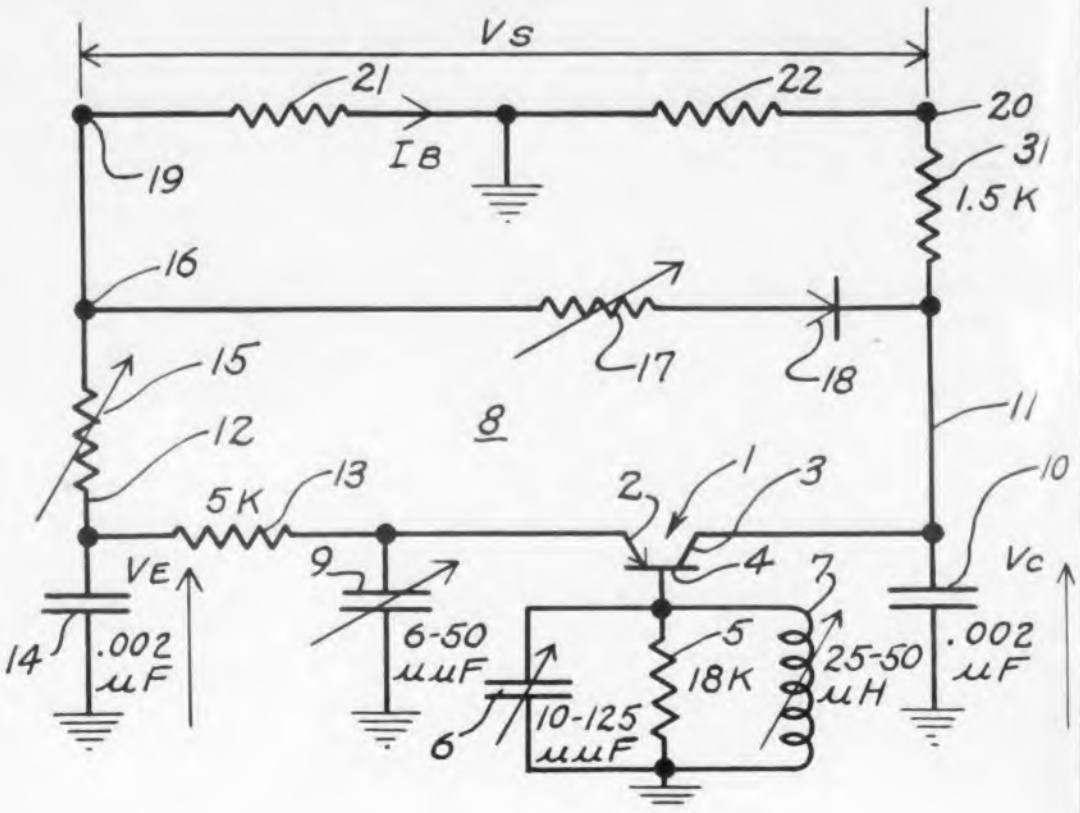
By using a special cut, the crystal is made miniature in size at low frequency. Typical circuit parameters are given for use in conjunction with one half of a type 5670 tube. The crystal dissipation is about 30 μw and the output may be 200 v peak-to-peak operating into a load of 100,000 ohms.

Frequency Multiplier

Patent No. 2,816,277. Alwin Hahnel. (Assigned to the United States of America)

The frequency multiplier may also be termed a spectrum generator. The multiplier uses a vacuum tube having in its grid circuit an rf generator. There are two discrete resonant networks in circuit with the plate of the tube and one of these resonant networks is tuned to the fundamental frequency. The other resonant network is tuned to a prescribed multiple of the fundamental frequency so that there are prduced respective simultaneous self-excited oscillations at the fundamental frequency and at the multiple frequency. The initial cycle of each of the periodic multiple frequency oscillations has the same relative phase.

PATENTS



Stable Transistor Oscillator

Patent No. 2,810,073. R. W. Bradmiller. (Assigned to Avco Manufacturing Corp.)

The circuit developed compensates for variations in voltage supply and temperature so that an improvement in the frequency stability of the oscillator is secured in the ratio of about 20 to 1.

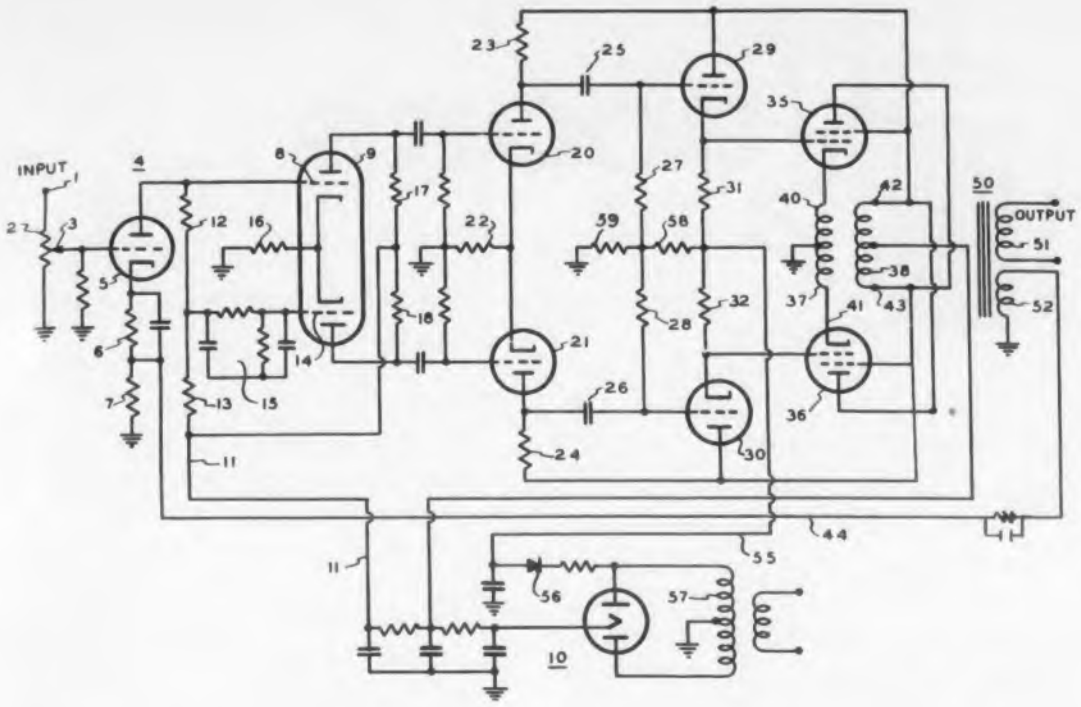
The oscillator shown in the figure uses a transistor 1 with an oscillating tank circuit in the circuit of the base electrode. The resistor 5 provides the proper potential for the base electrode. Feedback to the emitter 2 is accomplished through the adjustable condenser 9. Voltage is applied across the series resistors 21 and 22, the mid-terminal of which is grounded. The positive side of the supply is applied to terminal 19 and the negative terminal to the terminal 20. Values of resistance are chosen so that the proper positive potential is applied to the emitter 2 and the proper negative potential is applied to collector 3. It is necessary that the current through the resistors 21 and 22 be at least as great as the total oscillator current to assure a proportional distribution of the supply voltage between emitter and collector.

