ELECTRONIC DESIGN

ELECTRONIC DESIGN's Ninth Annual Transistor Data Chart (p 33) contains spe
tions for 1,714 transistor types--last year only 1,088 types were submitte
publication by semiconductor manufacturers. With close to a 60 per cent in
in the number of available types, the design engineer is now offered a gre
selection of devices as well as increased sources of supply--but his searc
for a transistor to do a certain job is likewise increased. Thus, ELECTRON
SIGN's unique listing, specifically tailored for the design engineer, shou
prove to be a handy time-saver. Contrary to existing lists which group tra
tors by manufacturer or in numerical sequence (fine for salesmen, of limit
to engineers), the 1961 Data Chart has transistors organized into six appl
categories: AUDIO--mostly general purpose types, under 1, listed in order
creasing forward-current transfer ratio. HIGH FREQUENCY--including types r
up to and above the vhf range and tabulated in order of increasing alpha-c
frequency. POWER DEVICES--transistors rated at 1 and above are listed in o
of increasing collector power dissipation. HIGH-LEVEL AND LOW-LEVEL SWITCH
devices intended for switching are listed in order of increasing alpha-cut
frequency. SPECIAL TYPES--low noise, high power/high frequency and other mi
laneous types are included. By this system of listing transistors, the des
engineer is offered a rapid method of selecting a particular type based on
meter value. In addition, close substitutes are apparent and multiple sour
of supply are listed when applicable. Only U.S. manufactured types are giv
One word of caution is included. Quite a few similar number types, made by
eral companies, were submitted with different characteristics due to the n
formity in test methods among manufacturers. The manufacturer whose data a
used for each particular type is listed under "Mfg." Other suppliers of th
types are found under "Remarks." Please take note that the company listed
MICROWAVES. . . p 129 "Mfg." is not necessarily the prime supplier, a chea
source or the original EIA registrant. The final choice of supplier is obv
up to the design engineer. It is thus advisable to use this listing as a

COVER: The introductory copy to ELECTRONIC DESIGN's Ninth Annual Transistor Data Chart makes an eye-catching typographical cover for this issue. For eye-filling details of transistors, consult the chart.

Sidelights of This Issue

Transistors . . . Transistors

Well, it's all there, bigger than ever and easy to use—ELECTRONIC DESIGN's Ninth Annual Transistor Data Chart, starting on p 33. Transistor types, in case you haven't guessed, are up 60 per cent this year. There are, we ruefully submit after more than three grueling months of counting and classifying, 1,714 types.

ED began its annual transistor chore early in April, when the first letters went out to manufacturers. The makers were asked to recheck their specifications on old types and furnish details on the new, if any. The rise over last year's total of 1,088 types became abundantly clear in due time. What wasn't so clear, though, was the difference in many cases between competitive types.

To make selection as easy as possible, we have organized all transistors into five basic types: audio, high-frequency, high-level switching, low-level switching and power. Then they are listed by the increasing value of the transistor's parameter.

Cash in on these valuable time-saving features when you select your transistors. And join us in a quiet "thank you" to our human data-processing machine, Miss Beverly Chesler. Beverly put in more than 150 hours collating the transistor data for you from companies over the nation. Don't mention "transistor" to her again this year.

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USE BEFORE AUGUST 16th, 1961

Name   Title

Company

Company Address   City   Zone   State

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
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601	611	621	631	641	651	661	671	681	691	701	711	721	731	741	751	761	771	781	791	801	811	821	831	841	851	861	871	881	891
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604	614	624	634	644	654	664	674	684	694	704	714	724	734	744	754	764	774	784	794	804	814	824	834	844	854	864	874	884	894
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609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899

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A New, Better ELECTRONIC DESIGN

We hope you noticed several physical improvements in the last issue of ELECTRONIC DESIGN. There were three that we are particularly proud of: (a) the strongest binding available in printing—indeed, the same type of binding used in the better paperback books (thus, *ED* can be maintained in good condition for the many readers using each copy); (b) improved type faces and layouts; and (c) better reproduction of illustrations.

These changes came about as a result of our switching printing operations to the midwest. Shifting printing to the central part of the country will also insure faster distribution of ELECTRONIC DESIGN.

Advertisers also get a new service coincident with our getting a new printer. A limited number of ads may be inserted only 12 days preceding the issue date, or three days before the magazine is mailed.

The late closing form will enable manufacturers to introduce new product advertising with minimum delay where such timing is critical.

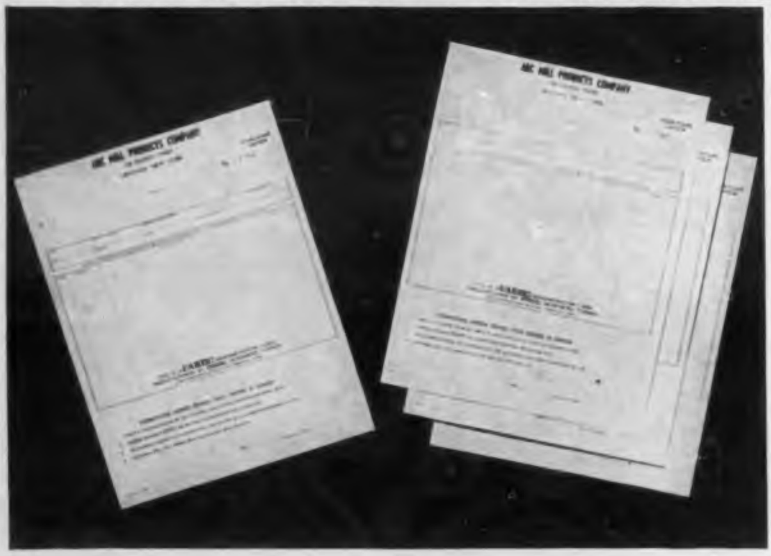
The switchover is not without its problems. The editorial department has to rely on airlines for daily messenger service. If a plane is grounded or "diverted" (that's a neat term to describe a crisis) as we approach press time we have to set copy and give make-up instructions via teletype. Fingers crossed, we hope we won't see crossed headlines.

The end result will be even more timely news reporting for design engineer readers.

Turn to page 6, for example, for a rundown on some of the top events at last week's Fifth National Conference on Military Electronics in Washington. On page 10 readers will find an even more timely report on two hardware-oriented developments discussed at an otherwise theoretically-oriented Joint Automatic Control Conference in Boulder, Col. This meeting was held last Wednesday through Friday, June 28 to 30.

As you read through the stories in the issue notice the easy readibility of the new type style used for text. We hope this will prove an added convenience to busy readers.

DRAFTING TRENDS



See how little difference can be noted between a nearly opaque original (left) and three fast, economical diazo copies (right) made with POST Super Vapo Black Paper.

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Cost is a key word in the consideration of any new product. POST Super Diazo Papers cost no more. Further, both large and small users will be quick to note that the combination of speed and economy basic to these new diazotype papers make them practical for longer runs—even 50 copies—and, less expensive than other duplicating methods often selected for such quantities.

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CONTENTS FOR JULY 5, 1961 VOL. 9 NUMBER 14

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Coming Next Issue

The interest of the electronics industry will soon be centered on San Francisco's Cow Palace. For the duration of WESCON, Aug. 21 to Aug. 24, manufacturers will proudly display their wares for evaluation and approval.

To assist visiting engineers in making the all-important decision of what to see first, the WESCON, Aug. 2, issue of ELECTRONIC DESIGN will feature the products to be introduced for the first time. For convenience in locating these items, booth numbers will accompany the product descriptions.

A trend survey, conducted by the editors of ELECTRONIC DESIGN, covering recent, present and future product developments will be a highlight of the issue. Don't miss it.

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ELECTRONIC DESIGN
NEWS

Laminar Devices Key Superconductivity Push

Laminating Films to Control Transistion Temperature Among Successes Reported at Top Research Meeting

Alan Corneretto
News Editor

RESEARCHERS trying to exploit superconductivity have developed a technique with high promise for designers: combining normally nonsuperconductive metallic thin films with superconductive ones and achieving superconductivity in the entire assembly.

Such devices have been made by superimposing thin films of superconductive lead and normally nonsuperconductive silver. Because the films become superconductive at temperatures dependent on film thickness, multilayered devices are foreseen in which different layers would become superconductive at different predetermined cryogenic temperatures.

The development was among recent successes reported at a conference on fundamental research in superconductivity held June 15-17 at the International Business Machines research center, Yorktown Heights, N. Y. It reflected a growing interest in the field.

Two reasons are given for the spurt in interest. One is the discovery last year of tunneling in superconductive thin films (*ED*, Dec. 7, 1960, p 4), and the other the recent development of materials that remain superconductive in high magnetic fields.

Present superconductive thin-film devices are made either of naturally superconductive metals, which are limited in number, or of difficult-to-process alloys. The new combination, or laminar, technique is expected to make it easier to tailor the transition temperatures of superconducting films than former methods permitted.

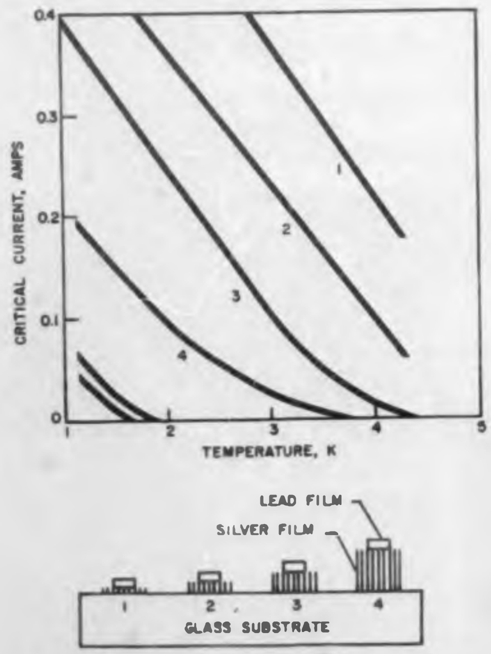
P. H. Smith of Arthur D. Little, Inc. (ADL), Cambridge, Mass., delivered a jointly authored paper on the process at the Yorktown Heights conference. Substantially the same reports appear in the June 15, 1961, issue of *Physical Review Letters*, published by the American Physical Society. Similar work has been done by Dr. Hans Meissner at the Stevens Institute of Technology.

Both Dr. James Nicol, one of the authors of the ADL paper, and Dr. Meissner, report that the two films—normal and superconducting—must be in intimate contact with each other before the effect can be achieved. At both organizations one film is deposited immediately after the other while the original vacuum is maintained. The reasons for the phenomenon are not completely understood at present.

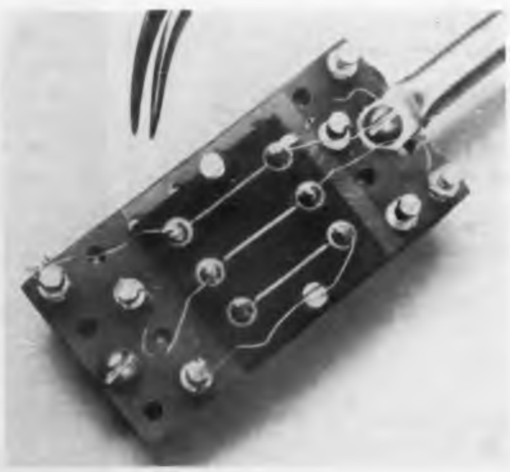
ADL reports that it has constructed devices by superimposing a film of one material between two films of the other, and by depositing one film on the other in an open-sandwich construction. It calls the resulting devices laminar superconductors. At the conference, Mr. Smith reported that the assembly of two metals in contact behaves as a unit having its own characteristic superconducting properties.

Films worked with at ADL measure from 500 to 10,000 A thick, he says. Typically they are made by superimposing along the length of a 10-by-0.3-mm silver film a longer lead film 0.15 mm wide. Electrical connections are soldered to the ends of the lead film. A glass substrate with lead, tin and normally nonsuperconductive gold and silver have been used.

Addition of the silver is said to reduce the transition temperature of the assembly below that of lead alone. In one sample, a tran-



Characteristics of combined superconducting and normal films are dependent on thickness of films, implying devices may be made that would become superconductive at predetermined cryogenic temperatures. Curves are for configurations shown under graph. Two curves at lower left resulted from a structure different from others shown. This work was done at Arthur D. Little, Inc.



Three laminar superconductors are formed by deposition of thin-film lead strips on wider and thicker thin-film strips of silver. Intimate superposition of strips makes normal silver become superconductive at proper cryogenic temperature. In these three separate samples on glass substrate, the lead film is about 500 A thick, and the silver films vary from about 1,000 to 5,000 A. Electrodes facilitate measurements.

sition temperature of 1.87 K was reportedly measured. Normally, lead has a transition temperature of 7.2 K, according to ADL.

Several samples can be deposited simultaneously on the same substrate. The superconductive effects appear to be unchanged by the type of construction used or the sequence of deposition of metals, says ADL.

According to Dr. Nicol, the phenomenon apparently can be harnessed to tailor the temperature at which a device will become superconductive. Another advantage he cites for the technique is that the pure metals involved are easier to work with than alloys, which may be relatively hard to vacuum-deposit.

Meeting Hears Evidence Backing Theories Of Bardeen, Cooper and Schrieffer

Many of the papers delivered at the conference reported work that supported the various theories of Professors Bardeen, Cooper and Schrieffer on the nature of superconductivity. The existence of energy gaps in superconductors, the dependence of the gaps on temperature position and field strength, and the possibly paired nature of electrons in superconductive materials were all discussed at the meeting, which was attended by virtually all the top superconductivity experts in the Western countries.

One of the highlights of the conference was a report by Dr. Naebauer, of Herrsching, Germany, on the measurement, for the first time, of the flux quantization unit in a superconducting ring. The unit was given as 4×10^{-7} gauss cm^2. The measurement, which constitutes one of the few direct observations of a quantum effect, supports the theoretical prediction that flux in a superconducting ring occurs in discrete units. The fact that the units are discrete was said to raise the possibility that devices may be built eventually in which the quantized nature of flux in a superconducting ring may be harnessed to count or to transduce.

Also at the conference, J. E. Kunzler, Bell Telephone Laboratories, reported that ductile alloys of niobium-zirconium appear to be the most promising superconductive materials for magnets with field strengths in the 80-to-100-kilogauss range, while the characteristics of niobium-three tin in wire-like form appear to be suitable for fields of at least 200 kilogauss.

Dr. Kunzler added that the prospects for material with electrical and magnetic characteristics capable of still higher fields appear bright. ■ ■

NEWS

2.2-Gc Transmitter Due for Telemetry

Details Are Described at Mil-E-Con Along With Data on High-G System

DETAILS of one of the first transmitters under development for the new 2.2-Gc telemetry band were disclosed last week in Washington, D. C., at the Fifth National Convention on Military Electronics (Mil-E-Con). Also described were a high-g telemetry system said to be capable of withstanding accelerative forces of more than 150,000 g.

The transmitter, designed by Radiation, Inc., of Melbourne, Fla., will contain only solid-state components and a voltage-tunable magnetron. The device is intended for use in satellites, where it is to transmit simultaneously a number of phase-coherent carriers for a special measurement program.

Typical power output is to be 10 w for a 33-w anode power input. The transmitter will weigh 40 lb and measure approximately 17-1/2 by 8 by 5-3/4 in.

Because the magnetron must generate discrete, phase-coherent carriers, its anode voltage will be modulated by a vhf power amplifier. The frequency of this all-solid-state stage will determine the frequency separation between the carriers. Thus, says Radiation, Inc., modulation of the anode voltage will provide a frequency modulation of the magnetron center frequency. A phase-lock servo loop will provide frequency stabilization.

Magnetron Amplifier to Have Efficiency of More Than 40 Per Cent

The amplifier that will provide power to modulate the magnetron will have an efficiency of more than 40 per cent, according to the company. It will be driven by a vhf crystal oscillator. Power will be supplied by a separate package in which magnetic amplifiers and regulating circuitry are to produce efficiencies ranging from 69 to 81 per cent for input voltages ranging from 30 to 22 v, respectively. The magnetron supply voltage of 2,000 v is to be regulated over 0.2 per cent from 0 to 75 C.

Use of the 2.2-Gc telemetry band is expected to produce more stable frequencies for space communications than the 216-235-mc band now being used.

High-G Telemetry System To Aid Projectile Speed Study

The high-g telemetry system described at the Mil-E-Con meeting is intended to aid study of the ionized shock layer generated by projectiles traveling at hyper velocities.

The airborne portion of the system is packaged as a 1.5-lb projectile and is designed to be fired down an instrumented range into an oncoming narrow uhf beam transmitted at 8.5 and 11 Gc. A video crystal detector in the package receives the pulsed signal, which, after amplification frequency, modulates a 60-mc oscillator in proportion to the amplitude of the incoming signal. A 60-mc signal is then telemetered via diplexed antennas through the solid metal shell of the projectile to range receivers.

The project, described by Essad Tahan of Sylvania Electronics Systems, Waltham, Mass., is being conducted as a joint effort of Sylvania and the Canadian Armament Research and Development Establishment.

To withstand 150,000 g's for several milliseconds, the telemetry package contains special components. Transistor cases were opened up and filled with an epoxy resin, a special microwave diode had to be developed, and the entire assembly had to be potted and reinforced in a glass-cloth laminate.

Microminiature Timer for Arming Programs Uses Micram Technique to Handle 370 W

Among the equipment on display was a 14-oz digital arming program timer designed by Diamond Ordnance Fuze Laboratories, Washington, D.C. It was said to be the first operating device using the Micram microminiature packaging technique developed by Cleveland Metal Specialities Co., Cleveland, in cooperation with several large electronic companies. In this technique standard microminiature parts are densely packed on photoetched circuitry. The timer shown was said to be packed to a density equivalent to 300,000 components per cu ft.

The modularized unit, intended for use in missiles, includes a clock, timer, and readout and switching sections. It is said to have no moving parts. The clock uses a 24-point, 8-kc quartz-crystal oscillator having a 10-cps output and an accuracy of 10 msec.

Aggregate power-handling capacity of the power-switching circuitry of the timer is 370 w says Cleveland Metal, which built the unit for DOFL. The company reports that the unit has been test flown successfully. It was developed under the Copperhead program. Cost of the unit is said to be in the $750-1,000 range. ■ ■

RFI Studies Leading to Important Design Shifts

New Requirements to Bar Square Pulse Modulation For Radar; Stiffen Other Equipment Requirements

RADICALLY new designs for radar and other military equipment will be demanded soon by the Defense Dept. in the light of its attack on radio frequency interference. The new specifications will eliminate in future equipment rectangular-pulse modulation of radar and many present antenna designs.

This was disclosed at the Third Annual Symposium on Radio Frequency Interference in Washington, D. C.

First set of specifications to near completion is a revised radar standard prepared by the Joint Frequency Allocation Board of the Joint Chiefs of Staff. Sufficient data for composing a tight, practical standard have already been gathered. The requirements of the standard will reflect latest state-of-the-art techniques and component designs.

The standard will specify stricter control of radar fundamental frequencies and improved selectivity, dynamic range, sensitivity of radar receivers. It will also re-

'Thermal Circuit' Removes Heat in Miniature Modules

HINTS on how to design "thermal circuits" which represent solid-state (no fans) solutions to heat removal in miniature module packaging were given in a paper presented before the IRE Production Group, June 14 and 15 in Philadelphia.

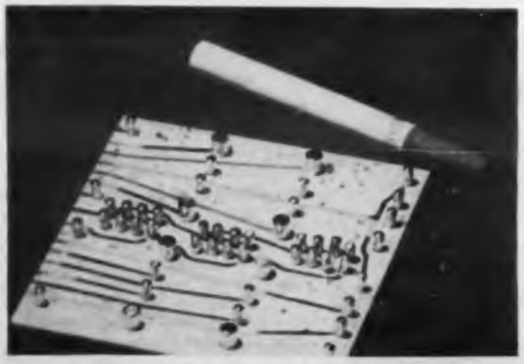
The paper explained how miniature circuit modules had been mounted on a heat-conductive ceramic board which provided an efficient heat removal path from the modules to a heat sink. The concept behind this type of packaging according to the paper is that with extreme miniaturization the designer may have to pay as much attention to the thermal "circuits" as he has in the past paid to the electrical ones.

The authors, Gerald Kriss and Louis Polaski of General Electric Co.'s Space Vehicle Dept., Philadelphia, showed how their design used the thermally conductive but electrically insulating ceramic board to integrate the heat removal, circuit interconnection, and module support functions into one solution. In a space vehicle application they said that the board would be attached to the side of the vehicle.

A beryllium oxide ceramic board was chosen for its known combination of high thermal and low electrical conductivity. Kovar studs were inserted into the 0.06-in thick board to transfer module lead heat and provide electrical connections from the module to the board's circuits. The board's circuits consisted of moly-manganese screened on and fired then copper plated. Electrically oversized 0.06-in. module lead wires were used to carry out part of the heat.

The modules themselves were epoxy-potted in two stages. First, a high thermal conductivity silver-flake-loaded epoxy was used around the transistor cases (which were purposely located close to the board for shortest thermal exit path of their heat). Then a less thermally conductive but more electrically insulative alumina-loaded epoxy was used for the rest of the module.

The authors pointed out that ceramic boards of this type might be the only solution for rf or high-voltage microcircuits where proximity to conventional metallic heat removal surfaces cannot be tolerated. ■ ■



Beryllium oxide board 3-in. square by 0.06-in. thick was used for the thermal link between the modules and the heat sink which would be clamped on one edge. Kovar studs were weld points for the module leads of nickel-plated copper.

Slice through module shows how two heat flow exit paths are provided out of module. The transistors are embedded in a high-thermal-conductivity silver-flake-loaded epoxy (lighter color) which is later epoxy-bonded to the ceramic board. Also, the leads are extra thick to conduct heat out to the Kovar studs.

Modules assembled on ceramic board. Thermocouples at hot and cold spots of modules showed that the board provided as good a thermal conduction path between the modules and heat sink (not shown) as if the modules were attached directly to the heat sink. Transistor case—heat sink drops were 6 to 8 F.

quire reduction of out-of-band modulation components and will place limits on frequency emissions.

To meet these requirements certain changes in design will have to be made. Thus, there will be a decrasing use of magnetrons, particularly at lower frequencies. It is anticipated that klystrons will be used in their place.

Rectangular pulses will no longer be permitted for radar modulation. Instead, there will be a shift to sine-cosine, $\cos^2$ or gaussian pulses which do not cause emissions remote from the fundamental.

Antennas will have to be constructed with greater precision in order to limit off-frequency responses, spill-over, backside emission, etc. Also, there will be a need for high-power waveguide and transmission line filters to limit the transmitter emission to the tightly specified frequency bands, and in addition to limit receiver susceptibility.

Also disclosed at the Symposium was the progress made in the Department of Defense's Electromagnetic Compatibility Program. The major effort of the Program is currently devoted to establishing a Joint Analysis and Prediction Center in Annapolis, Md. This Center, being organized by the Armour Research Foundation, is charged with devising methods for predicting the electromagnetic environment at given geographic areas. To do this it will need data on environmental conditions and equipment emission characteristics (spectrum signatures).

A first test of the possibilities of prediction will be made in the San Diego area, one of the worst areas for electromagnetic interference in the country according to RFI specialists. Environmental data for the area have already been collected. Most of the spectrum signatures are, however, still to be gathered.

Armour is currently selecting a mathematical model for the project. Several models are being reviewed, including ones developed by Melpar, AMF, Georgia Tech, and Jansky and Bailey. Also yet to be chosen is the computer in which the information will be processed. Both the STRETCH and IBM 7090 units are said to be under consideration.

It is anticipated that data will be collected by February of 1962, and the processing can begin. The Analysis and Prediction Center at Annapolis will be ready for occupancy by January of that year. ■ ■

CIRCLE 9 ON READER-SERVICE CARD ➤

NEWS

Two Advances Cited At Automation Parley

Digital Speed-Control System And Lightweight Motor Outlined

Robert Cushman
Technical Editor

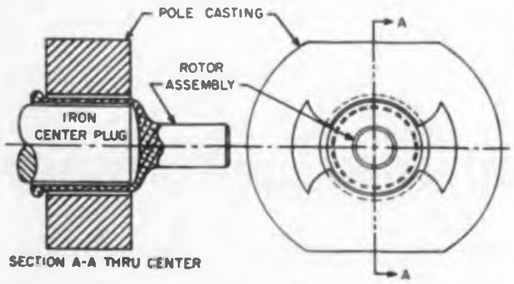
TWO PRACTICAL developments were described last week in Boulder, Colo., at the otherwise highly theoretical Joint Automatic Control Conference: a computer-compatible digital speed servo and a very light, compact, powerful motor.

The digital speed-control system has been developed by Westinghouse Electric Corp. for large industrial process drives, such as those used in papermaking. It was explained that in papermaking not only is 0.1 per cent regulation desired for each drive but also, with the paper strips being driven through the mill at 3,000 ft per min by a 4,000-hp system, it is important to be able to synchronize the speeds of all the drive motors along the process.

The digital speed servo has both position and speed loops. It includes all the features normally associated with analog servos, such as time-limit acceleration and vernier speed adjustment. Therefore it can be used directly in place of existing analog systems, Westinghouse says.

As might be expected, pulse rates from a master crystal reference are compared with feedback pulse rates from a digital tachometer connected to the output drive. A coincidence canceler had to be added to prevent ambiguity when pulses arrive at the same time.

Under steady operating conditions all of the control signal is provided by the position loop error. The position loop integrates the feedback and reference pulses from the coincidence pulse canceler by feeding them into the up and down lines of a high-speed reversible binary counter. The level of this counter is then determined by the respective pulse rates between reference and feedback, going up for one and down for the other. This level is then converted into an analog current level by a weighted decoder, and the level of this current is used to



Highly efficient dc motor design is expected to produce 7-1/2 hp inside a 5-in. diam and with a weight of only 11 lb. Commutation would be by silicon-controlled rectifiers mounted in rotor and switched optically by phototransistors.

drive the power amplifier.

The speed loop, on the other hand, operates on the difference of the pulse rates. Pulses from the reference and feedback lines are made to cancel each other alternately.

Part of the significance of this type of system, according to Westinghouse, is that it facilitates digital computer control of large industrial processes.

The very lightweight, compact motor is a dc actuator, designed as a replacement for hydraulic actuators on missiles. The motor, said to be equally as efficient but more reliable than its hydraulic counterpart, was described by Prof. George C. Newton and R. W. Rasche of the Massachusetts Institute of Technology.

The design, which so far is only on paper, indicates a power rate of 550 kw per sec (7-1/2 hp) with a 5-in.-diam motor weighing only 11 lb. It will therefore be competitive with hydraulic actuators for missile applications, the authors contend. Hydraulic actuators have so far been much more powerful and efficient than any electric actuator, but they are less reliable because of their susceptibility to dirt.

The key to the MIT improvement is a highly efficient molded aluminum-epoxy-fiberglass rotor with integral conductors. It would be molded as a hollow shell and supported at one end, so that a ferromagnetic plug could be used inside the rotor to increase the flux. The rotor would be evaporatively cooled by a sprayed freon fog.

Other papers at the conference covered most of the topics of current interest to theoreticians in the automatic control field: optimization schemes including "cost" feedback loops, adaptive techniques, nonlinear control and statistical control.

The conference was held last Wednesday through Friday, June 28-30. ■ ■

Hot TV Cooled Thermoelectrically

Westinghouse Units Improve Operation of Vidicon Tube In Closed-Circuit System at Steel Plant Soaking Pits

Thermoelectrically cooled television camera (with front cover removed). At top are the heat-radiating fins of the cooling elements, which enclose the vidicon. Motors and pulleys at the bottom control the focus and aperture of the lens.

Cooling element consists of three Westinghouse WX-814 bismuth telluride units connected in series. Note common hot and cold plates and single set of input terminals.

THERMOELECTRIC coolers improve performance of the vidicon tube in a closed-circuit television system that monitors the operation of cranes at a steel mill.

Operating in a 140-F ambient, three Westinghouse WX-814 coolers, with a total cooling capacity of 5 w, maintain the 7735 vidicon at 90 F and dissipate heat generated by filaments and deflection and focus coils. Without this cooling, operation of the temperature-sensitive tube would be marginal.

The television system was built by General Precision Laboratory, Pleasantville, N.Y., for soaking pits at a large steel mill.

Because of the high ambient temperature and the camera's remote location (at the end of a traveling crane), thermoelectric elements were selected as the most practical cooling method.

"We couldn't use forced air at 140 F for cooling, and losses in long piping runs would have required about 250 w of mechanical refrigeration for the job," explained Murray Altman, designer of the camera. "Instead we provide the cooling directly at the point of use."

The three thermoelectric units, strapped together to provide common hot and cold junctions, draw about 16 amp and are 50 per cent efficient.

Reliable Operation Is Essential Because of Camera's Inaccessibility

The rest of the camera, however, is cooled by forced air at 140 F and operates at 160 F. Reliable operation despite elevated temperatures is particularly important because of the camera's relatively inaccessible location and a need for maintaining uninterrupted three-shift operation at the mill.

Much of the circuitry normally contained in a television camera was moved to more accessible boxes elsewhere on the crane. Only a 10-mc video preamp strip was retained in the camera. Frame grid tubes, tantalum

Interior of camera. Left to right: aperture and focus controls, 10-mc video preamp strip, and vidicon tube enclosed within the thermoelectric coolers.

capacitors and military components rated for 125 C service are used throughout. Modular construction is employed to speed maintenance.

The camera also includes motor-driven focusing and lens-aperture controls. The aperture controls respond automatically to the video signal level and adjust the lens diaphragm and vidicon target voltage to accommodate an illumination range of more than 20,000 to 1. This readily covers the brightness range encountered between the white-hot soaking pit and the rest of the mill.

Other components of the television system, including the camera control unit, power supplies and voltage regulators are also designed for high-temperature operation. About one-third of the circuitry, including the synchronizing generator and portions of the power supply, are transistorized. Silicon units are specified.

The control unit is enclosed in a watertight case to exclude the ultrafine steel dust emanating from the soaking pits. Cooling is by means of a heat exchanger employing ambient air at 140 F.

Video signals are transmitted from the mobile crane to monitor viewers by slotted line and antenna probe arrangement.

Five of these television systems have been delivered by General Precision Laboratory. Initial units already installed are reported to be operating around the clock for several months between servicing. ■ ■

NEWS

Foxboro Ends Exclusive Pact With RCA for Control Systems

Foxboro Co. of Foxboro, Mass., has severed its exclusive arrangement with Radio Corp. of America for joint development of industrial computer-control systems. The decision was announced in a statement that Foxboro has sent to its customers.

Foxboro, an instrumentation manufacturer, said it had become "sobered" by the many large technical and economic roadblocks to computer control of industrial processes. The company had been cooperating with RCA's Industrial Computer Div. in nearby Needham, Mass.

Now, Foxboro says, it will be freer to pursue more immediate, smaller-scale analog computer solutions to industrial automation.