To secure compensation for variations in voltage supply the diode 18 is used in series with a variable resistor 17 and in shunt with the resistors 21 and 22. The diode is connected to operate in the "Zener" breakdown region, in which the diode passes current at a minimum supply voltage. If now the supply voltage should increase, the effect of which is to lower the collector potential, voltage across the diode remains constant. Current flow through the diode increases and passes through the resistor 31 to raise the potential on the oscillator. By adjusting the resistor 17 to give the proper current for compensation, the potential of the collector electrode remains substantially constant and, hence the frequency of oscillation remains constant. Increase in collector voltage transistor temperature tends to decrease. When this occurs the diode 18 again operates to maintain a substantially constant potential across the terminals of the compensating circuit. The collector voltage is thus maintained constant.

High Fidelity Audio Amplifier

Patent No. 2,825,766. Sidney A. Corman. (Assigned to McIntosh Laboratory, Inc.)

Disclosed is an improved McIntosh Amplifier. The required driving power is obtained by cathode followers which have the same ac voltage on their p



electrodes as the cathodes of the output stage. The circuit is incorporated into the Model MC-60 Power Amplifier which is currently manufactured by the Laboratory. The McIntosh amplifier has negligible distortion even at the higher audio frequencies since unity coupling in the bifilar windings reduces the leakage reactance of the output transformer. Consequently the transient voltage is negligible when the current shifts from one of the push-pull output tubes to the other.

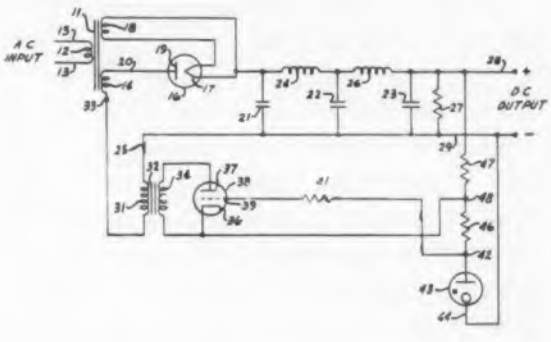
The most significant features of the amplifier described are the separate bifilar windings 51-52 and 37-38, and cross-connection of the plates in the output stage and the cathode follower driver stage, tubes 29 and 30. These tubes have the same ac voltages in the plate circuits as the cathodes of the output stage. The latter feature reduces the necessary power capacity of the driver stage since the power requirement is compensated for by the resulting counter balancing of the ac voltage on the cathode of the output stage. In this manner, the power dissipation in the driver stage is maintained at a more reasonable value.

Voltage Regulated Power Supply

Patent No. 2,830,250. Arden H. Frederick, Alfred S. Gano. (Assigned to General Precision Laboratory)

Voltage regulation of a dc power supply is obtained using a saturable reactor connected in series with the ac supply to the rectifier. Compared to the series tube control circuit, this method is preferred since the design is not limited by the range of conductance or power capacity of the tube. However, the control range using a saturable reactor is severely restricted unless a condenser input filter is used.

A typical circuit is illustrated. The half wave rectifier 16 is connected to condenser 21 which returns back to the



rectifier through secondary winding 31. The amount of current flow in primary winding 34 is determined by the voltage at terminal 48 since the grid voltage of tube 38 is held constant by regulator 43. When the voltage at terminal 48 changes due to a change in load, the current in winding 34 changes in phase and magnitude. This change is sufficient to change the inductance of winding 31 to compensate for the change in output voltage. Since the transformer is step-down from winding 34 to winding 31, triode plate resistance if divided by the transformer ratio is effectively inserted in series with the ac supply to the rectifier. The rectifier current changes and, as a result, the output voltage is stabilized.

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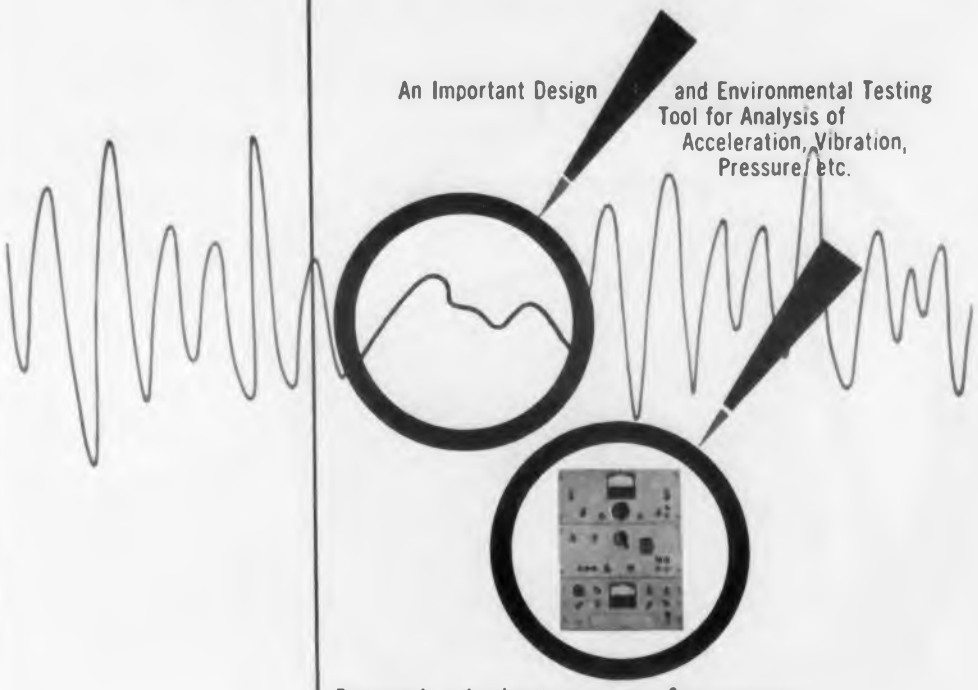

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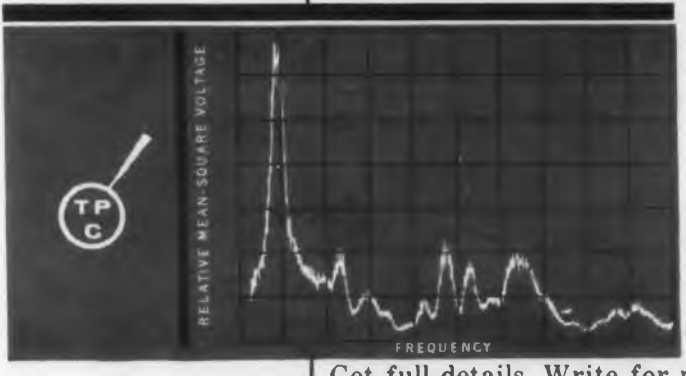

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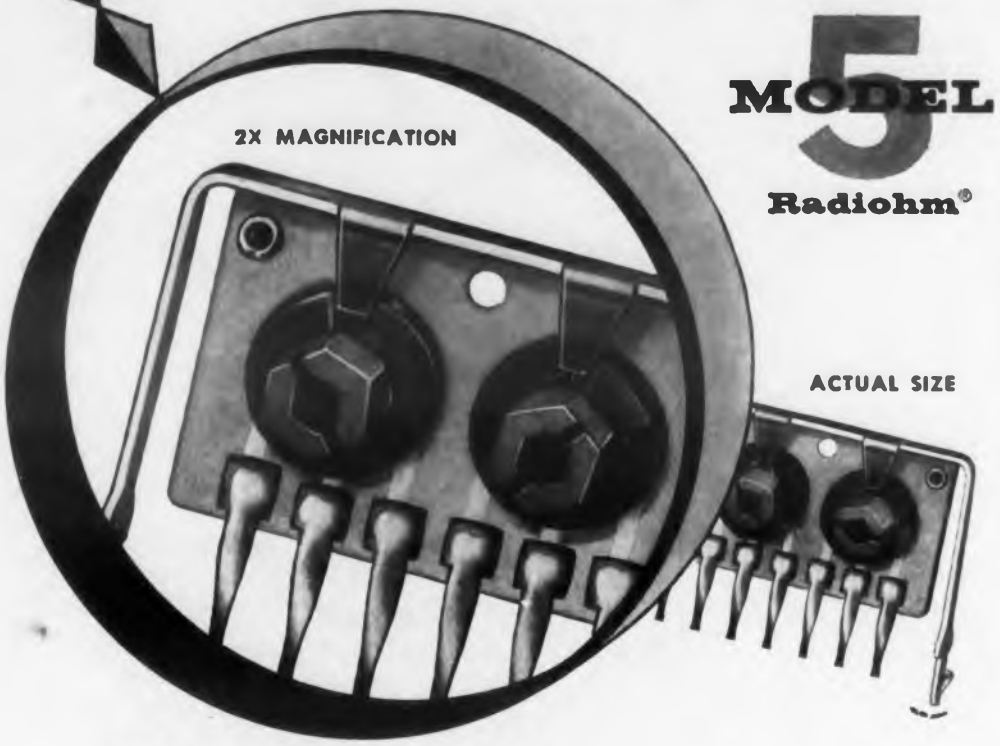

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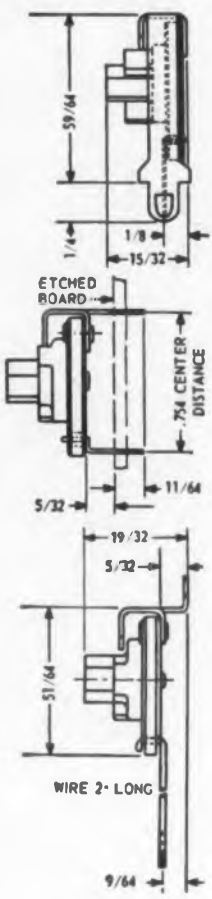

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BOOKS

Electronic Semiconductors

Eberhard Spenke, McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y., 375 pp, $11.00.

A translation of the second edition of *Elektronische Halbleiter*, this book develops the subject of semiconductor physics in a logical and consistent manner from simple concepts. The reader is familiarized with the fundamentals of semiconductor devices such as rectifiers and the various transistor types.

The book specifically features treatments of the acceleration of electrons and the Zener effects. A chapter covers statistics and kinetics of electrons as modified by electrostatic potentials.

The first part describes basic theoretical concepts of semiconductors leading up to a detailed description of the operation of crystal rectifiers and the physics of crystal amplifiers.

Quantum mechanics of the hydrogen molecule, the band model, Fermi statistics of electrons in a crystal, imperfection equilibria, and boundary layers in semiconductors are considered in the second part. The translators have added a section on junction capacitance and separate problems for each chapter.

High-Speed Data Processing

C. C. Gotlieb, McGraw-Hill Book Co., 330 West 42nd St., New York, N.Y. 305 pp, $9.50.

Important principles and general techniques of processing data at high speeds, particularly for business purposes, are thoroughly outlined in this new book. A wide range of subjects, from the method of representing information in a processor to advances in automatic programming, is covered. This volume shows precisely how data processors work, how they are used, and what their advantages are.

The book does not confine itself to any particular machine but covers data processors of all types from all manufacturers. To focus attention on the fundamental operational principles of all high-speed data processors, a hypothetical machine is used as a model. This model is a synthesis of several existing machines and has the full complexity of a real machine.

With scores of tables and illustrations, the book gives a detailed study of coding and programing, and provides several helpful examples showing typical applications of high-speed data processing in the major fields.

The Theory of Networks in Electrical Communication and Other Fields

F. E. Rogers, D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 560 pp, $11.50.

In this comprehensive volume the author makes a clear and thorough analysis of the subject. The principles covered in Chapters 1 through 7 are general. They provide the background for the special approaches associated with the transmission lines and communication networks, which are developed in Chapters 8 through 11; and also for the survey of light-current measurements presented in Chapter 12.

The Laplace Transform and matrices are omitted, but the treatments in Chapters 2 and 3, which include the Fourier integral and the generalization of network solutions respectively, should lead smoothly into such specialized studies and suitable references are given.

Conductance Curve Design Manual

Keats A. Pullen, John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. 128 pp, $4.25.

Dr. Pullen is a familiar figure to ELECTRONIC DESIGN readers. He has presented many articles here which describe the design of specific circuits using conductance curves. His contributions in this

area have been expanded with the recent publication of the Conductance Curve Design Manual. This authoritive book explains the use of these curves in circuit design and provides more than 70 of the most representative curves used in all services. With the aid of these two-colored, full-page, clearly drawn graphs, design using small signals parameters can be used to predict large signal performance. A set of tables useful in making tube substitutions, and tables to simplify the selection of tubes for given applications have also been included.

Proceedings of the 1958 Electronic Components Conference

Engineering Publishers, Div. of the AC Book Co., Inc., GPO Box 1151, New York 1, N.Y. 222 pp, $6.00.

Contained within this hard cover volume are the papers presented at the 1958 Electronic Components Conference. The technology advanced represents generally the designs, developments, production, and applications of electronic component parts in evidence today. Included for discussion are the latest developments in resistors, capacitors, and dielectrics; transistors and solid-state devices; electron tubes and their applications; economic aspects of component reliability; application aspects of component reliability, and progress with materials.

The book was published prior to the actual conference representing the 25 papers chosen by the Program Committee.

The theme for this conference was "Reliable Application of Component Parts." The material presented shows evidence where reliability is actually being applied as a prime design consideration in component part specification, application, and ultimate use.

Motion and Time Study

Ralph M. Barnes, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. 665 pp, $9.25.

In this revised edition, the basic principles that underlie the successful application of motion and time study are presented. Each is supplemented with illustrations and practical examples. Five new chapters deal with: motion study, mechanization, and automation; mechanized time study and electronic data processing; systems of motion-time data; work sampling; evaluating and controlling factors other than labor; and multifactor wage incentive plans.

The book includes new material on developments in the industrial use of pulse rate as an index of physical activity. All known systems of motion data are outlined and four of these systems are described in detail, including complete tables of motion-time data for each.

Introduction to Electromagnetic Engineering

Roger F. Harrington, McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N.Y., 312 pp, $8.00.

Fields theory is introduced as an extension of circuit theory, with Maxwell's equations obtained early in the text. These equations are then specialized to the static case, and considerable time is spent on static field theory. An introduction to the study of time-varying field theory is given in the last chapter. The theory of vector analysis is developed as needed. The mksc systems of units is employed throughout. An analytical approach to the theory has been emphasized. This text was designed for the introductory study of electromagnetic theory at the junior, senior, or first-year graduate level.

Zone Melting

William G. Pfann, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 236 pp, $7.50.

This first book on the subject includes all the information needed to plan a zone melting process or to decide whether one is feasible. It covers both theory and practice and spells out potentialities of crystallization as yet unexploited.