Another reason for the Foxboro move, industry sources speculate, is that the company will now be in a position to sell its "sub-loop" equipment to other digital process-control computer manufacturers.

New National Group to Study Business Data Processing

A National Committee for Business Data-Processing is being formed under the sponsership of the Association for Computer Machinery. Its fields of interest will include business theory, operations research, management gaming, simulation and forecasting techniques, as well as the more usual business data-processing functions.

The association said that the formal organization of the committee would be completed at its September meeting in Los Angeles.

Mobile Ground Surveillance Radar Will Be Modified AN/TPS-25

The Army's first mobile radar set for ground surveillance is under development by Hazeltine Corp. as a modification of the shelter-housed AN/TPS-25 set now in operational use.

Conversion of the Hazeltine-built AN/TPS-25 for use on tracked amphibious armored personnel carriers will involve three alterations: replacement of fixed antenna by a 25-ft telescoping antenna mast for "quick look" capability at longer range; a smaller plotting board; and addition of an ac to dc converter for the 115-v, 400-cycle, gas-driven power unit.

The telescopic antenna will enable the set to detect moving targets at a range of more than 11 miles. At closer range, the set has the capability of distinguishing between the walk of a man and a woman up to a mile away.

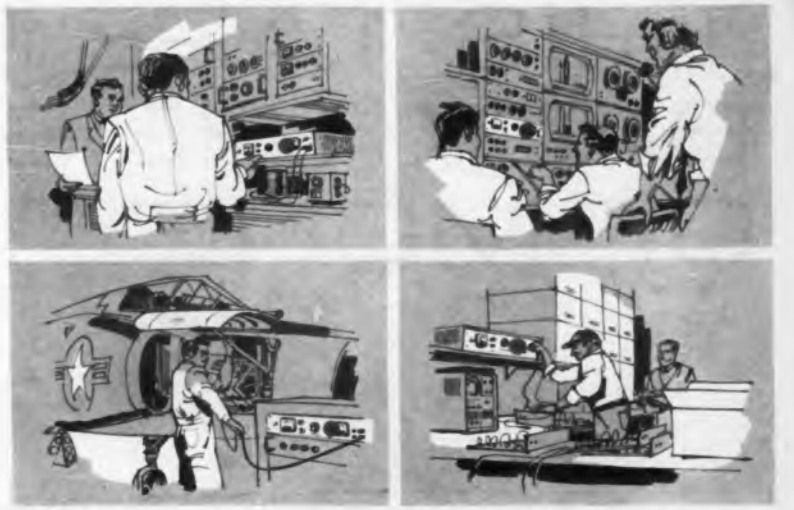
Device Measures Blood Volume With Improved Speed and Accuracy

A new instrument, the Volemetron, measures blood volume—or the volume of plasma or red cells—quickly and accurately. Regarded as a boon to surgeons, the instrument obviates the usual guess-work as well as the inaccurate method of weighing blood-soaked sponges (which does not account for blood on the patient or on the drapes).

Accurate to within 5 per cent, this transistorized product of Atomium Corp., a Waltham, Mass., affiliate of Perkin-Elmer Corp., uses well-known dilution-monitoring techniques. A measured amount of radioactive iodine is injected into the blood and allowed to circulate for a few minutes. After it is diluted in the blood stream, a sample of the isotope-diluted blood is placed in the Volemetron. A calibrated meter shows the blood volume in about a minute.

The instrument should help surgeons avoid the dangers of over or under-replacement of lost blood. While the Volemetron can be used by relatively unskilled personnel, earlier isotope-dilution measurements required highly skilled personnel with very complex instrumentation. The instruments were normally located in laboratories remote from operating rooms.

Transistorized digital circuitry counts output of scintillation counter which gives indication of radioactivity in patient's blood sample. Accurate measurements are first made of background radiation in patient's blood before he receives injection of measured dose of radioactive iodine.



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Transistorized digital circuitry counts output of scintillation counter which gives indication of radioactivity in patient's blood sample. Accurate measurements are first made of background radiation in patient's blood before he receives injection of measured dose of radioactive iodine.

NEWS

Styrofoam Antenna Can Be Built on Site

New Radar Dish Reported to Weigh Fifth as Much as Metal Parabolics

A LIGHTWEIGHT radar antenna of styrofoam planks is designed to be machined and assembled directly at the radar site.

It is, its developer says, only one-fifth the weight of metal parabolic dishes. Transportability and lightness are further enhanced by a novel antenna positioning device that employs a series of hydraulic jacks to steer the antenna.

The new dish was developed by Sylvania's Electronic Defense Laboratories of Mountain View, Calif. To construct it, one joins styrofoam planks into an egg-crate structure using urethane foamed-in-place seams. A computer-controlled milling machine, designed by Sylvania then automatically machines the reflector to the desired shape. For high-precision reflectors, a solid layer is first foamed-in-place over the cellular structure.

The reflective surface is then machined from this layer and is metalized by application of aluminum foil or copper mesh. A final layer of foam is then applied to protect the reflective surface and to receive the mounting plate.

Milling Maching Also Shapes Front End of the Antenna

The front of the antenna is also contoured by the milling machine. This provides a slight amount of beam focusing, but, more important, it streamlines the antenna to reduce wind drag by as much as two-thirds over conventional parabolic reflectors, the company says.

The feed system is buried in the foam for rigid support. The outer surface is then covered with a white fiber-glass skin for weather-proofing and to minimize solar heating.

The computer-controlled milling machine that shapes the antenna consists of lightweight, readily disassemblable parts that can be conveniently transported to the fabrication site. Antennas up to 20 ft in diameter can be fabricated with the present machine. Equipment and techniques to make antennas up to 50 ft across are being developed.

Foam antenna is examined by its developer, Mack Suliteanu, engineer at Sylvania's Electronic Defense Laboratories. Semi-transparent fiber-glass mesh covering the face of the antenna forms a base for a subsequently applied outer plastic coating. Note feed horn buried in the foam. The antenna is supported by a series of hydraulic jacks that can be programed to impart any desired tracking motion to the antenna.

The computer itself is an analog instrument, programed to fabricate a given contour by inserting pre-calculated constants into a series of potentiometers.

A hydraulic positioning system replaces the conventional system of mounting rings, bearings and driving motors. The antenna is supported by four tripods, each consisting of three hydraulic jacks. Programed changes in the length of each leg, controlled by a digital computer and hydraulic servo steer the antenna through any desired search or track pattern.

Operation of the positioning system has been confirmed by manual programing, but the computer required for automatic operation is still in development.

This arrangement results in an unusual antenna motion. In a 360-deg horizon search, for example, the antenna rolls on its edge through a full circle. In overhead tracking, the reflector merely flips over between opposite horizons.

The hydraulic positioner is "much faster" than conventional antenna drives, according to a Sylvania spokesman. This is due to the inherently fast response of the hydraulic system and to the reduced inertial and gyrating loads of the foam antenna with its unusual rolling motion.

The antenna and positioning system were developed under a contract from the Army Signal Corps. ■ ■

NEWS

Nationwide Data Loop Speeds Airline Work

1,000-Station Centralized System Uses Both Fast and Slow Bit Rates

A NATIONWIDE data-processing loop linking all ticket agents of United Air Lines to a central computer has been put into operation.

The loop has:

- A main trunk in which the data are transmitted at 1,000 bits per sec.
- Secondary lines, which feed into the main trunk at 75 bits per sec. Once the information reaches the main trunk, however, it is speeded to 1,000 bits per sec.

The system handles flight reservations from 1,000 stations around the country to a central processing terminal in Denver. Agents in major cities—about 80 per cent of all the agents—are linked directly to the fast trunk, and those in smaller cities to the slower lines. Use of the slower lines permits a considerable savings in operating costs.

The loop, called Instamatic, was designed for United Air Lines by the Teleregister Corp. of Stamford, Conn. Data communication equipment was constructed by North American Philips Co., Inc., of New York City.

Central Units Include Trunk Terminal, Computer and Memory

The electronic equipment in the system includes a Central Trunk Terminal in Denver and a series of concentrators along two loops running east and west from Denver. Each loop is composed of two telephone trunk lines that carry traffic at the rate of 1,000 bits per sec in opposite directions.

A central processing computer and memory storage unit is also in Denver.

The central terminal links the trunk lines with the processor. Equipment at the terminal regulates information going into and out of the computer, handles the reception and transmission of traffic through the trunk lines, and detects errors in messages by applying horizontal and vertical parity checks.

Messages concerning such information as availability of space on a certain flight are generated and received at agent sets. These

Map of western portion of Instamatic flight-reservation network shows (1) Concentrator, (2) High-speed trunk line, (3) Low-speed line, (4) Distant Central Office Transceiver, (5) Keyset Multiple Selector, and (6) Agent set.

sets also contain printing units on which reservation confirmation information and cancellations are printed.

At the concentrators, messages are handled and operations carried out at the rate of 54,000 per hr, Philips says. The concentrators along the trunk lines continually read the addresses of all messages passing through the circuit, determining whether they are for agent sets under their control or are to be forwarded. And they check them for errors.

11 Switching to Spare Unit Possible in Case of Failure

Concentrators also answer test and supervisory messages from the control center in Denver. Finally, if necessary, they can switch traffic to a spare unit should there be a mechanical or electrical failure.

Theoretically ticket agents can receive information about the availability of seats on a given flight up to a year in advance. The average elapsed time from the moment an agent on the main trunk sends the question until he receives an answer from the central terminal is 1 sec. Response time on the secondary lines is slightly longer, owing to the time lag in storage and retransmission. Here it is about 5-1/2 sec.

Engineers have included in the system provisions for redesign and the addition of other services. These could include maintenance of passenger records, fare computations, flight-crew schedules, and anything else to insure a high operational speed. ■ ■

Twofold Rise Seen In Consumer Sales

Executive Predicts an Industry Volume of $21 Billion by 1970

CONSUMER electronic sales will double in the next decade—from $10.2 billion last year to $21 billion by 1970—W. Walter Watts, chairman of RCA Sales Corp., told the June 19-20 Chicago Spring Conference on Broadcast and TV Receivers.

Among the new products to be offered in the near future, he said, are multiplex adapters to receive the newly approved fm stereo broadcasts. More than 75 per cent of present fm stations have indicated they will be broadcasting stereo within a year or two.

Color TV, in which RCA pioneered, for many years, Mr. Watts said, is now included in the marketing plans of almost all major TV manufacturers. Closed-circuit TV for industrial uses and educational TV offer additional sales areas for the TV-set supplier, he added.

Other prospects listed by the electronic executive included transistorized TV sets, electronic air-conditioners and home video-tape recorders. These await clever ideas by design engineers, he said.

Various approaches to the design of multiplex adapters were discussed at the conference. Major manufacturers are ready to supply adapters that are either self-powered or obtain power from the basic fm tuner or amplifier chassis, it was indicated. Several one-tube and two-tube schemes have been devised, it was brought out, but most manufacturers prefer to field-test their units rather than risk consumer drop in interest following hasty, premature product delivery.

The radio-TV industry has long awaited

Table 1. Per Cent Tube Failures by Year and by Circuit Application

Circuit	July to July Test					
	1954 1955	1955 1956	1956 1957	1957 1958	1958 1959	1959 1960
Horiz. Defl. Amp.	25	34	17	10	10	5
Vert. Defl. Amp.	25	29	16	3	5	1
Damper	33	17	9	15	9	15
VHF Amp.	22	18	7	12	10	5
UHF Osc.	—	—	—	14.6	7.4	12.4

Table 2. Per Cent Tube Failure By Cause and Year

Cause	1955	1956	1957	1958	1959	1960
Open Heater	1.86	1.775	1.025	1.17	0.73	0.725
Shorts	2.02	1.17	1.19	0.935	1.08	0.83
Arcing	—	0.72	0.22	0.56	0.34	0.76
Gas	1.50	0.82	0.29	0.14	0	0
Other (20 items)	1.35	1.37	1.20	1.5	1.45	1.3

stereo fm approval as a boom to a saturated and dropping TV market, conferees said privately. Pessimists were wary of rushing into production and delivery without adequate field experience.

Strides in receiving tube reliability were outlined by a company applications engineer, E. H. Boden. In 1954, he said, Sylvania began a reliability study TV receiver tubes. The tubes were operated in various manufacturers' sets under 130-v ac input for 50 min, turned off for 10 min and then turned on again. This cycle was repeated each hour for 1,500 hr. Mr. Boden noted that 59 per cent of the tube failures occurred in five circuits: horizontal-output, damper, vertical-deflection-amplifier, rf-amplifier and uhf-oscillator.

From 1955 to 1960, he said, horizontal-amplifier failure was reduced from 34 per cent to 5; vertical-amplifier from 29 per cent to 1, and rf-amplifier from 22 to 5 per cent (see Table 1 and 2). Tubes exhibiting no failure after 1500 hr at 130-v ac cycling, increased from 38.5 to 72.5 per cent. From tests comparing the life of single and double-section tubes used in similar applications, Mr. Boden reported, Sylvania concluded that no serious difference in reliability was noted. ■ ■

Pigeon Wired for VHF Tracking

Miniature vhf transmitter riding piggyback on this homing pigeon was used to track the bird for 25 miles. The 140-mc, crystal-controlled transmitter, powered by four mercury cells, delivers about 1 mw to a modified half-wave dipole antenna. The 5-oz transmitter package was developed by American Electronics Laboratories for an animal homing instinct study of the Office of Naval Research.

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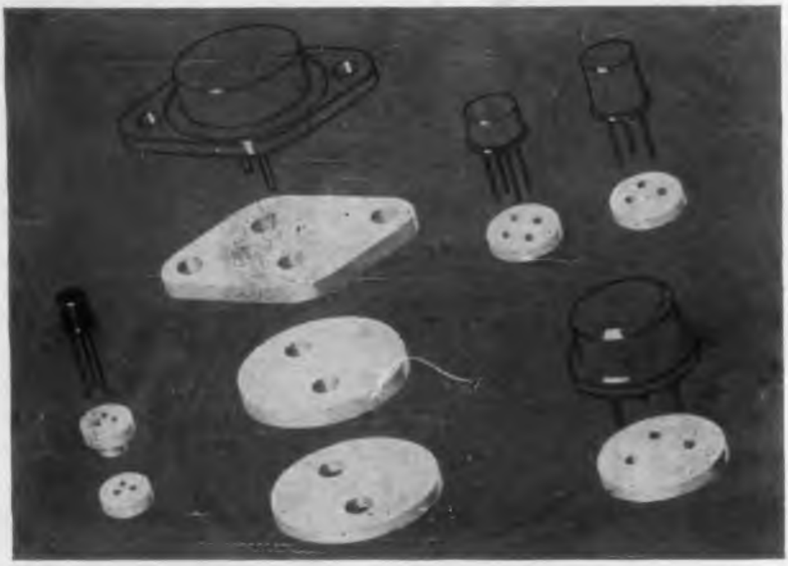

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MECHANICAL PROPERTIES

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DIELECTRIC PROPERTIES

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Dielectric Loss Tangent 1 mc less than .0005, 10 mc less than .0005, 8500 mc .0008

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CIRCLE 22 ON READER-SERVICE CARD

WASHINGTON REPORT

John J. Christie
Washington Editor

A PREMIUM ON SPACE TALENT

The proposed all-out acceleration of the National Space Program puts NASA in the market for a wide range of professional and technical skills. Of particular concern to the agency is its need for personnel to fill key professional and administrative posts, carrying responsibilities for which industry is willing to pay from 25 to 100 per cent higher salaries.