Among the features: a comprehensive description of how to build and operate zone refineries; a complete set of computed zone-refining curves showing impurity concentrations throughout an ingot as a function of the number of passes; a discussion of the largely unexploited continuous multistage techniques; extensive coverage of solidification methods for growing and controlling properties of semiconducting crystals.

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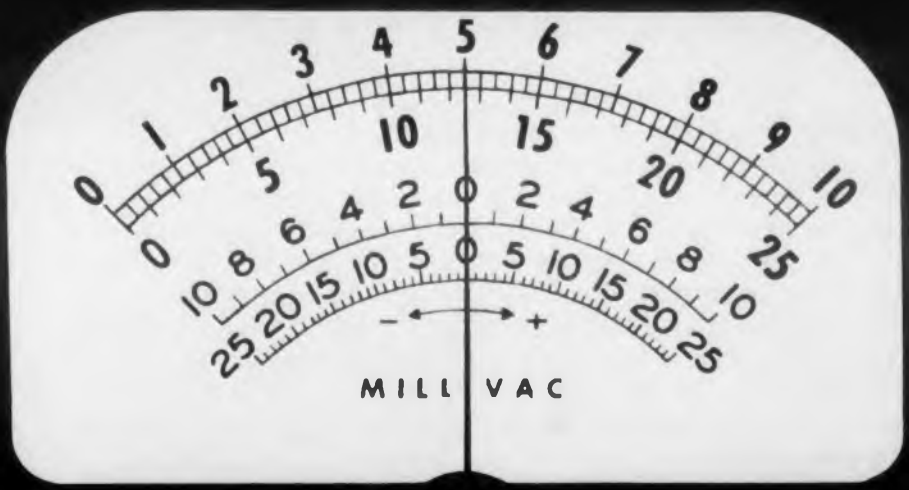

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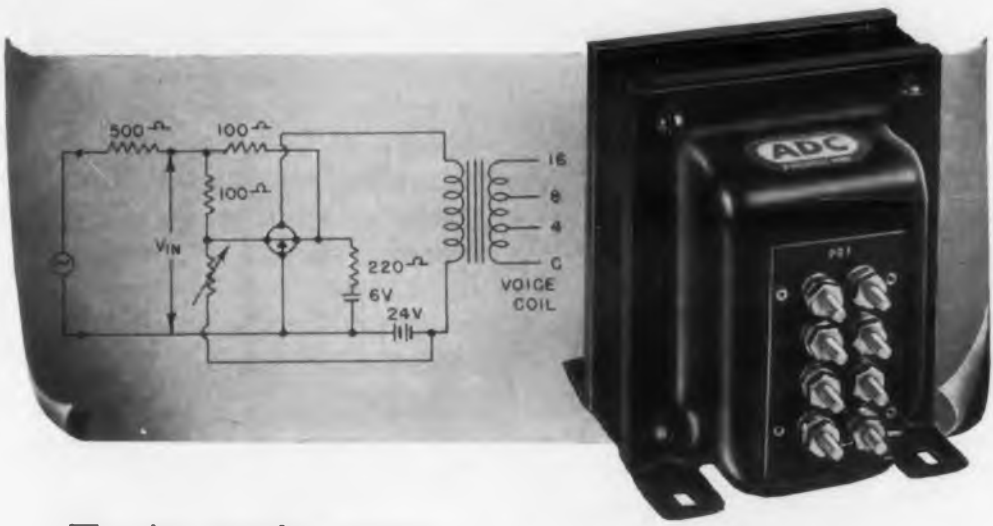

The tiny transistor transformers such as those illustrated at the right are for low power applications. Introduction of new, low distortion, power transistors has required larger transformers, especially for operation at low frequency. While these may be new to transistor circuits, the design problems and solutions are identical with those of vacuum tube circuitry.

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What The Russians Are Writing

J. George Adashko

Drawing by Frueh, © 1958 The New Yorker Magazine, Inc.

INFORMATION THEORY

On the Probability of n-Coincidences by A. R. Livshitz. REE 8/57, pp 947-950, 3 figs.

Statistical discussion of the problem of determining the probability of coincidence of pulses in n-pulse random sequences. Equations are derived for the probability of coincidence and for the average duration of coincidence for equal and different duration of pulses contained in the pulse sequences. Reference is made to "Theoretical Aspects of Asynchronous Multiplexing" by W. D. White, *Proceedings IRE*, Vol. 38, No. 3, pp 270-275.

Estimate of the Parameters of the Distribution of a Random Function at Limited *a Priori* Data by Yu. P. Leonov and L. A. Tel'ksnis. AT 11/57, pp 984-998, 6 figs.

The authors show that reducing the *a priori* data concerning the parameters whose estimate is being sought can be effected if one can verify the correctness of certain hypotheses concerning these parameters. Reference is made to a large number of standard American works on prediction and statistical approaches to information theory.

From Mechanical Relays to Synchronous Static Detectors by A. A. Pirogov. EC 11/57, pp 6-16, 2 figs.

Although this is essentially devoted to the development of information theory in the U.S.S.R., it does have a detailed description of Kotel'nikov's maximum interference-immunity theory. This has received a lot of publicity in recent times. The article also discusses efforts of Soviet scientists to overcome certain substantial informational defects of present-day communication systems.

Correlation Function and Energy Spectrum of Speech Signals that are Strongly Limited in Amplitude by Yu. G. Rostovtsev. EC 12/57, pp 45-49, 5 figs.

The author calculates the correlation function and the energy spectrum of speech signals that are limited (above 40-50 db) so as to have the signal acquire rectangular form. The jumps take place at the instant when the values of the speech signal are zero. The sensible information is carried by the zero points of the signal.

Principal Problems in the Theory of Signals and Tasks in Its Further Development on the Basis of a New Stochastic Model by N. A. Zheleznov. RE 11/57, pp 3-12, 1 fig.

Assuming the spectrum is limited, in the analysis of a basic model for a modern theory of signals, leads to a complete statistical breakdown of the signal and leads to the impossibility of forming these signals in physically realizable systems. The limited nature of the signal concept excludes all types of radio signals. A new stochastic model, which retains the principal properties of real signals, is proposed. Refers to the standard articles by Shannon, Paley, Wiener and Middleton.

Optimum Regulation of Parameters of a Radio Line by S. I. Samoylenko. EC 12/57, pp 3-8, 2 figs.

To increase the amount of information transmitted per unit time under varying transmission conditions, it is possible to employ optimum regulation of the parameters of the radio line, the optimum depending on the transmission conditions. A procedure is examined for constructing optimum-regulation systems in the case of continuous and binary-coded signals. The method is illustrated by an example of optimum regulation of the amplitude threshold level in the transmission of communication coded with a binary code. Reference is made to an article by R. A. Silverman, Transactions IRE, IT-1, No. 3, 1955.

CIRCUITS

Procedure for Calculating the Optimum Parameters of DC Bridge Measuring Circuits by E. A. Yakubaytis. Izvestiya (Bulletin), Academy of Sciences, Latvian SSR, 6/57, pp 95-109.

A procedure is given for choosing the optimum parameters of a measurement dc bridge circuit operating with an input from an amplifier having a control

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VHF Mobile Receiver Uses

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RUSSIAN TRANSLATIONS

winding (magnetic dynamoelectric, carbon pile, etc.) The nonlinear bridge elements used in this article are barreters, but the procedure described can be readily extended to include other bridge circuits with nonlinear elements, whose characteristics lend themselves to piecewise-linear approximation.

Synthesis of Networks with Lumped Elements, Which Reproduce the Properties of Networks with Distributed Constants by N. S. Kochanov. RE 11/57, pp 72-78, 6 figs.

Considers the problem of representing several irrational and transcendental functions, and expressing the input impedance of a long line, with the aid of continuous fractions. It is shown possible to synthesize two and four-terminal networks with lumped elements, simulating the properties of long lines both with respect to the input impedance and the propagation constant.

Certain Problems in the Theory of Microwave Tetrode Oscillators by V. S. Mikhaylov. RE 12/57, pp 3-9, 6 figs.

The author considers the electronic phenomena that take place in the screen grid—anode region of a planar tetrode. He derives formulas for the efficiency of the microwave tetrode oscillator used either for power amplification or for frequency multiplication. Equations are derived for the motion of the electrons and for the coefficient of energy utilization of a single electron.

Simplified Design Method for a Transistor Amplifier Stage by A. A. Sokolov. AT 12/57, pp 1139-1141, 1 fig, 3 tables.

In this simplified procedure the transistor equivalent circuit is taken to be an active four-terminal network, thus leading to rather simple design equations.

KEY

The sources of the Russian articles and their dates of issue follow the authors' names. Here is the key to the names of the journals in which the articles originally appeared.

AT	Automation and Telemechanics *(Avtomatika i Telemekhanika)*
CJ	Communications Journal *(Vestnik Svyazi)*
EC	Electrical Communications *(Elektrosvyaz')*
IET	Instruments and Experimental Techniques *(Pribori i Teknika Eksperimenta)*
R	Radio
RE	Radio Engineering *(Radiotekhnika)*
REE	Radio Engineering and Electronics *(Radiotekhnika i Elektronika)*

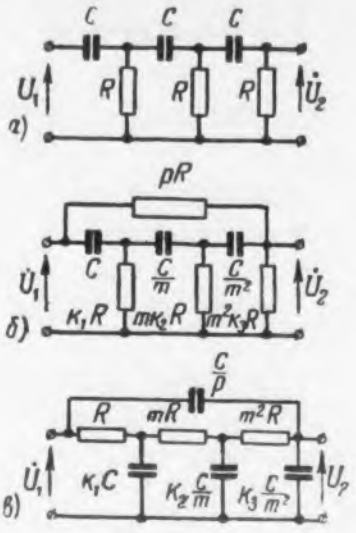

Fig. 1. Typical ladder networks used frequently in vacuum tube oscillators for feedback.

Improving the Parameters of RC Ladder Networks by I. A. Zakhariya. RE 11/57, pp 66-71, 7 figs.

This article analyzes improvement in the properties of ladder RC circuits by bridging. Comparative graphs are given for a three-element and four-element network with parallel resistances. Formulas are derived for the characteristics of the three-element RC circuit for changes in individual resistance and progressive changes in the circuit elements. The basic networks are shown in Fig. 1.

Increasing the Useful Power of a Tuned Semiconductor Amplifier by Increasing Its Efficiency. Part I by L. S. Berman. RE 11/57, pp 62-65, 3 figs, 2 tables.

Since there are no practical limitations to the emission current in transistors, the useful power is limited principally by the maximum heat dissipation. By increasing the efficiency of a tuned semiconductor amplifier with an additional tuned circuit to filter the third harmonic, it is possible to double the useful power compared with the usual circuit, using equal dissipation in both cases.

TRANSLATIONS AVAILABLE

ELECTRONIC DESIGN is gratified to learn of the growing availability of full translations of important Russian electronics journals.

Consultants Bureau, Inc. of 227 W. 17th St., New York 11, N.Y. translates *Automation and Telemechanics* regularly.

Pergamon Press of 122 E. 55th St., New York 22, N.Y. is preparing translations of *Radio Engineering, Radio Engineering and Electronics,* and *Electrical Communications.*

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DB Switched	41 db in 6 steps						101 db in 9 steps		
Steps	20 db, 10 db, 5 db, 3 db, 2 db, 1 db						20 db, 20 db, 20 db, 20 db, 10 db, 5 db, 3 db, 2 db, 1 db		
Frequency Range	DC to 500 mc (useful to 1000 mc)								
Accuracy of Attenuation	1.0 db max at 500 mc 0.5 db max at 250 mc Better accuracy at lower frequencies						1.5 db max at 500 mc 0.75 db max at 250 mc		
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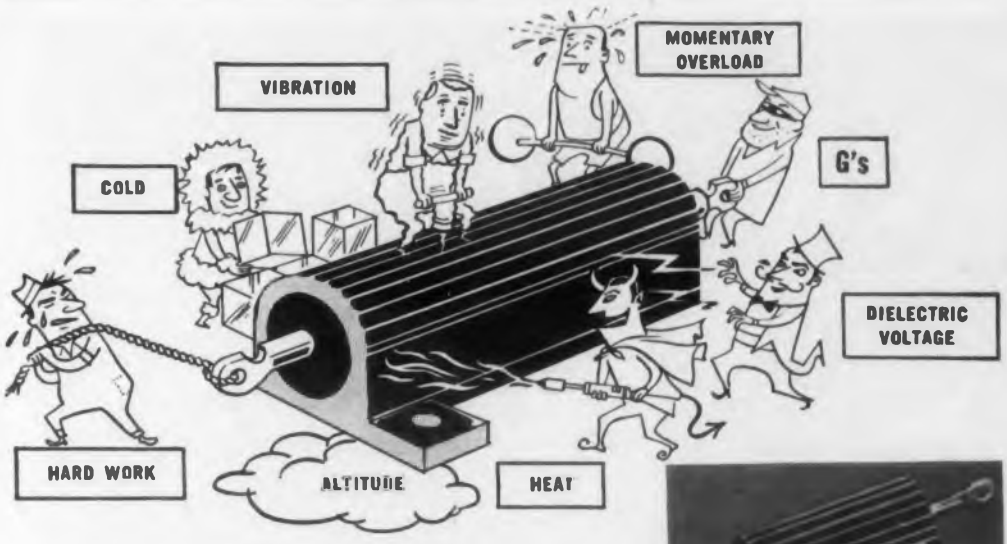

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RUSSIAN TRANSLATIONS

Calculations for Grounded Grid Oscillators by Ye. P. Korchagina and G. M. Utkin. RE 11/57, pp 29-38, 14 figs.

Discusses the choice of the optimum operating modes for amplifiers and frequency multipliers with grounded grids. If the resonant impedance of the tank circuit is limited, the energy relations in the plate circuit must take into account the power consumed by the preceding state of the transmitter. Recommendations are given concerning the choice of the cutoff angle and the amplitude of the plate-current pulse in amplifiers and frequency multipliers with allowance for the power gain of the stage.

Transients in a High Frequency Amplifier-Detector System by L. S. Gutkin and O. S. Chentsova. RE 11/57, pp 50-61, 19 figs.

A preceding article by the same authors (Radiotekhnika, April 1957) showed that the analysis of transients in a system comprising a high frequency amplifier and a strong signal diode detector is carried out more simply and obviously by using a low-frequency equivalent. In this article the method proposed is applied to the analysis of transients in the most widely used detector circuits (tuned resonant circuit, untuned resonant circuit, two coupled circuits).