NASA is now seeking a bigger allotment of grades eligible for salaries above the ceiling for career Government service. Its present authorization is for 290 such positions at salaries up to $19,000, with 17 of them earmarked for a special top bracket of $21,000. The agency has requested Congress to authorize 135 more "excepted" positions for a total of 425, of which 30 would be in line for the $21,000 maximum. In order to hold key personnel, NASA would reserve some of the new salary authorizations for its present staff. But, many of the new posts would have to be filled from the outside.

The agency is currently engaged in a recruiting drive to fill some 500 jobs ranging from technicians to experienced scientists. Its campaign has included the college campuses, where last year NASA representatives interviewed 3,000 grads in competition with industry's talent scouts. In fiscal '62 a 4,000 increase in personnel is projected.

Industry's Space Work Load will increase sharply along with NASA'S, if, as seems likely, Congress goes along with the President's recommendation that the nation mount a crash program to gain undisputed leadership in lunar and planetary exploration. It will be primarily an R&D workload, with heavy demand for top-flight scientists.

Congress willing, the space agency's estimated expenditures in fiscal '62 will total an estimated $1.7 billion for an increase of 43 per cent over the original budget submitted by the outgoing Eisenhower administration. Of this amount, almost $1.3 billion is earmarked for R&D, with the man-in-space program getting the overwhelming share.

Space agency procurement officials estimate that at least 80 per cent of NASA'S R&D spending will be placed under contract with industry, the universities and other private organizations. These officials are now at work revising procedures in an effort to reduce time lags in selecting contractors and conducting contract negotiations.

AIR FORCE TO PUSH DATA AUTOMATION

Incentive type CPFF contracts have been used to a limited potential of data automation techniques is the Air Force decision to set up an office to coordinate and foster improvements in automated data-processing systems for both administrative and command and control functions.

The new activity, which will become operational Aug. 1 under the Air Force Comptroller's Office, will evaluate the data requirements and existing data-processing facilities of all administrative more precisely, to foster development of new system design concepts and to seek improvements through the re-engineering of existing facilities.

IN SEARCH OF COMPETITION

Top Defense Dept. officials have promised Congress an intensive new effort to curtail sole-source procurement, which is chiefly responsible for the fact that 60 per cent of military contracting is noncompetitive.

The growing complexity of military hardware and the frequent need for telescoping development and first-run production to shorten lead time inevitably have fostered single-source buying. But while award of first-run production to development contractors is considered a justifiable expedient in most cases, defense officials readily acknowledge that the services should seek competition for follow-on production.

Delayed Delivery of Technical Data and manufacturing drawings accounts for a good deal of the failure to shift promptly from single-source to competitive buying. Thus the Pentagon intends to ride herd on procurement agencies to see that the Government gets the data to which it is entitled in time for competitive re-procurement. Contractors may be subject to financial penalties for failure to meet contract provisions on this score.

Such action, in turn, will require further steps to insure that the data ordered by the procurement agencies are adequate for re-procurement. Studies have indicated considerable laxity in specifying the Government's rights to data during contract negotiations.

In some cases, data are unavoidably incomplete because contractors withhold "proprietary" information. However, regulations defining such information are currently under review, and indications are that contractors will be subject to further restrictions on what they can claim as trade secrets.

Despite all efforts to correct deficiencies, some sole-source procurement will persist, even though adequate technical data and drawings are available, for the reason that quality cannot otherwise be assured.

NEW COST REDUCTION TACTICS

The Pentagon has instituted what amounts to an R&D program on contracting techniques. It is investigating all sorts of schemes to achieve tighter control of costs under the controversial cost-plus-fixed-fee contracts, which now account for 42 per cent of military expenditures, compared with 24 per cent only five years ago.

CPFF contracts, like sole-source procurement, started as an expedient but rapidly became common practice owing to the difficulty of projecting costs for complex weapons systems and to the pressure for concurrent development and production.

Incentive type CPFF contracts have been used to a limited extent in an effort to capture the profit motivation and risk-taking inherent in fixed-price contracts. Defense officials now want to make greater use of incentive contracting. But they also want to provide a wider range of incentives and stiffer penalties, as well as more effective means of evaluating technical and cost performance.

Imaginative, If Nothing Else, is a proposed new form of incentive contract dubbed the "cost-plus-award-fee contract." It would provide that a board of assessors evaluate a contractor's technical and cost performance during the life of a contract and determine his exact fee on completion of the work.

Something NEW in counting techniques!

Sprague type 73Z1 core-transistor

DECADE COUNTERS

Sprague's Special Products Division, the largest and most complete facility in the magnetics industry, offers a simple yet versatile, low-cost yet reliable component for counter applications. Counting to speeds of 10 kc, the 73Z1 decade counter provides an output signal for every 10 input pulses, then resets in preparation for the next cycle. For higher counting, two or more counters may be cascaded. Typical characteristics are shown in the following table:

CHARACTERISTIC	INPUT	OUTPUT
Amplitude	1.5 to 8 volts	6.5 volts min.
Pulse Width	1 μsec min.	50 μsec nom.
Impedance	100 ohms	20 ohms

Utilizing two rectangular hysteresis loop magnetic cores and two junction transistors to perform the counting operation, the 73Z1 counter is encapsulated in epoxy resin for protection against adverse environmental conditions. It has five terminals—B+ (12v ±10%), input, output, ground, and manual reset.

The 73Z1 decade counter is available as a standard item. However, "customer engineered" designs can be supplied when other counting cycles, speeds, and package configurations are required for special applications.

Other Special Products Division components for the digital equipment industry include: LOGILINE 5 mc/s digital circuits; 1 μsec access time memory; magnetic shift registers and logic components; computer pulse transformers; switching transformers; precision toroidal inductors.

For complete technical data or application assistance on the 73Z1 counter or other Sprague components, write to Special Products Division, Sprague Electric Co., 347 Marshall Street, North Adams, Massachusetts.

SPRAGUE
THE MARK OF RELIABILITY

CIRCLE 23 ON READER-SERVICE CARD

400-Cps Phase-Shift Standard Useful from 0 to 180 Deg

Designers at the National Bureau of Standards, Washington, D. C., have designed a phase-angle master standard said to be capable of measuring phase shift to within 0.01 deg at 400 cps. It can do this reportedly from 0 to 180 deg.

The instrument consists of 12 π-sections each of 14.6 deg, and three 4.3-deg π sections, plus switching arrangements that permit any combination of sections to be connected as a delay line. It was considered desirable, the bureau reports, to provide several different phase-shift steps and a continuously variable fine control.

The input to the delay line is used as part of an RC network that incorporates 10 capacitor steps, each giving 0.44-deg of phase shift.

According to NBS, all π-sections must be exactly adjusted to have the same characteristic impedance in order to prevent reflections and to make the phase shift put in by the RC circuit independent of the number of π-sections connected.

Similar phase-angle standards could be made for higher audio frequencies, but the upper limit in frequency would probably be about 20 kc, the bureau believes. At higher frequencies, reportedly, stray capacitance introduced by connecting and switching leads might prove troublesome. However, it might be feasible to use the same master standard over a 2-to-1 frequency range by readjustments on the π-sections and termination for each frequency.

Phase-angle master standard designed by National Bureau of Standards operates continuously from 0 to 180 deg at 400 cps with 0.01-deg accuracy. One of the designers, H. N. Cones, adjusts a mercury contact for a portion of π-section used as delay line.

WESCON

VISIT US AT BOOTH No. 3101-03

RELAY NEWS from Union Switch & Signal

Contact Redundancy in New UNION Crystal Case Relays

The UNION 2-pole double throw General Purpose Crystal Case Relay is designed to consistently meet the requirements of Mil-R-5757D and Mil-R-5757/10. Its essential features . . . from minimum size to optimum reliability . . . permit it to be used in aircraft, guided missiles, shipboard and ground control electronic equipment.

A unique torsion-wire armature suspension system and a rugged all-welded frame construction provide a high level of vibration and shock immunity. Contact redundancy, which assures reliability in dry circuit and higher level contact loads, is provided through the use of bifurcated contacts.

Available with 0.2" grid-spaced header or "S" type header, with various mountings, terminals, and operating voltages. Write for Bulletin 1064.

Why UNION Relays Are So Denendable

There's a good reason why our relays are the standard for reliability. For years, we've been building tough, reliable relays for use in airborne and guided missile electronic equipment and similar vital applications where perfect operation under severe environmental conditions is mandatory.

Our engineers created a compact 6-PDT miniature relay with just three major assemblies . . . instead of a fistful of small parts. This was accomplished by using a balanced rotary-type armature that provided a maximum resistance to the severe shock and vibration environment of aircraft and guided missiles. The rotary principle of operation is utilized in all our relays.

We have a reputation for building reliable electronic components and we intend to maintain our tradition for building reliable relays. And we supply these quality relays in quantity. Stocks are now available for prototype requirements in New York, Pittsburgh, Dallas and Los Angeles.

New 4-PDT-10-amp Relay Most Compact Rotary Type Available

This new durable relay is designed to meet the requirements of Mil-R-6106. It's a rugged relay featuring exceptionally sturdy terminals and husky contacts for high current applications. Glass-coated cylindrical contact actuators attached to the rotary armature provide square mating of contact surfaces, thereby assuring longer relay life. The balanced rotary armature provides maximum resistance to severe shock and vibration.

This small 4-PDT-10-Ampere relay is currently available with 115VAC and various DC operating voltages. Various mounting styles are provided. Write for bulletin 1069.

For additional information, write for Bulletin 1017 or call Churchill 2-5000 in Pittsburgh.

MEMBER OF THE NATIONAL ASSOCIATION OF RELAY MANUFACTURERS

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY —

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CIRCLE 26 ON READER-SERVICE CARD

Space Center Awards $7 Million In Work Contracts in a Month

More than $7 million in contracts were awarded in April by the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration, Huntsville, Ala. Manufacturers and Government agencies in 16 states and the District of Columbia shared in the awards.

Of the total, more than $2 million in work went to industrial concerns in Texas; $2 million to private and Federal groups in Alabama, Florida, Georgia and Tennessee; $800,000 in California; more than $1 million in Connecticut, Massachusetts, New Jersey, New York, Pennsylvania and Washington, D. C., and more than $300,000 in Indiana, Illinois, Michigan, Ohio and Wisconsin.

The contracts to manufacturers ranged from $2,083,832 to the Chance Vought Corp. of Dallas, Tex. — the largest single award — for 70-in. fuel and oxidizer tanks for Saturn; to $5,065 to the Interelectronics Corp. of New York City for transmitters.

Epsco, Inc., of Cambridge, Mass., has announced receipt of a $360,000 contract from the Goddard Space Flight Center in Maryland for three pulse-code-modulation receiving stations.

Million-Bit Computer Aids Navy

This real-time computer, designated AN/USQ-20V, collects, processes and evaluates naval tactical data in combat and recommends courses of action. The memory section contains 1 million bits of information. Thirty-bits, comprising a single word, can be drawn from any location in the memory in 2.5 μsec. The computers are being produced by Remington Rand Univac, St. Paul, Minn., under a $5,534,526 contract.

NEWS

Doppler Navigator on Way For All Aircraft Types

A versatile navigation system applicable to all types of aircraft including fixed-wing rotary, vertical/short take-off and landing, drones and airships is under development.

Called the Ryanav IV, the completely self-contained unit is undergoing air tests in a DC-3 of Ryan Electronics of San Diego, the system's developer. The system is reported to provide "all-weather, automatic navigation and hovering, without radio aids, wind estimates or true air speed data."

The Ryanav IV, the company says, accommodates all speed ranges from −50 knots to +2,000 knots; all altitudes from 0 to 70,000 ft; drift velocities from 0 to ±300 knots; velocities from −50 knots to +2,000; ground track from 0 to 360 deg, and vertical velocities to 60,000 ft per min.

Velocity error is less than 1/2 per cent and navigation positional error 0.7 per cent of the distance traveled, Ryan says. The hovering threshold is put at 1/4 knot. The use of pure continuous-wave techniques permits this accuracy to be achieved without altitude or attitude "holes," from take-off to landing, according to the company.

Ground Speed and Drift Computed on Visual Displays

Its electrical outputs are: heading velocity, drift velocity, vertical velocity, ground speed, ground track, drift angle, true heading, and east-west, north-south distance traveled. Visual displays include a navigation indicator showing ground speed and ground track, or wind speed and wind heading; a hovering indicator showing heading velocity, drift velocity, vertical velocity and a control indicator with five switch positions: Off, Silence, Land, Sea and Test.

The receiver-transmitter in the Ryanav IV is designed as a space-duplexed, fixed-antenna system with no moving parts and requiring no adjustments. Attitude capability is not limited by radome cutout area or the gimbals usually found in systems employing stabilized antennas. Supersonic speeds are accommodated simply by shifting the receiver band. No change in antenna angles or other system parameters is necessary.

Outputs are provided for tie-in with plotting boards and other position-indicating equipment, inertial navigation equipment, bomb-director sets, anti-submarine warfare sets, and terrain-clearance radar.

The Ryanav IV employs continuous-wave eletromagnetic energy at 13,300 mc. The set's antenna directs this energy toward the earth's surface in three narrow beams. The frequency of the energy back-scattered from the ground is "Doppler shifted" by an amount proportional to the aircraft's velocity along the individual beam. The three Doppler frequencies are measured and used to compute the aircraft's velocity components. This is accomplished in the converter/computer unit, which comprises a low-voltage power supply module, a frequency-tracker module, a frequency-converter and velocity-computer module, and a computer module.

The various configurations of the Ryanav IV family of Doppler ground-velocity indicators may omit, modify or add certain units to meet specific needs. Antennas can be provided to meet specialized aircraft structural or operational requirements.

Maser Method Amplifies Sound

Direct amplification of sound waves using microwave radio energy has been achieved with this apparatus being assembled by Dr. E. B. Tucker of General Electric Research Laboratory. Amplification of the sound waves, or phonons, is accomplished by "stimulated emission" of energy by atoms as they change from higher to lower energy levels in a ruby crystal. The same mechanism is used in the maser (microwave amplification by stimulated emission of radiation) to amplify electromagnetic radiation.

NEWS

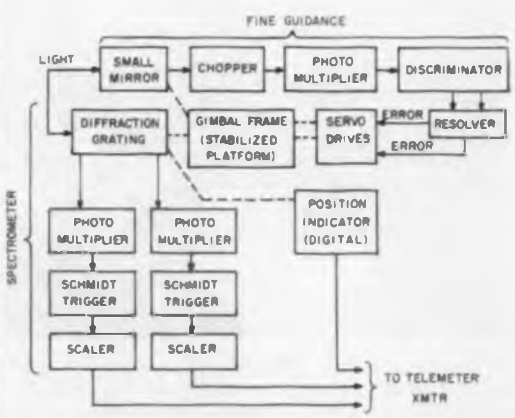
Space 'Pointer' Slated With 6-Sec Accuracy

Servoed System to Aim Spectrometer For Measuring UV Star Radiation

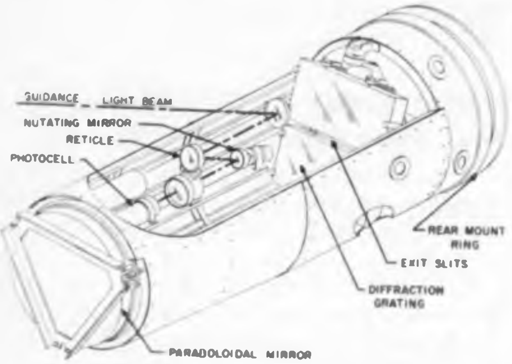
A SPECTROMETER to be rocketed more than 62 miles above the earth will be aimed by a fine-guidance system, being designed for accuracy of ±6 sec of arc over a ±2-deg field. The spectrometric system is intended to measure ultraviolet starlight in the 1,000-to-3,000-A range to a resolution of 2 A. It is planned for launching early in 1962 by Princeton University scientists working with the support of the National Aeronautics and Space Administration.