Square-Law Detection with Aid of a Semiconductor by O. V. Sorokin. REE 10/57, pp 1293-1294, 3 figs.

This is a continuation of the subject discussed by the author previously in the May 1957 issue of Radiotekhnika i Elektronika, p 664.

Use of Nonlinear Feedback to Eliminate Saturation of Transistors in Pulse Circuits by B. N. Kononov. REE 10/57, pp 1253-1260, 9 figs.

A method is proposed to eliminate saturation in junction transistors and the associated delays in the pulse circuits with nonlinear feedback. Two ways to design these circuits are shown. In addition to eliminating delay, nonlinear feedback extends the limits of permissible dispersion of transistor current gain. This makes it possible to use transistors whose gain ranges from a certain minimum to infinity without a change in circuit parameters. Refers to work by Ebers & Moll (*Proceedings IRE*, 1954, Vol. 42, Page 1761), Moll (*Proceedings IRE*, 1954, Vol. 42, Page 1773), Cooke-Yarborough (Journal of Electronics, 1956, Vol. 1, Page 539), Bothwell & Booth (Transactions IRE, 1956, EC-5, Page 132) and Prom & Crosby (Transactions IRE, 1956, EC-5, 4, Page 192).

Semiconductor DC Transformer by G. S. Tsykin. RE 12/57, pp 56-62, 8 figs.

The article discusses several methods for trans-

forming dc at one voltage into dc at another voltage, at power ratings which can supply vacuum tube equipment. A semiconductor keying power amplifier is proposed, controlled by a master oscillator. The fundamental properties of the design are given. See Figs. 2-5.

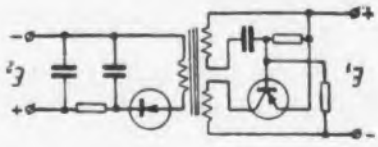

Fig. 2. Basic dc to dc transformer using a transistor to generate nearly rectangular pulses and diodes to rectify them.

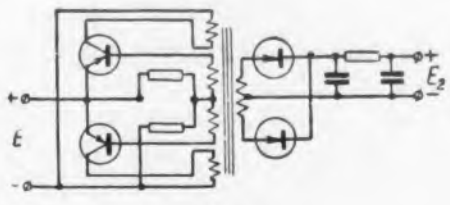

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Fig. 3. Full wave version of the same scheme.

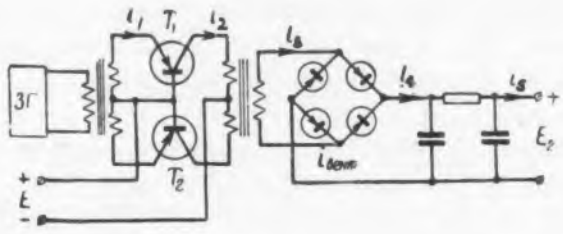

Fig. 4. The circuits of Figs. 2 and 3 have the shortcoming that the frequency and waveform of the self-excited oscillations vary with the load and with the supply voltage. A better semiconductor dc transformer would be the one shown here. It includes a master oscillator with rectangular waveform, a power amplifier, a semiconductor rectifier, a filter, the load, and the dc power source whose voltage is to be transformed. Theoretically its efficiency may reach 90 to 95 per cent.

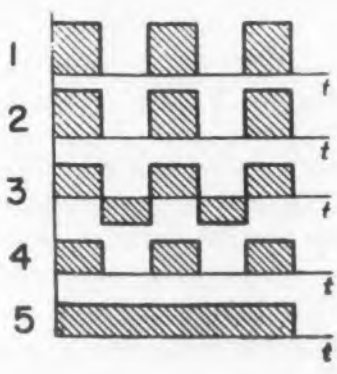

Fig. 5. Waveforms in the circuit of Fig. 4. 1—emitter current, 2—collector current, 3—input to rectifier, 4—current to filter, 6—output current.

(continued on following page)

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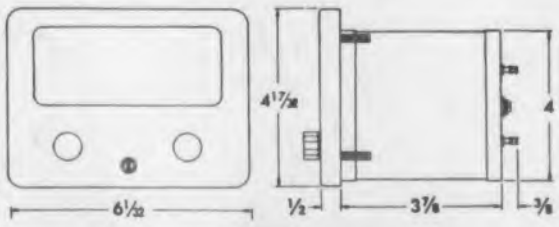

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RUSSIAN TRANSLATIONS

Scheme for Switching Radio Broadcast Programs by P. A. Palladin. CJ 1/58, p 12.

Brief description of a circuit permitting automatic selection of programs and checking the correctness of the switching in a central broadcast studio.

Auxiliary Multi-Channel Transistorized Amplifier by K. P. Yegorov and I. V. Sukhodoyev. EC 12/57, pp 58-64.

The authors discuss the possibility of designing a group amplifier for multi-channel communication using pnp transistors, and describes methods for reducing the noise.

SPUTNIK

Second Soviet Artificial Earth Satellite. R 12/57, pp 24-29, 5 figs.

Reprint of description, unsigned, of the Soviet second Sputnik, originally printed in "Pravda" November 13, 1957. The arrangement and the description of some of the electronic and cosmic-ray apparatus are described.

Exact Determination of the Velocity of a Satellite by S. Khaykin. R 12/57, pp 5-7.

Outlines the fundamental principles, in a popular manner, of how the speed of a moving satellite can be determined by its frequency shift.

Preliminary data on Propagation of Radio Waves by A. Kazantsev. R 12/57, pp 7-8.

Relates briefly how signals from the satellite can throw new light on the various ionized layers around the atmosphere.

COMPONENTS

Single Cycle Switching Circuits with Intermediate LC Network Employing Ferrites with Rectangular Hysteresis Loop by Ya. G. Koblents and D. A. Yakovenko. EC 11/57, pp 101-112, 12 figs.

Description of a contactless magnetic switching element developed by the authors, intended for automatic control equipment in automatic telephone stations and for long-distance apparatus.

Germanium Rectifiers by B. A. Piontkovskiy. CJ 11/57, pp 5-7, 4 figs.

Most rectifiers used for power supply for communications apparatus contain selenium rectifiers. Recently the Russian industry has developed new semiconducting germanium rectifiers, whose electrical parameters and properties are considered in this article.

Estimate of Nonlinear Properties of Junction Transistors by A. I. Borisov. EC 12/57, pp 37-44, 8 figs.

The author introduces coefficients that charac-

terize the fundamental nonlinear properties of junction transistors. He shows that the nonlinear distortion introduced by the transistor is due to electric processes originating in the emitter and collector p-n junctions in the base region and he recommends a method for selecting transistors with least pronounced nonlinear properties. Reference is made to an article by W. M. Webster, *Proceedings IRE*, Vol. 42, Page 914-920, 1954.

RGM-500, an Oscillator Triode with Continuous Vacuum Pumping by A. L. Mints, M. I. Basalayev, N. I. Oganov, and Ye. V. Rudnev. REE 10/57, pp 1240-1252, 10 figs, 2 tables.

Describes the construction of a dismountable oscillator triode with continuous vacuum pumping, having a useful power of 500 kw. The tube has several features that distinguish it from previous models. The article contains an extensive description of the mechanical and electrical parameters of the tube, as well as some test results.

Effect of Impurity Distribution in the Base of Drift Transistors on Frequency Characteristics by Ya. A. Fedotov. REE 10/57, pp 1261-1270, 4 figs, 1 table.

The distribution of impurities in the base due to diffusion, determines certain properties of a transistor. In particular, this diffusion produces an internal accelerating field, which affects the process of the charge transport from the emitter to the collector. This article considers the frequency characteristics of such drift transistors, and discusses the diffusion of impurities in germanium, the connection between the collector voltage, thickness of the junction, and the capacitance of the junction, and also the influence of uneven distribution of the impurities in the base region on the motion of the carriers from the emitter to the collector. The maximum power gain frequency is also determined.

RADIO ASTRONOMY

New Radio Telescope (Preliminary Communication) by V. V. Vitkevich and V. A. Udal'tsov. REE 12/57, pp 1548-1549, 1 fig.

Short report on the new large radio telescopes, installed in July 1957 at the Crimean Scientific Station of the Physics Institute of the Academy of Sciences, USSR. The dish has a diameter of 31 meters and was used to study radio waves from the sun and from the Crab nebula at 50 and 10 cm, and from the sun at 3 cm.

A more detailed report on this article appears in *Soviet Bloc International Geophysical Year Information* published by the U.S. Department of Commerce, Office of Technical Services, Washington 25, D.C.

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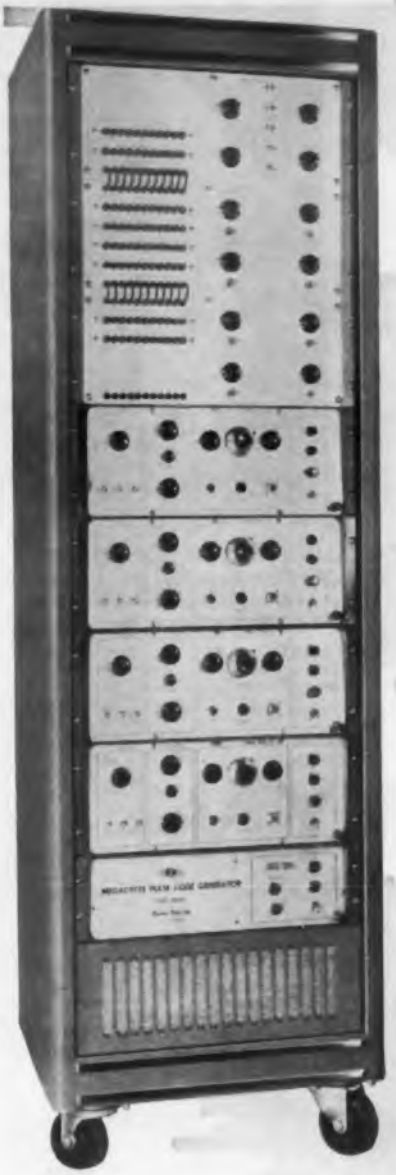

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GERMAN ABSTRACTS

E. Brenner

Temperature Stabilization Of Transistors

BOTH LINEAR and non-linear circuitry can be used for temperature compensation. The use of non-linear elements can, in principle, completely compensate for changes in quiescent collector current, collector voltage or gain.

If the collector current is maintained constant an experimental curve relating emitter-base voltage to temperature can be obtained. For an OC811 transistor this curve is a straight line with slope —2.7 mv/deg C. In general the temperature dependence of emitter-base voltage (V_{EB}) with temperature (θ) gives values of $\Delta V_{EB}/\Delta \theta$ between —2 and —3 mv/deg C.

A temperature dependent resistor (semiconductor) can be used, as illustrated, to compensate for the transistor characteristics. For a limited temperature range such elements are described by the equation

$$R = R_o e^{-c\Delta\theta}$$

where c depends on the temperature but is treated as constant over small ranges. For the circuit shown one sets

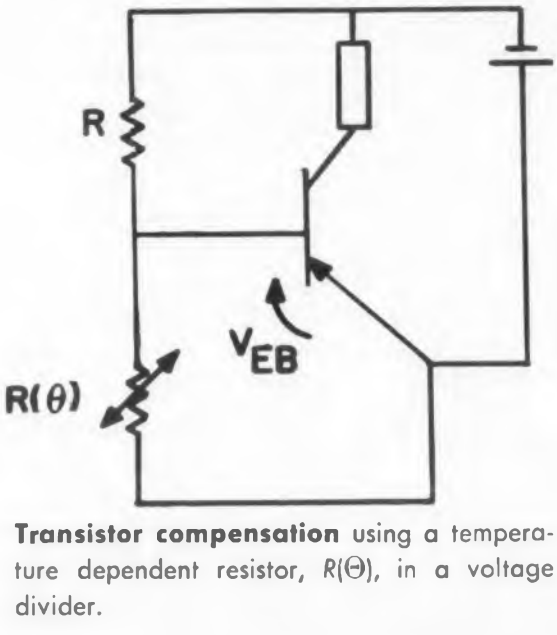
$$\frac{V_{EB}}{\Delta\theta} = \frac{d}{d\theta}\left(\frac{E \cdot R(\theta)}{R + R(\theta)}\right) \approx \frac{E}{R}\frac{dR(\theta)}{d\theta}$$

Because the parameter c is actually temperature dependent, compensation is achieved only over a limited range of temperatures.

The range can be extended by linearization, i.e. by connecting a linear resistor in series or in parallel with the temperature dependent semiconductor. This requires, of course, that the non-linear element have greater temperature sensitivity.

The original paper includes a review of the basic temperature/transistor characteristics relationships and a discussion of various linear compensation schemes.

Abstracted from an article by R. Lunze, Nachrichtentechnik, *Vol. 8, No. 3, March 1958, pp 98-108.*



Transistor compensation using a temperature dependent resistor, $R(\Theta)$, in a voltage divider.

Transistor Oscillators

LINEAR analysis of the block diagram shown in Fig. 1 indicates that two types of transistor oscillators can be built. In one case the conditions for oscillation depend on the parameters of the transistor; in the second the frequency of the oscillation is independent of the transistor and depends only on the frequency selective feedback network.

If the ideal transformer with turns ratio a is considered part of the transistor four pole, as shown in Fig. 2, then the Barkhausen criterion for oscillation becomes

$$a\,(-\alpha+h_{11}) \geq \frac{a^2\,(1-\delta)\,A_{12}}{Z_{2s}} + Z_{1s}\,A_{21} + a^2\,A_{22}\,\frac{Z_{1s}}{Z_{2s}} + A_{11}$$

where α is the short circuit current gain; h_{12} is the feedback voltage gain (generally negligible compared to α); Z_{1s} and Z_{12} are the short circuit input and output impedances respectively; the A_{ij}'s are the elements of the cascade matrix (general circuit parameters $ABCD$) of the coupling four-pole. The parameter is the "short circuit stability" defined as $Y_{21}\,Y_{12}\,Y_{22}\,Y_{11}$ where Y_{ij} represents the elements of the open circuit admittance matrix of the transistor without the transformer.

The ideal transformer is introduced into the calculations for convenience. In the physical realization of the coupling network it is often possible to "absorb" this element by using unsymmetrical four-poles. If the coupling network is assumed to be a symmetrical lattice with reactance X_1 in the series arm and reactance X_2 in the cross-arm, then the conditions for oscillations are described by the following relationships:

To satisfy the amplitude condition, i.e., "magnitude of gain"

$$(-\alpha+h_{12})_{min} - 2\,\frac{X_1+X_2}{X_2-X_1}\left(\frac{Z_{1s}}{Z_{2s}}\right)^{\frac{1}{2}}$$

where a^2 is chosen as the ratio Z_{2s}/Z_{1s}.