Coarse guidance will be provided by inertial gyroscopes, which are expected to stabilize the rocket to within ±1 deg of the desired pointing position. The fine-guidance system, being developed by Perkin-Elmer Corp., Norwalk, Conn., will actuate servo controls to point the spectrometer with the anticipated 6-sec accuracy.

This system will stabilize in two axes and use a rotating-image technique that is said to be relatively simple. Servos will signal two gimbal ring mounts to adjust their axes and position the spectrometer's stabilized diffraction grating. The servo signals will be gen-



Fine-guidance system to aim ultraviolet spectrometer from rocket depends on rotating image formed by optical system to actuate servos that adjust gimbal ring mounts. Spectrometer is to be rocketed above the atmosphere early next year to analyze radiation from bright stars.



Spectrometer portion of system will fit in 30-in. long by 14-in. diam volume. Before fine-guidance system takes over, coarse positioning will be provided by inertial gyroscopes.

erated when a star's light beam is picked up on a rotating, tilted mirror and directed through a reticle. The segmented reticle will modulate the beam passing through it according to the amount and direction of error. The system is designed to scan its portion of the UV spectrum in units of 30 A per sec.

The modulated beam, which is to contain information on the position of the star's image, will be focused on a phototube. The position data will be converted into error signals by an fm discriminator and resolver.

The 100-lb spectrometer package is to be 35 in. long by 14-1/4 in. diam. Radiation from stars will enter through an opening in the nose section of the rocket and will arrive at the instrument already collimated. After being diffracted, the radiation is to be focused on a photomultiplier detector to generate photon-count signals for telemetering to ground-receiving equipment. ■ ■

Closed-Circuit TV System Used To Verify Check Signatures

A closed-circuit TV system used for verification of check signatures has been installed in the First Pennsylvania Banking and Trust Co. of Philadelphia.

The system, developed by John F. McCarthy, Inc., Philadelphia, uses cameras and components furnished by Philco Corp.

The teller phones the bank's Signature Dept., identifies his numbered station, and requests the specific account. The clerk at the other end pulls the card from its alphabetical file, places it face down on one of two cameras, and the reproduction appears on the monitor.

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Here's a pressure-sensitive tape that packs great strength into thinner gauges (20,000 psi for 1 mil). Tape of Mylar* polyester film saves space because manufacturers can use thinner gauges with no loss in performance... at lower cost per linear foot.

Want more? "Mylar" also provides —flexibility for snug wraps—high dielectric strength (4,000 v/m†)—dimensional stability at high humidities —moisture and chemical resistance —resistance to temperatures from –60°C to 150°C. And "Mylar" lasts and lasts because there's no plasticizer to dry out with age.

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†ASTM D-149

Soviet Hopes to View Venus And Mars With Color TV

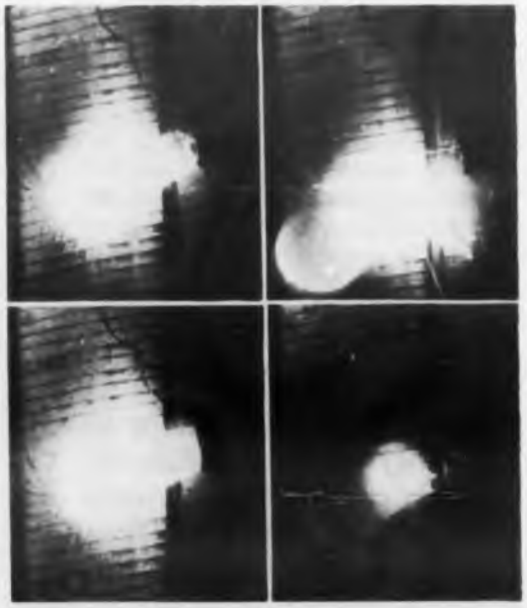
A Soviet television scientist, Dr. Pavel V. Shmakov, predicts that "in the near future" his country will observe Venus and Mars by color tv.

The prediction was one of several made at the first International Festival of TV Arts and Sciences, held in Montreux, Switzerland. Dr. Shmakov declined to elaborate on his forecast, however.

The Soviet expert was questioned about TV equipment used in recent Russian space shots. He explained that although the moon rockets did not contain true TV apparatus, more recent vehicles, such as the one that carried Maj. Yuri Gagarin, did.

Dr. Leonard Jaffe, chief of the United States space agency's Operation Relay, pre-

Sonic 'Death' of a Light Bulb



When a 25,000-w beam of sonic power—energy equivalent to a thousand symphony orchestras playing simultaneously—is directed at a light bulb, this is what happens. Sequence shots show the actual separation of the bulb from the lamp base, the filament still glowing even though exposed to the air, and the final failure of the filament. The experiment, performed at facilities of Bolt, Beranek & Newsman, acoustical consultants of Cambridge, Mass., was televised for the public by WBZ in Boston. The photos were taken by Jonathan Karas & Associates of Durham, N. H.

dicted at the festival that a permanent translation TV link would be "bounced" from satellites within four to five years.

Another prediction, sent to the conference by David Sarnoff, president of the Radio Corp. of America, stated: "Ten years from now a billion people will watch the same TV show at the same time in color." Mr. Sarnoff added that simultaneous translation techniques would make the show understandable to all.

He suggested that new satellite television systems should be used by the heads of all nations for face-to-face discussions, and proposed that every TV set should have a special channel reserved for United Nations telecasts.

Dr. Jaffe was one of six recipients of a festival citation "in recognition of outstanding contributions to the advance of television." The others were Dr. Shmakov, of the Leningrad Technical Institute; Sir Noel Ashbridge of Great Britain, Prof. G. A. Boutry of France, Dr. Kenjiro Takayanagi of Japan, and Eric Esping of Sweden.

Thirty-two nations took part in the conference.

Israel Seeks Electricity In Shallow Salt Waters

A group of Israeli scientists is experimenting with a principle that may make it possible to get electricity from small, shallow bodies of salt water. The principle, based on a natural phenomenon discovered in a lake in Hungary, where the bottom waters were found warmer than the top, can be explained by a difference in density.

In the heavy brine of a "dead sea," the water tends to form two distinct layers: a heavy dense layer underneath and a less dense layer on top. The top layer acts as a transparent cover over the bottom. When the water is shallow and the bottom is black, the lower layer gets hotter and hotter. The heat cannot escape because the nonmixing of the layers prevents convection. Heat thus retained could be transferred to general electricity.

Since arid countries with abundant sunshine usually have some waters too salty for human use, a curse can be turned to an advantage.

This idea, as well as many others, will be discussed at the United Nations Conference on New Sources of Energy, to be held in Rome, Italy, from Aug. 21 to 31.

EDITORIAL

Transistor Reliability Specs Well on Way

In last year's Transistor Data Chart issue our editorial called for reliability figures to be included with other important transistor characteristics contained in data sheets. Military specifications for components, including transistors, had been lax in reliability specifications due to lack of definitions and environmental standards. We cannot report this data this year, but progress is being made.

Since the release of the Darnell Report (Parts Specification Management for Reliability), improvement in component specifications has been in evidence. Perhaps the most significant in terms of semiconductor specifications is the use of LTPD (lot tolerance per cent defective) in newly prepared MIL-S-19500 documents in place of AQL (acceptable quality level) found in early MIL-STD-105 specs. AQL is normally considered the quality level for which the producer takes a 5 per cent risk of having a good lot rejected while LTPD is generally defined as the quality level for which the customer takes a 10 per cent risk of accepting a defective lot. Therefore the manufacturer's risk is linked with AQL and LTPD is a measure of the customer's risk. Based on sample size, an AQL of 4 per cent can exist with LTPD figures ranging from 12 to 38 per cent. Thus, MIL-STD-105 clearly defines the manufacturer's obligation but offers rather a vague reliability promise to the customer responsible for producing reliable equipment from his incoming components.

With newer transistor specifications outlining specific LTPD values and environmental conditions, the customer is fully aware of the confidence he can place on his incoming devices. Manufacturers can determine their acceptance number from the charts included in the specs.

Other improvements in reliability specifications soon to be adopted include the listing of failure-rate figure for components placed on the Qualified Products List. In addition, products will remain on the QPL only as long as they meet specification requirements; failure to maintain a given quality level will result in deletion from QPL.

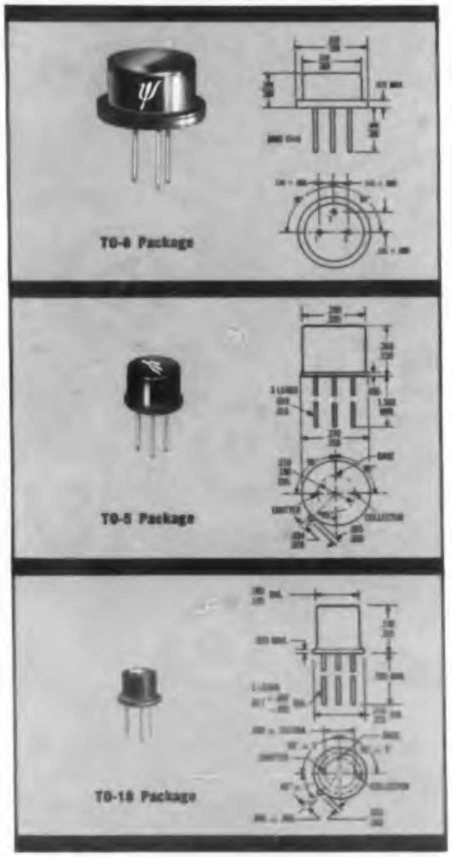
Based on the earnest efforts being applied by government personnel responsible for the preparation of components specifications, meaningful reliability will be contracted and delivered. Reliability figures may appear in next year's Transistor Data Chart if the rate of effort and enthusiasm generated by the Darnell Report is maintained by the military and industry.

Howard Bierman

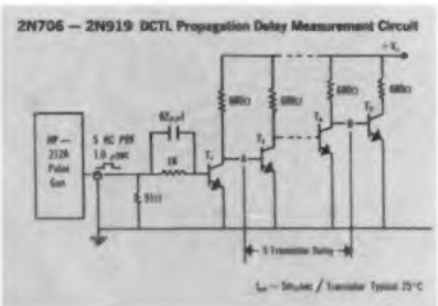
SWITCHING TRANSISTORS

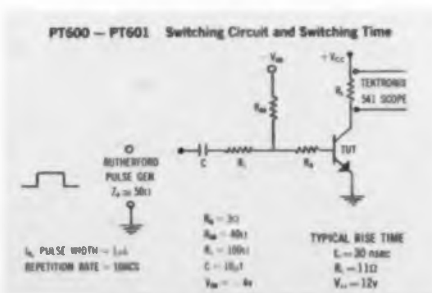
NPN TRIPLE DIFFUSED SILICON MESA

Wide Range of Types μA to 10 Amps .2V to 140V



DIMENSIONAL DRAWINGS
All dimensions shown in inches





TYPE	TOTAL POWER AT 25°C CASE Watts	V_{CBO} Min.	V_{CEO} Min.	V_{EBO} Min.	f_t mc TYP.	h_{FE}*	V_{CE} sat* Max.
TO-18 PACKAGE — HIGH SPEED TRANSISTORS							
2N706	1.0	25	20	3	350	20 min	.60
2N706A	1.0	25	20	5	350	20- 60	60
2N706B	1.0	25	20	5	350	20- 60	.40
2N753	1.0	25	20	5	350	40-120	.60
2N919	1.2	25	20	5	400	20- 60	.20
2N920	1.2	25	20	5	400	40-120	20
2N921	1.2	50	30	5	400	20- 60	.25
2N922	1.2	50	30	5	400	40-120	.25
TO-5 PACKAGE — HIGH SPEED TRANSISTORS							
2N1252	2.0	30	20	5	210	15- 45	1.5
2N1253	2.0	30	20	5	210	30- 90	1.5
TO-5 PACKAGE — PREMIUM TRANSISTORS							
2N1837	2.0	80	50	8	210	40-120	.80
2N1837A	2.8	80	50	8	210	40-120	.80
2N1409	2.0	30	25	4	230	15- 45	.80
2N1409A	2.8	30	25	4	230	15- 45	80
2N1410	2.0	45	30	4	230	30- 90	80
2N1410A	2.8	45	30	4	230	30- 90	.80
PT850	2.0	120	80	5	200	40-120	2.0
PT850A	2.8	120	80	5	200	40-120	2.0

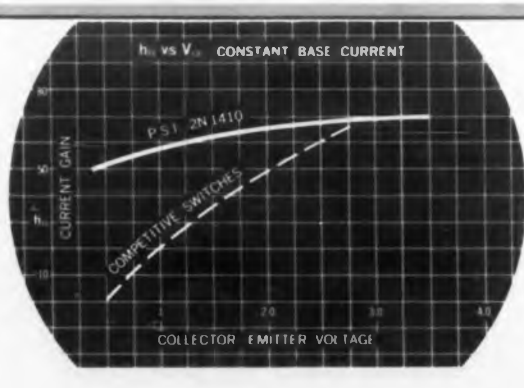
STANDARD TRANSISTORS

TYPE	TOTAL POWER AT 25°C CASE Watts	V_{CBO} Min.	V_{CEO} Min.	V_{EBO} Min.	f_t mc TYP.	h_{FE}*	V_{CE} sat* Max.	PKG
2N696	2.0	60	40	5	200	20- 60	1.5	TO- 5
2N697	2.0	60	40	5	200	40-120	1.5	TO- 5
2N698	2.0	120	80	5	190	20 min	5.0	TO- 5
2N699	2.0	120	80	5	190	40-120	5.0	TO- 5
2N717	1.5	60	40	5	200	20 min	1.5	TO-18
2N718	1.5	60	40	5	200	40-120	1.5	TO-18
2N719	1.5	120	80	5	190	20 min	5.0	TO-18
2N720	1.5	120	80	5	190	40-120	5.0	TO-18
2N1420	2.0	60	30	5	170	100-300	1.5	TO- 5
TO-5 PACKAGE — GENERAL PURPOSE TRANSISTORS								
2N1336	2.8	40	25	3	190	—	—	—
2N1838	2.0	45	30	4.5	190	40-150	1.4	—
2N1839	2.0	45	30	4.5	170	12- 50	1.4	—
2N1840	2.0	25	20	5	150	10 min	1.4	—

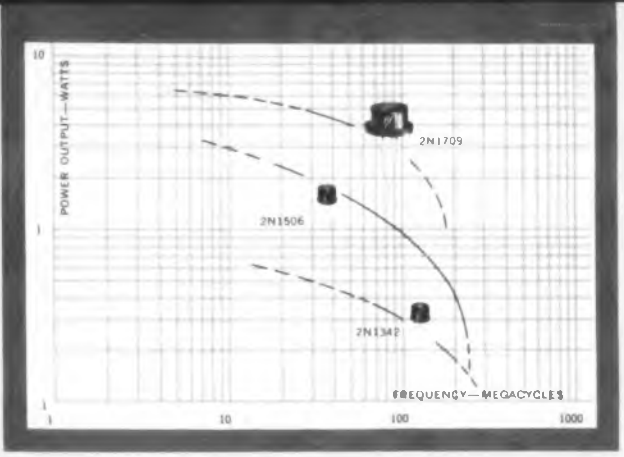
SPECIAL PURPOSE TRANSISTORS

TYPE	TOTAL POWER AT 25°C CASE Watts	V_{CBO} Min.	V_{CEO} Min.	V_{EBO} Min.	f_t mc TYP.	h_{FE}*	V_{CE} sat* Max.	PKG
2N1340	2.8	150	100	5	220	5 min	0.7	TO- 5
PT601	13.0	60	45	4	210	30-90	1.0	TO- 8
PT600	13.0	60	45	4	210	15-45	1.0	TO- 8
2N1900	125.0	140	100	5	50 min	10-20	2.0	POWER
2N1901	125.0	140	100	5	50 min	15-40	2.0	POWER

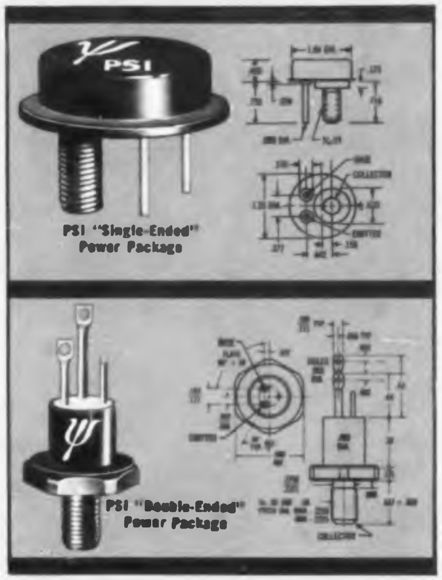
*SEE DATA SHEETS FOR CONDITIONS



Extremely flat Beta vs. Collector Voltage is one of the many advantages made possible by the PSI Triple Diffusion Process.

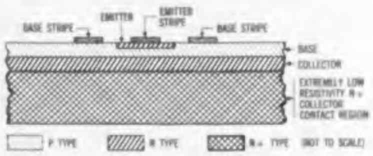


FREQUENCY-POWER OUTPUT RANGE OF PSI COMMUNICATIONS TRANSISTORS



DIMENSIONAL DRAWINGS
All dimensions shown in inches

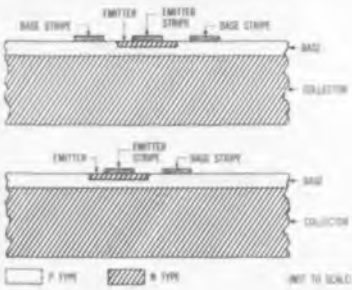
PSI TRIPLE DIFFUSED PROCESS



PSI triple diffusion makes possible these outstanding performance characteristics: Low V_{CE} saturation, faster switching, excellent high current beta, high small signal beta and broad VHF versatility.

The triple diffusion process, above, provides manufacturing control unmatched by any other process.

OTHER MESA PROCESSES



HF HIGH POWER TRANSISTORS

NPN TRIPLE DIFFUSED SILICON MESA

Wide Range of Types . . . for many new applications.

TYPE	V_{CBO} Min.	V_{CEO} Min.	V_{EBO} Min.	h_{FE}	10mc h_{fe}	f_T mc	5 mc Class C AMPLIFIER Power Out	Power Gain	PACKAGE
2N1899 (formerly PT901)	140	100	5	10 min	3	50 min	125W	10db	Single End
2N1900	140	100	5	10-20	3	50 min	125W	10db	Single End
2N1901	140	100	5	15-40	3	50 min	125W	10db	Single End
2N1902	140	100	5	10 min	3	50 min	125W	10db	Double End
2N1903	140	100	5	10-20	3	50 min	125W	10db	Double End
2N1904	140	100	5	15-40	3	50 min	125W	10db	Double End
PT900	80	50	5	10 min	3	50 min	125W	10db	Single End

KILOWATT MEGACYCLES AMPERES NANOSECONDS — Now possible with PSI Load Tested Silicon Mesa Power Transistors. In a typical switching application the rate of current rise can be as high as 100 million Amperes per second. Selected Beta ranges now available.

Power Switching at higher speeds and RF Power Generation at higher levels than previously attainable are now possible.

Availability: Single Ended packages are available in production quantities. Double Ended in Engineering quantities.

COMMUNICATION TRANSISTORS

NPN TRIPLE DIFFUSED SILICON MESA

Wide Range of Types

mW to Watts   10 to 100 + Source Voltages

VERY HIGH FREQUENCY

TYPE	TOTAL POWER AT 25°C CASE Watts	V_{CBO} Min.	V_{CEO} Min.	V_{EBO} Min.	POWER GAIN AT f = 30mc Typ.	POWER GAIN AT f = 70mc Typ.	POWER GAIN AT f = 100 mc Typ.	PKG
2N1338	2.8	80	50	3	18 db 0.35W	10.5db P_o = 0.35W	7db P_o = 0.35W	TO-5
2N1342	2.8	150	125	5		13db P_o = 0.4W	10db P_o = 0.3W	TO-5
2N1505	3.0	50	40	3	10db P_o = 1.8W	8db P_o = 1.2W	6db P_o = 1W	TO-5
2N1506	3.0	60	40	4	12db P_o = 1.8W	10db P_o = 1.2W	8.5db P_o = 1W	TO-5
2N1710	13.0	60	45	3	10db P_o = 5W	6db P_o = 6W	5db P_o = 6W	TO-8
2N1709	13.0	75	60	4	12db P_o = 5W	8db P_o = 7W	6db P_o = 7W	TO-8

THESE TRANSISTORS OFFER THE DESIGNER A WIDE SELECTION OF CHARACTERISTICS.
SUPPLY VOLTAGE: 10 VOLTS TO 125 VOLTS
OPERATING CURRENT: 1 mA TO SEVERAL Amps
OPERATING FREQUENCY: UP TO SEVERAL HUNDRED mc (HIGHER WITH VARICAP® DOUBLING CIRCUITS)
POWER OUTPUT: MILLIWATTS TO NEARLY 10 WATTS
The 2N1338, 2N1342, 2N1505, 2N1506 are available in production quantities.
The 2N1709 and 2N1710 are available in prototyping quantities.

PICO-TRANSISTORS and MICRO-TRANSISTORS

PSI Pico and Micro transistors are ultra miniature triple diffused silicon mesa devices. They are designed for low level amplification and for low power, high speed switching applications. These unique transistors are extremely valuable where weight and size are prime design and operational factors.

The remarkable high reliability standards of PSI Micro-Diodes are the result of simplified construction and advanced surface passivation techniques. These same techniques are employed in the manufacture of PSI Micro Transistors.

The surface passivation process and coating materials provide protection from extreme environmental conditions of heat, moisture, thermal shock, mechanical stresses and electrical load.

After manufacture all devices are subjected to environmental testing to assure reliability and device parameters.

- **Meet MIL-S-19500B and MIL-STD-202A**
- **200 hr. 200°C Reliability Assurance**
- **—65°C to 200°C temperature range**
- **100 mW power dissipation**
- **Pico size 1/1000 of TO-5 package**
- **Micro size 1/100 of TO-5 package**
- **Companion components to PSI Micro-Diode**

ABSOLUTE MAXIMUM RATINGS (25°C)

TYPES	[illegible]	[illegible]	[illegible]	TJ	[illegible]
PMT 011-111	25v	30v	4v	150°C	100 mW
PMT 012-112	25v	30v	4v	150 C	100 mW
PMT 013-113	40v	60v	5v	150°C	100 mW
PMT 014-114	40v	60v	5v	150°C	100 mW
PMT 015-115	50v	60v	5v	150°C	100 mW
PMT 016-116	35v	25v	3v	150°C	100 mW
PMT 018-118	35v	40v	5v	150°C	100 mW
PMT 019-119	30v	40v	5v	150°C	100 mW

ELECTRICAL CHARACTERISTICS

TYPES	[illegible]	[illegible] (sat)	[illegible] (sat)	[illegible]	[illegible]	[illegible] (Typ.)
PMT 011-111	[illegible]	1.2v	1.1v	20 pf	[illegible]	3.0
PMT 012-112	10µA [illegible]	1.2v	1.1v	20 pf	[illegible]	3.5
PMT 013-113	1µA (30v)	1.2v	1.1v	20 pf	[illegible]	4.0
PMT 014-114	1µA (30v)	1.2v	1.3v	20 pf	[illegible]	[illegible]
PMT 015-115	[illegible]	1.2v	1.3v	15 pf	[illegible]	[illegible]
PMT 016-116	5µA (15v)	[illegible]	[illegible]	[illegible]	20 (10mA-1v)	4.0
PMT 018-118	1µA (10v)	[illegible]	[illegible]	20 pf	[illegible]	4.0
PMT 019-119	1µA (10v)	[illegible]	[illegible]	20 pf	[illegible]	[illegible]

NOTE: ① Pulse Conditions Length ≤ [illegible] sec. Duty Cycle ≤2%

EQUIVALENT TYPES

PSI PICO	MICRO	EQUIVALENTS
PMT 011	PMT 111	2N1409
PMT 012	PMT 112	2N1410
PMT 013	PMT 113	2N696
PMT 014	PMT 114	[illegible]
PMT 015	PMT 115	2N1837
PMT 016	PMT 116	2N706
PMT 018	PMT 118	Low Level Premium [illegible]
PMT 019	PMT 119	Low Level Premium [illegible]

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BULLETIN 62-661

ELECTRONIC DESIGN's Ninth Annual

TRANSISTOR DATA CHART

Howard Bierman
Technical Editor

ELECTRONIC DESIGN's Ninth Annual Transistor Data Chart contains specifications for 1,714 transistor types—last year only 1,088 types were submitted for publication by semiconductor manufacturers. With close to a 60 per cent increase in the number of available types, the design engineer is now offered a greater selection of devices as well as increased sources of supply—but his search time for a transistor to do a certain job is likewise increased. Thus, ELECTRONIC DESIGN's unique listing, specifically tailored for the design engineer, should prove to be a handy time-saver.

Contrary to existing lists which group transistors by manufacturer or in numerical sequence (fine for salesmen, of limited use to engineers), the 1961 Data Chart has transistors organized into six application categories:

Audio—mostly general purpose types, under 1 w, listed in order of increasing forward-current transfer ratio, (h_{fe} or h_{FE}).

High frequency—including types ranging up to and above the vhf range and tabulated in order of increasing alpha-cut-off frequency, (f_{ae}).

Power devices—transistors rated at 1 w and above are listed in order of increasing collector power dissipation.

Special types—low-noise, high-power high-frequency and other miscellaneous types are included.

High-level and low-level switching—devices intended for switching are listed in order of increasing alpha-cut-off frequency, (f_{ae}).

By this system of listing transistors, the design engineer is offered a rapid method of selecting a particular type based on a parameter value. In addition, close substitutes are apparent and multiple sources of supply are listed when applicable. Only U. S. manufactured types are given.

One word of caution is included. Quite a few similar number types, made by several companies, were submitted with different characteristics due to the nonconformity in test methods among manufacturers. The manufacturer whose data are used for each particular type is listed under "Mfg." Other suppliers of the same types are found under "Remarks." Please take note that the company listed under "Mfg." is not necessarily the prime supplier, a cheaper source or the original EIA registrant. *The final choice of supplier is obviously up to the design engineer.* It is thus advisable to *use this listing as a guide to selection* and then follow up with a detailed evaluation of specific test methods and data as outlined in each manufacturer's spec sheet.

A cross index is included to identify a type number with its listed category. The JEDEC type numbers are tabulated in numerical order and the category group is indicated.

For a free reprint of the Transistor Data Chart, circle 251 on the Reader-Service card.

◀ CIRCLE 35 ON READER-SERVICE CARD

Audio

Type No.	Mfg.	Type	h_{fe} or h_{FE}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics I_{co} μa	NF db	C_c μμf	$f_{\alpha e}$ mc	Remarks
2N160	RRD	npn,GJ,si	0.93	150	175	–	40	25	0.2	25	7	4	
2N160A	RRD	npn,GJ,si	0.93	150	175	–	40	25	0.2	25	7	4	
2N349	RRD	npn,GJ,si	0.95	750	175	–	125	40	10	–	–	3	
2N161	RRD	npn,GJ,si	0.96	150	175	–	40	25	0.2	25	7	5	
2N161A	RRD	npn,GJ,si	0.96	150	175	–	40	25	0.2	25	7	5	
2N348	RRD	npn,GJ,si	0.96	750	175	–	90	50	10	–	–	3	
2N1096	RRD	npn,GJ,si	0.96	500	175	–	90	30	6	–	–	3	
2N347	RRD	npn,GJ,si	0.98	750	175	–	60	60	10	18	7	3	
2N1095	RRD	npn,GJ,si	0.98	500	175	–	60	40	5	–	–	3	
2N163	RRD	npn,GJ,si	0.99	150	175	–	40	25	0.2	25	7	6	
2N163A	RRD	npn,GJ,si	0.99	150	175	–	40	25	0.2	25	7	6	
952	TI	npn,GJ,si	6	750	150	6	80	50	6	–	–	8	2N1155
951	TI	npn,DJ,si	9	750	150	6	50	60	5	–	–	8	2N1154
2N953	TI	npn,GJ,si	9	750	150	6	120	40	8	–	–	8	2N1156
2N1154	NA	npn,DM,si	9	750	150	5	50	60	5	–	–	–	
2N1155	NA	npn,DM,si	9	750	150	5	80	50	6	–	–	–	
2N1156	NA	npn,DM,si	9	750	150	5	120	40	8	–	–	–	
2N117	TI	npn,GR,si	9-20	150	175	1	45	25	2	20	–	4	TR, USN
2N332	TI	npn,GR,si	9-20	150	175	1	45	25	2	20	–	6	GE,TR, RRD, NA,RA
2N332A	NA	npn,MS,si	9-20	150	175	0.86	45	–	2	–	30	–	GE
2N333A	NA	npn,MS,si	9-20	500	175	2.8	45	–	0.5	–	15	–	GE
2N903	TI	npn,GJ,si	9-20	150	175	1	45	25	2	25	–	4	2N1149
2N1149	TR	npn,DJ,si	9-20	150	150	–	30	25	0.1	25	7	7	NA
2N243	TI	npn,GJ,si	9-32	750	150	6	60	60	1	–	–	7	NA
2N472A	TR	npn,DG,si	10-25	.200	200	–	45	25	0.02	22	7	8	100% reliability assurance processed
2N470	TR	npn,GJ,si	10-25	200	200	–	15	25	0.02	22	7	8	
2N471	TR	npn,GJ,si	10-25	200	200	–	30	25	0.02	22	7	8	
2N472	TR	npn,GJ,si	10-25	200	200	–	45	25	0.02	22	7	8	
2N102/13	SY	npn,AJ,ge	10.5	1w	75	20	30	1.5a	5ma	–	–	–	
2N144/13	SY	npn,AJ,ge	10.5	1w	75	20	60	0.8a	5ma	–	–	–	
2N45*	GI	npn,AJ,ge	12	150	100	2	45	–	10	22	40	–	*MIL
2N1439	NA	pnp,AJ,si	12	400	200	2.28	50	100	0.01	12	25	1	audio/med. power
2N756	NA	npn,DM,si	12-20	500	200	2.5	45	–	9.2	–	–	–	
2N756A	NA	npn,DM,si	12-20	500	200	2.5	60	–	0.1	–	–	–	
CK64B	RA	pnp,AJ,ge	13.5	75	85	1.25	45	100	10	–	–	–	Sub min
CK64C	RA	pnp,AJ,ge	13.5	75	85	1.25	45	100	10	–	–	–	Sub min
2N935	SSD	pnp,AJ,si	14	385	160	2.85	40	50	.005	18	70	2	TO-18
2N284	AMP	pnp,AJ,ge	15	125	75	2.5	32	125	–	–	–	–	
2N284A	AMP	pnp,AJ,ge	15	125	75	2.5	60	125	–	–	–	–	
2N339A	TR	npn,DJ,si	15	1000	200	8	55	1	–	–	–	–	Beta specs at 3 I_c levels
2N340A	TR	npn,DJ,si	15	1000	200	8	85	0.1	1	–	–	–	Beta specs at 3 current levels.
2N341A	TR	npn,DJ,si	15	1000	200	8	125	0.1	1	–	–	–	Beta specs at 3 current levels.
2N927	NA	pnp,AJ,si	15	150	200	2.5	70	–	.005	–	12	.8	
2N938	SSD	pnp,AJ,si	15	250	175	1.7	35	100	.001	–	7	2	TO-18
2N1247	NA	npn,DM,si	15	30	150	0.2	6	5	1.5	–	12	–	TR
2N1248	TR	npn,GJ,si	15	300	150	–	6	5	.002	6	15	–	
2N1440	NA	pnp,AJ,si	15	400	200	2.28	50	100	0.01	12	25	1	audio/med. power
2N1623	RA	pnp,AJ,si	15	250	160	0.54	20	50	.005	18	70	.1	
2N1655	RA	pnp,AJ,si	15	250	160	0.54	125	50	.005	18	70	.2	
TR34	IND	pnp,AJ,ge	15	120	85	3	40	150	10	15	15	1.6	
2N925	NA	pnp,AJ,si	16	150	200	2.5	50	–	.005	–	12	.8	
2N529	G.I	*	17	100	85	2	15	–	3	14	14	–	matched pnp,npn
2N118	TI	npn,GR,si	18-40	150	175	1	45	25	2	20	–	5	TR
2N333	TI	npn,GR,si	18-40	150	175	1	45	25	2	20	–	8	GE,TR,NA,RA
2N334A	NA	npn,MS,si	18-36	500	175	2.8	45	–	0.5	15	–	–	
2N757	NA	npn,MS,si	18-36	500	200	2.5	45	–	0.2	–	–	–	
2N757A	NA	npn,MS,si	18-36	500	200	2.5	60	–	0.1	–	–	–	
2N904	TI	npn,GR,si	18-40	150	175	1	45	25	2	25	–	5	2N1150
2N1150	NA	npn,DM,si	18-40	150	175	0.86	45	25	2	–	7	1	
2N334	TI	npn,GR,si	18-90	150	175	1	45	25	2	20	–	10	GE,TR,NA,RA
2N758	NA	npn,MS,si	18-90	500	200	2.5	45	–	0.2	–	–	–	
2N758A	NA	npn,DM,si	18-90	500	200	2.5	60	–	0.1	–	–	–	
2N904A	TI	npn,GR,si	18-90	150	175	1	45	25	2	25	–	8	2N1151
2N1151	NA	npn,DM,si	18-90	150	175	0.86	45	25	2	–	7	8	TR
2N129	SPR	pnp,AJ,ge	20	30	85	–	3	5	–	–	–	30	
2N923	NA	pnp,AJ,si	20	150	200	2.5	40	–	.005	–	12	.8	
2N1051	WE	npn,DD,si	20	600	150	0.25	60	–	0.1	–	8	70	US, MIL only
2N1670	GI	pnp,DR,ge	20	120	85	2	100	–	3	–	3	–	Hi-volt switch
OC200	AMP	pnp,PADT,si	20	250	150	–	25	50	10	–	–	1	
2N475A	TR	npn,DG,si	20-50	200	200	–	45	25	0.02	20	7	10	100% reliability assurance processed