To uniquely specify the frequency of oscillation

$$-a^2\,(1-\delta)\,X_1\,X_2 + Z_{1s}\,Z_{2s} = 0$$

This last equation can be satisfied if

$$X_1\,X_2 = Z_{1s}\,Z_{2s}/a^2\,(1-\delta)$$

or if the product X_1X_2 is indeterminate in the sense that X_1 has a zero when X_2 has a pole or vise versa. In the latter case the frequency of oscillation is independent of the transistor parameters. These parameters appear in the last equation through the quantity δ.

In the original paper several realizations of each type of oscillator without ideal transformer are discussed: the problem of losses; the possibility of not meeting exactly the requirement for zero (or pole) in X_1 when a pole (or zero) is required in X_2. In either case the frequency of oscillation differs slightly from the value calculated from the last equation.

Abstracted from an article by J. Paul, Nachrichtentechnik, Vol. 8, No. 3, March 1958, pp 109-116.

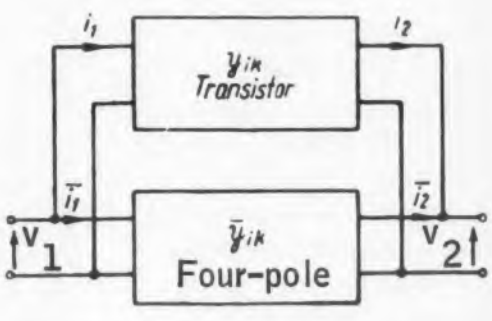


Fig. 1. Block diagram of the oscillator.

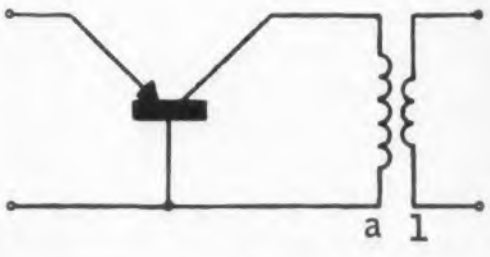


Fig. 2. Transistor with ideal transformer. The transformer is introduced to facilitate computations. The use of unsymmetrical four-poles often eliminates the transformer.

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Hotel Statler, Los Angeles, Calif. Sponsored by AIEE. The four technical sessions will include: technological and theoretical aspects of non-linear magnetics and magnetic amplifiers; computer applications; special purpose devices and applications; "new frontiers" in the field. Exhibits will be displayed by 40 manufacturers selected for their contributions to the industry. For more information about the conference, write AIEE, 33 West 39th St., New York 18, N.Y.

Aug. 13-15: Conference on Electronic Standards and Measurements

NBS Boulder Labs., Boulder Colo. Sponsored by the Professional Group on Instrumentation of IRE, Electronic and High-Frequency Instruments Committee of AIEE, and the Radio Standards Lab. of the National Bureau of Standards. Six technical sessions will cover the following subjects: The Relationship of Standards to Physical Constants; Frequency and Time Interval Standards; Direct-Current and Low-Frequency Standards; Radio-Frequency Standards (Measurement of voltage, current, power, impedance, attenuation, phase shift, field strength); Microwave Standards (Measurement of power, impedance, attenuation, noise); and The Organization and Operation of Standards Laboratories. Write James F. Brockman, National Bureau of Standards, Boulder Labs., Boulder, Colo.

Aug. 13-15: 7th Annual Conference on Industrial Applications of X-Ray Analysis

Albany Hotel, Denver, Colo. Sponsored by University of Denver, Denver Research Institute,

Metallurgy Div. For additional information write William M. Mueller, Metallurgy Div., Denver Research Institute, University of Denver, Denver 10, Colo.

Aug. 19-22: Western Electronic Show and Convention

Los Angeles, Calif. Details will be announced later. For more information write Western Electronic Show and Convention, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 12-14: 7th Annual High Fidelity Show

Palmer House, Chicago, Ill. Write to International Sight and Sound Exposition, Inc., One N. La Salle St., Chicago 2, Ill., for further details.

Sept. 15-19: 13th Annual Instrument-Automation Conference and Exhibit

Philadelphia Convention Hall, Philadelphia, Pa. Sponsored by ISA. Two technical sessions on the use of instruments in the nuclear field will highlight the 5-day conference. Ask Fred J. Tabery, Conference and Exhibit Manager, 3443 S. Hill St., Los Angeles, Calif., for further information.

Sept. 22-24: National Symposium on Telemetering

Americana Hotel, Miami Beach, Fla. Sponsored by PGTRC of IRE. Ken West, 1345 Indian River Dr., Eau Gallie, Fla., has additional information about the symposium.

Sept. 24-25: 7th Annual Symposium on Industrial Electronics

Rackham Memorial Auditorium, Detroit, Mich. Co-sponsored by PGIE and AIEE. Address queries to William R. Thurston, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Courses—Seminars

Aug. 4-15: Summer Study Course in Microwave Theory and Technique. Case Institute of Technology, Cleveland, Ohio. The course will be directed toward the engineer in industry who has found a growing need for training in the methods of measuring and analyzing with microwaves. Requests for additional information on the course should be directed to the *Director of Special Programs, Case Institute of Technology, 10900 Euclid Ave., Cleveland 6, Ohio.*

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A report to Engineers and Scientists from Lockheed Missile Systems -- where expanding missile programs insure more promising careers

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Expanding research and development activities have coincided with acceleration on top priority programs like our Polaris IRBM, and Reconnaissance Satellite. At the same time, positions for qualified engineers and scientists have opened up that are unequalled in responsibility or in opportunities for moving ahead.

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Maurice Tucker, Aero-Thermodynamics Department Manager, right, discusses combined aero-thermodynamic re-entry body tests being conducted in Division's new "hot-shot" wind tunnel. Others are Dr. Jerome L. Fox, Assistant Department Manager, Thermodynamics, left, and Robert L. Nelson, Assistant Department Manager, Aerodynamics.

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July 9, 1958

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New, improved RCA-2N301 and RCA-2N301-A—now can provide an audio-frequency power output up to 5 watts in class A service at a mounting-flange temperature of 80°C—a significant increase (85%) over the original class A power output of 2.7 watts! These two units offer high reliability, high power efficiency, and low-distortion characteristics in power output stages of automobile radios, high-fidelity amplifiers, juke boxes, intercoms, PA systems, marine and mobile communications equipment, and electronic musical instruments.

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MAXIMUM RATINGS				TYPICAL OPERATION[A]		
				Class A Service		Class B Service
Type	Collector[A] Dissipation Watts	Peak Collector-to-Base Volts	Peak Collector Current Amperes	Max.-Sig. Power Output Watts	Power Gain db	Max.-Sig. Power Output (2 transistors) Watts
2N301	**11**	**—40**	**—3**	**5**	**33 at 5 watts**	**12**
2N301-A	**11**	**—60**	**—3**	**5**	**33 at 5 watts**	**12**
2N176	10	—40	—3	2	35.5	—
2N351	10	—40	—3	4	33.5	—
2N376	10	—40	—3	4	35	—

[A] At mounting-flange temperature of 80°C

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