Index of Manufacturers

Abbrev.	Company	Location
AMP	Amperex Electronic Co.	Hicksville, N. Y.
BE	The Bendix Corp.	Holmdel, N. J.
CBS	CBS-Hytron, Semicond. Operations	Lowell, Mass.
CL	Clevite Transistor	Waltham, Mass.
CT	Crystalonics, Inc.	Cambridge, Mass.
DE	Delco Radio Div., GM Corp.	Kokomo, Ind.
EM	Electromation Co.	Venice, Calif.
FA	Fairchild Semicond. Corp.	Mountain View, Calif.
GE	General Electric Co.	Syracuse, N. Y.
GI	General Instrument Corp.	Newark, N. J.
HO	Hoffman Semicond. Div.	El Monte, Calif.
HU	Hughes Semicond. Div.	Newport Beach, Calif.
IND	Industro Transistor Corp.	Long Island City, N. Y.
KF	Kearfott Semicond. Corp.	West Newton, Mass.
MH	Minneapolis-Honeywell	Minneapolis, Minn.
MO	Motorola Semicond. Products Inc.	Phoenix, Ariz.
NA	National Semicond. Corp.	Danbury, Conn.
PH	Philco Corp. Lansdale Div.	Lansdale, Pa.
PSI	Pacific Semicond., Inc.	Culver City, Calif.
RCA	Radio Corp. of America	Somerville, N. J.
RRD	Radio Development and Research Corp.	Paterson, N. J.
RA	Raytheon Co. Semicond. Div.	Newton, Mass.
RH	Rheem Semicond. Corp.	Mountain View, Calif.
SE	Secoa Electronic Corp.	Westbury, L. I., N. Y.
STC	Silicon Transistor Corp.	Clare Place, L. I., N. Y.
SSD	Sperry Semicond. Div.	South Norwalk, Conn.
SPR	Sprague Electric Co.	North Adams, Mass.
SY	Sylvania Semicond. Div.	Woburn, Mass.

Abbrev.	Company	Location
TI	Texas Instruments Inc.	Dallas, Tex.
TR	Transitron Electronic Corp.	Wakefield, Mass.
TS	Tung-Sol Electric Inc.	East Orange, N. J.
US	U. S. Transistor Corp.	Syosset, L. I., N. Y.
WE	Western Electric Co., Inc.	Laureldale, Pa.
WT	Western Transistor Corp.	Gardena, Calif.
WH	Westinghouse Electric Corp.	Youngwood, Pa.

Abbreviation of Terms

AJ Alloy Junction
DD Double Diffused
DG Grown Diffused
DJ Diffused Junction
DM Diffused Mesa
DP Diffused Planar
Dr Drift
Ep Epitaxial
FA Fused Alloy
FJ Fused Junction
GD Grown Diffused
Ge Germanium
GJ Grown Junction
GR Grown Rate
MB Meltback
MD MADT
Ms Mesa
RG Rate Grown
Si Silicon
SBT Surface Barrier

C_{oe} = Collector-to-emitter capacitance measured across the output terminals with the input ac open-circuited.

f_{ae} = Frequency at which the magnitude of the forward-current transfer ratio (small-signal) is 0.707 of its low-frequency value.

f_t = Frequency at which common emitter gain is unity.

h_{fe} = Common emitter-small signal forward current transfer ratio.

h_{FE} = Common emitter-static value of short-circuited forward current ratio.

I_{co} = Collector current when collector junction is reverse-biased and emitter is dc open-circuited.

Audio (continued)

Type No.	Mfg.	Type	h_{fe} or h_{FE}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics I_{co} µa	NF db	C_c µµf	f_{ae} mc	Remarks
2N406	SY	pnp,AJ,ge	20-80	150	75	3	20	35	14	–	–	250	
2N761	NA	npn,DM,si	20-55	500	200	2.5	45	–	.2	–	–	–	
2N530	GI	*	22	100	85	2	15	–	3	14	3	–	*matched pnp, npn
TR722	IND	pnp,AJ,ge	22	150	2.5	3	45	200	10	15	20	2.5	
CK22A	RA	pnp,AJ,ge	22.5	80	85	–	20	100	2	6-5	–	1.2	micromin
CK64A	RA	pnp,AJ,ge	22.5	80	85	–	29	100	2	22	–	0.8	micromin
CK64	RA	pnp,FA,ge	23	80	85	–	29	100	2	22	–	0.8	
2N186A	GE	pnp,AJ,ge	24	200	85	4	25	200	16	–	40	0.8	
2N189	GE	pnp,AJ,ge	24	75	85	2	25	50	16	15	40	0.8	
2N1476	SSD	pnp,AJ,si	24	250	175	1.7	100	100	0.5	–	7	1	
2N381	SY	pnp,AJ,ge	24-45	200	85	3.3	25	200	20	–	–	10	
2N44	GE	pnp,AJ,ge	25	240	100	4	45	300	16	6	40	1	MIL, GI
2N229	SY	npn,AJ,ge	25	50	75	1	10	–	100	–	–	600	
2N330A	SSD	pnp,AJ,si	25	–	160	3	30	50	0.1	8	–	0.5	
2N460	TS	pnp,AJ,ge	25	200	100	0.3	45	400	15	–	–	–	
2N564	IND	pnp,AJ,ge	25	150	85	2.5	30	300	3	12	20	0.8	US
2N592	GI	pnp,AJ,ge	25	150	100	0.2	20	–	5	116	35	0.4	Bilateral
2N726	TI	pnp,DM,si	25	1w	175	–	25	50	.007	–	–	–	
2N1265	SY	pnp,AJ,ge	25	50	85	0.9	10	100	100	–	–	600	
2N1441	NA	pnp,AJ,si	25	400	200	2.28	50	100	0.01	12	25	1	audio/med. power
2N1101	SY	npn,AJ,ge	25-50	180	75	3.6	20	100	50	–	–	0.01	RCA
2N1102	SY	npn,AJ,ge	25-50	180	75	3.6	40	100	50	–	–	0.01	
2N34	SY	pnp,AJ,ge	25-125	150	75	3	40	100	50	–	–	0.01	Driver, TI
2N35	SY	npn,AJ,ge	25-125	150	75	3	40	100	50	–	–	0.01	Driver, TI
2N306	SY	npn,AJ,ge	25-125	50	85	0.83	20	100	100	–	–	0.6	
2N464	MO	pnp,AJ,ge	26	200	100	2.5	45	100	6	–	–	0.7	IND, RA, US, GI
2N1474	SSD	pnp,AJ,si	26	250	175	1.7	60	100	.005	–	7	1	
2N531	GI	*	27	100	85	2	15	–	3	14	14	–	* matched pnp, npn
CK65B	RA	pnp,AJ,ge	27	75	85	1.25	45	100	10	–	–	–	Sub min
CK65C	RA	pnp,AJ,ge	27	75	85	1.25	45	100	10	–	–	–	Sub min
2N936	SSD	pnp,AJ,si	28	385	160	2.85	35	50	.005	18	70	2.5	TO-18
2N244	TI	npn,GJ,si	28-90	750	160	6	60	60	1	–	–	8	NA
2N118	TI	npn,GR,si	29	150	175	1	45	25	2	20	–	5	TR
2N279	AMP	pnp,AJ,ge	30	25	75	2.5	20	10	110	10	–	0.15	
2N524	SY	pnp,AJ,ge	30	225	100	3	45	500	10	–	–	2	GE, MO
2N594	GI	npn,AJ,ge	30	150	85	1.67	20	–	2	16	15	2	Bilateral
2N939	SSD	pnp,AJ,si	30	250	175	1.7	35	100	.001	–	7	3	TO-18
2N1446	IND	pnp,AJ,ge	30	200	85	3.33	45	400	5	6	20	2	
2N1474A	SSD	pnp,AJ,si	30	250	175	1.7	60	100	.005	–	7	2	
2N1654	RA	pnp,AJ,si	30	250	160	0.54	80	50	.005	18	70	.2	
2N1656	RA	pnp,AJ,si	30	250	160	0.54	125	50	5	18	70	.2	
CK25A	RA	pnp,AJ,ge	30	80	85	–	20	400	2	–	14	4	micromin RF switch
OC201	AMP	pnp,PADT,si	30	250	150	–	25	50	10	–	–	4	
2N331	MO	pnp,AJ,ge	30-70	75	85	1.2	30	–	1	20	50	.4	
2N1372	SY	pnp,AJ,ge	30-90	150	100	2	25	200	100	–	–	–	
2N1373	SY	pnp,AJ,ge	30-90	150	100	2	45	200	100	–	–	–	
2N1432	SY	pnp,DD,ge	30-120	80	85	1.3	35	10	15	–	–	250	
2N1380	SY	pnp,AJ,ge	30-300	150	100	2	15	200	14	–	–	–	
2N1381	SY	pnp,AJ,ge	30-300	150	100	2	25	200	100	–	–	–	
2N532	GI	*	32	100	85	2	15	–	3	14	14	–	* matched pnp, npn
2N319	GE	pnp,AJ,ge	34	225	85	4	20	200	16	–	25	2	
2N405	RCA	pnp,AJ,ge	35	150	–	–	20	70	14	–	–	0.25	SY
2N406	RCA	pnp,AJ,ge	35	150	–	–	20	70	14	–	–	–	
2N593	GI	pnp,AJ,ge	35	150	100	2	35	–	5	16	35	0.6	Bilateral
2N734	TI	npn,MS,si	35	1.0	175	–	80	50	1	20	5	50	TO-18 TR, NA
2N738	TI	npn,DM,si	35	1w	175	–	125	35	1	–	–	–	TR
2N926	NA	pnp,AJ,si	35	150	200	2.5	50	–	.005	–	12	0.8	
2N928	NA	pnp,AJ,si	35	150	200	2.5	70	–	.005	–	12	0.8	
2N1010	RCA	npn,AJ,ge	35	20	55	–	10	2	10	5	–	2	
2N1564	TI	npn,MS,si	35	1.2	175	–	80	50	1	20	5	50	TO-5 TR, NA
2N1572	TI	npn,DM,si	35	1.2w	175	–	125	50	1	–	–	–	TR
OC57	AMP	pnp,PADT,ge	35	10	55	–	7	10	1.5	–	–	1.4	
OC53	AMP	pnp,AJ,ge	35	10	55	0.7	3	5	0.1	10	–	0.01	Hearing Aid
2N383	SY	pnp,AJ,ge	35-110	200	85	3.3	30	200	20	–	–	10	TS
2N187A	GE	pnp,AJ,ge	36	200	85	4	25	200	16	–	40	1	
2N190	GE	pnp,AJ,ge	36	75	85	2	25	50	16	15	40	1	
2N119	TI	npn,GR,si	36-90	150	175	1	45	25	2	20	–	6	TR, USN
2N335	TI	npn,GR,si	36-90	150	175	1	45	25	2	20	–	11	TR, GE, NA, RA
2N335A	NA	npn,MS,si	36-90	500	175	2.8	45	–	0.5	–	–	–	GE
2N759	NA	npn,DM,si	36-90	500	200	2.5	45	–	0.2	–	–	–	
2N759A	NA	npn,DM,si	36-90	500	200	2.5	60	–	0.1	–	–	–	
2N905	TI	npn,GR,si	36-90	150	175	1	45	25	2	25	–	6	2N1152
2N1152	NA	npn,DM,si	36-90	150	175	0.86	45	25	2	–	7	1	TR
2N533	GI	*	37	100	85	2	15	–	3	14	14	–	* matched pnp, npn

TRANSISTORS—1961

Audio (continued)

Type No.	Mfg.	Type	h_{fe} or h_{FE}	Maximum Ratings					Characteristics				Remarks
				W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	I_{co} μa	NF db	C_c μμf	f_{ae} mc	
2N742	NA	npn,MS,si	40	–	200	1.71	60	100	0.1	–	5	200	Switch
2N1009	SY	pnp,AJ,ge	40	150	85	2.5	25	20	1	–	–	–	
2N1176	BE	pnp,AJ,ge	40	300	85	6.6	15	300	10	–	–	–	
2N1176A	BE	pnp,AJ,ge	40	300	85	6.6	40	300	10	–	–	–	
2N1176B	BE	pnp,AJ,ge	40	300	85	6.6	60	300	15	–	–	–	
2N1191	MO	pnp,AJ,ge	40	200	100	2.7	40	200	2	10	–	1.5	
2N1678	GI	pnp,DR,ge	40	120	85	2	60	–	3	–	3	–	Trixie Driver
2N1730	TI	npn,DM,si	40	2w	175	–	60	50	0.5	–	–	–	
CK4	RA	pnp,AJ,ge	40	80	85	–	24	100	2	–	14	6	Submin RF switch
CK4A	RA	pnp,AJ,ge	40	80	85	–	24	100	2	–	14	6	micromin RF switch
CK26A	RA	pnp,AJ,ge	40	80	85	–	18	400	2	–	14	6	Micromin RF switch
TR-650	IND	pnp,AJ,ge	40	150	85	2.5	45	400	1.0	10	20	2	2N650
TR-653	IND	pnp,AJ,ge	40	150	85	2.5	30	400	1.0	10	20	2	
2N382	SY	pnp,AJ,ge	40-78	200	85	3.3	25	200	20	–	–	10	
2N480A	TR	npn,DG,si	40-100	200	200	–	45	25	0.02	20	7	11	100% reliability assurance processed.
2N43	GE	pnp,AJ,ge	42	240	100	4	45	300	16	6	40	1.3	
OC79	AMP	pnp,PADT,ge	42	550	75	–	26	300	10	–	–	1.2	
2N104	RCA	pnp,AJ,ge	44	150	–	–	30	50	10	12	–	0.7	
2N215	RCA	pnp,AJ,ge	44	150	–	–	30	50	10	12	–	0.7	
2N525	GE	pnp,AJ,ge	44	225	100	4	45	500	10	6	25	2.5	MO, SY
2N1924	GE	pnp,AJ,ge	44	225	85	–	40	500	4	–	–	–	
2N238	TI	pnp,AJ,ge	45	150	85	.0025	25	200	6	7.5	–	1.5	
2N291	TI	pnp,AJ,ge	45	180	85	.003	25	200	6	7.5	–	1.5	
2N322	GE	pnp,AJ,ge	45	140	85	4	16	100	16	–	25	2.0	Driver
2N465	IND	pnp,AJ,ge	45	150	85	2.5	45	200	6	15	20	0.8	MO, RA, US, GI, SY
2N595	GI	npn,AJ,ge	45	150	85	1.67	20	–	2	16	15	4	Bilateral
2N924	NA	pnp,AJ,si	45	150	200	2.5	40	–	.005	–	12	0.8	
2N1098	GE	pnp,AJ,ge	45	140	85	4	16	100	16	–	25	–	Driver
2N1372	TI	pnp,AJ,ge	45	250	100	3.3	25	200	3	7	–	1.5	
2N1373	TI	pnp,AJ,ge	45	250	100	3.3	45	200	3	7	–	1.5	
2N1442	NA	pnp,AJ,si	45	400	200	2.28	50	100	0.01	12	25	1	audio/med. power
2N1145	GE	pnp,AJ,ge	45	140	85	4	16	100	16	–	40	–	Driver
2N1447	IND	pnp,AJ,ge	45	200	85	3.3	45	400	5	6	20	3	
2N1451	IND	pnp,AJ,ge	45	200	85	3.3	45	400	7.5	9	20	1.5	
2N1477	SSD	pnp,AJ,si	45	250	175	1.7	100	100	0.5	–	7	1	
CK65	RA	pnp,FA,ge	45	80	85	–	24	100	2	22	–	1	
CK65A	RA	pnp,AJ,ge	45	80	85	–	24	100	2	22	–	1.0	micromin
TR721	IND	pnp,AJ,ge	45	150	2.5	3	30	200	10	15	20	3	
2N762	NA	npn,DM,si	45-150	500	200	2.5	45	–	0.2	–	–	–	
2N280	AMP	pnp,AJ,ge	47	25	75	2.5	20	10	150	10	–	0.1	
TR320	IND	pnp,AJ,ge	48	150	85	3	25	100	10	–	25	2.5	2N320
2N650	MO	pnp,AJ,ge	49	200	100	2.7	45	500	3	5	–	1.5	US
2N650A	MO	pnp,AJ,ge	49	200	100	2.8	45	500	10	15	25	1.5	Mega life
2N653	MO	pnp,AJ,ge	49	200	100	2.8	30	250	5	10	20	1.5	SY
2N1186	MO	pnp,AJ,ge	49	200	100	2.7	60	500	5	5	–	1.5	
2N43A *	GI	pnp,AJ,ge	50	150	100	2	45	–	10	18	40	3.5	*MIL, GE
2N320	GE	pnp,AJ,ge	50	225	85	4	20	200	16	–	25	2.5	
2N331	BE	pnp,AJ,ge	50	200	85	–	30	200	16	9	–	1.16	IND, MO, GI
2N363	IND	pnp,AJ,ge	50	150	85	2.5	30	200	10	–	–	–	RA, US
2N368	TI	pnp,AJ,ge	50	150	85	2.5	30	30	7	–	33	–	
2N369	TI	pnp,AJ,ge	50	150	85	2.5	30	50	7	–	33	1.3	
2N422	RA	pnp,FA,ge	50	150	85	–	20	100	6	6.5	–	0.8	
2N941	SSD	pnp,AJ,si	50	250	175	1.7	8	50	.001	–	7	–	TO-18
2N942	SSD	pnp,AJ,si	50	250	175	1.7	11	50	.003	–	7	–	TO-18
2N943	SSD	pnp,AJ,si	50	250	175	1.7	18	50	.003	–	7	–	TO-18
2N944	SSD	pnp,AJ,si	50	250	175	1.7	18	50	.005	–	7	–	TO-18
2N945	SSD	pnp,AJ,si	50	250	175	1.7	50	50	2	–	7	–	TO-18
2N946	SSD	pnp,AJ,si	50	250	175	1.7	80	50	2	–	7	–	TO-18
2N1273	TI	pnp,AJ,ge	50	150	85	.0025	15	150	3	6.5	–	–	
2N1274	TI	pnp,AJ,ge	50	150	85	.0025	25	150	3	6.5	–	–	
2N1383	TI	pnp,AJ,ge	50	200	85	–	25	200	.001	7.0	–	1.5	
2N1917	SSD	pnp,AJ,si	50	250	175	1.7	8	50	.001	–	7	–	TO-5
2N1918	SSD	pnp,AJ,si	50	250	175	1.7	11	50	.003	–	7	–	TO-5
2N1919	SSD	pnp,AJ,si	50	250	175	1.7	18	50	.003	–	7	–	TO-5
2N1920	SSD	pnp,AJ,si	50	250	175	1.7	18	50	.005	–	7	–	TO-5
2N1921	SSD	pnp,AJ,si	50	250	175	1.7	50	50	2	–	7	–	TO-5
2N1922	SSD	pnp,AJ,si	50	250	175	1.7	80	50	2	–	7	–	TO-5
TR-320	IND	pnp,AJ,ge	50	150	85	2.5	30	200	7.5	–	20	2.5	2N320
2N214	SY	npn,AJ,ge	50-100	180	85	3	40	100	50	–	–	0.01	Matched
2N228	SY	npn,AJ,ge	50-100	50	75	1	40	100	100	–	–	0.01	
2N241A	SY	pnp,AJ,ge	50-100	200	85	3.3	30	200	16	–	–	10	
2N270	SY	pnp,AJ,ge	50-100	150	85	2.5	25	75	12	–	–	0.08	
2N321	SY	pnp,AJ,ge-	50-100	200	85	3.3	25	200	16	–	–	10	
2N1059	SY	npn,AJ,ge	50-100	180	75	3.6	20	100	50	–	–	0.01	
2N408	SY	pnp,AJ,ge	50-135	150	85	2.5	20	70	14	–	–	–	

Audio (continued)

Type No.	Mfg.	Type	h_{fe} or h_{FE}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics I_{co} μa	NF db	C_c μμf	f_{ae} mc	Remarks
2N109	SY	pnp,AJ,ge	50-150	50	85	0.9	25	75	12	–	–	–	
2N217	SY	pnp,AJ,ge	50-150	–	85	–	25	75	12	–	–	10	
2N323	SY	pnp,AJ,ge	50-150	140	85	2.3	16	100	16	–	–	800	
2N1374	SY	pnp,AJ,ge	50-150	150	100	2	25	200	100	–	–	–	TI
2N1375	SY	pnp,AJ,ge	50-150	150	100	2	45	200	100	–	–	–	TI
2N188A	GE	pnp,AJ,ge	54	200	85	4	25	200	16	–	40	1.2	
2N191	GE	pnp,AJ,ge	54	75	85	2	25	50	16	15	40	1.2	Driver
CK22B	RA	pnp,AJ,ge	54	75	65	1.25	35	100	10	6.5	–	–	Submin.
CK66B	RA	pnp,AJ,ge	54	75	85	1.25	35	100	10	–	–	–	Submin.
CK66C	RA	pnp,AJ,ge	54	75	85	1.25	35	100	10	–	–	–	Submin.
2N566	IND	pnp,AJ,ge	55	150	85	2.5	30	300	3	12	20	1	US
2N1097	GE	pnp,AJ,ge	55	140	85	4	16	100	16	–	25	–	Driver
2N1144	GE	pnp,AJ,ge	55	140	85	4	16	100	16	–	40	–	Driver
CK27A	RA	pnp,AJ,ge	55	80	85	–	15	400	2	–	14	11	micromin RF switch
OC54	AMP	pnp,AJ,ge	55	10	55	0.7	3	5	0.1	10	–	0.01	Hearing aid
OC58	AMP	pnp,PADT,ge	55	10	55	–	7	10	1.5	–	–	1.6	
2N226	PH	pnp,AJ,ge	60	250	75	5.0	30	150	8	–	140	0.4	
2N596	GI	npn,AJ,ge	60	150	85	1.67	20	–	2	16	15	6	Bilateral
2N633	IND	pnp,AJ,ge	60	150	85	2.5	35	200	10	–	–	0.8	RA, US
2N937	SSD	pnp,AJ,si	60	385	160	2.85	30	50	.005	18	70	3	TO-18
2N940	SSD	pnp,AJ,si	60	250	175	1.7	35	100	.001	–	7	3	
2N1475	SSD	pnp,AJ,si	60	250	175	1.7	60	100	.005	–	7	1	
OC60	AMP	pnp,PADT,ge	60	10	55	–	7	10	1.5	–	–	1.6	
2N526	SY	pnp,AJ,ge	64	225	85	3.7	45	500	10	–	–	3	GE, TS, MO
2N1925	GE	pnp,AJ,ge	64	225	85	–	40	500	4	–	–	–	
2N175	RCA	pnp,AJ,ge	65	50	–	–	10	2	12	6	–	0.85	
2N220	RCA	pnl,AJ,ge	65	50	–	–	10	2	12	6	–	0.85	
2N398A	MO	pnp,AJ,ge	65	150	100	2	105	200	12	–	–	1	
2N407	RCA	pnp,AJ,ge	65	150	–	–	20	70	14	–	–	–	SY
2N408	RCA	pnp,AJ,ge	65	150	–	–	20	70	14	–	–	–	
2N649	RCA	npn,AJ,ge	65	100	–	–	20	100	14	–	–	–	
2N1448	IND	pnp,AJ,ge	65	200	85	3.33	45	400	5	6	20	4	
2N1452	IND	pnp,AJ,ge	65	200	85	3.33	45	400	7.5	9	20	2.2	
OC56	AMP	pnp,AJ,ge	65	10	55	0.7	3	5	120	15	–	–	Hearing aid
OC74	AMP	pnp,PADT,ge	65	550	75	–	20	300	10	–	–	1.5	
2N323	GE	pnp,AJ,ge	68	140	85	4	16	100	16	–	25	2.5	Driver
2N281	AMP	pnp,PADT,ge	70	165	75	–	32	250	4.5	–	–	0.9	
2N361	IND	pnp,AJ,ge	70	150	85	2.5	45	200	10	–	–	–	RA, US
2N591	RCA	pnp,AJ,ge	70	100	–	–	32	40	7	–	–	–	SY
2N647	RCA	npn,AJ,ge	70	100	–	–	25	100	14	–	–	–	
2N735	TI	npn,MS,si	70	1.0	175	–	80	50	1	20	5	50	TO-18, TR, NA
2N739	TI	npn,DM,si	70	1w	175	–	125	70	1	–	–	–	
2N1247	TR	npn,DG,si	70	30	150	0.24	6	–	0.8	–	9	5	Low drift, dc amp.
2N1352	IND	pnp,AJ,ge	70	150	85	2.5	30	200	2.5	–	18	2.5	
2N1565	TI	npn,MS,si	70	1.2	175	–	80	50	1	20	5	50	TR, NA
2N1573	TI	npn,DM,si	70	1.2w	175	–	125	50	1	–	–	–	TR
2N213	SY	npn,AJ,ge	70-250	150	85	2.3	40	100	50	–	–	0.01	
2N1251	SY	npn,AJ,ge	70-250	150	85	2.5	20	100	50	–	–	7.5	
TR-383	IND	pnp,AJ,ge	72	200	85	3.33	25	200	7.5	–	20	1.8	2N383
2N241	GE	pnp,AJ,ge	73	100	85	3	25	200	16	–	40	1.3	
2N109	RCA	pnp,AJ,ge	75	150	–	–	25	70	14	–	–	–	
2N192	GE	pnp,AJ,ge	75	75	85	2	25	50	16	15	40	1.5	
2N217	RCA	pnp,AJ,ge	75	150	–	–	25	70	14	–	–	–	
2N1192	MO	pnp,AJ,ge	75	200	100	2.7	40	200	2	10	–	2	
2N1442	NA	pnp,AJ,si	75	400	200	2.28	50	100	0.01	12	25	1	audio/med. power
2N1672	GI	npn,AJ,ge	75	120	85	0.5	40	–	5	–	–	–	Trixie driver
GT-74	GI	pnp,AJ,ge	75	150	100	2	25	–	5	6	35	–	
GT-81	GI	pnp,AJ,ge	75	150	100	2	25	–	5	16	35	–	
TR-323	IND	pnp,AJ,ge	75	150	85	2.5	16	200	7.5	–	20	2.5	2N323
2N1376	SY	pnp,AJ,ge	75-150	150	100	2	25	200	100	–	–	–	
2N1431	SY	npn,AJ,ge	75-150	180	75	3.6	25	100	50	–	–	10	
2N1950	IND	npn,DM,si	75-250	600	175	4	20	–	0.01	–	–	–	
2N1951	IND	npn,DM,si	75-250	600	175	4	30	–	0.01	–	–	–	
2N1952	IND.	npn,DM,si	75-250	600	175	4	40	–	0.01	–	–	–	
2N120	TI	npn,GR,si	76-333	150	175	1	45	25	2	20	–	7	TR
2N336	TI	npn,GR,si	76-333	150	175	1	45	25	2	20	–	13	TR, GE, NA, RA
2N336A	NA	npn,MS,si	76-333	500	175	2.8	45	–	0.5	–	–	–	
2N760	NA	npn,DM,si	76-333	500	200	2.5	45	–	0.2	–	–	–	
2N760A	NA	npn,DM,si	76-333	500	200	2.5	60	–	0.1	–	–	–	
2N910	TI	npn,GR,si	76-333	150	175	1	45	25	2	20	–	7	2N1153
2N1153	NA	npn,DM,si	76-333	150	175	0.86	45	25	2	–	7	1	TR
2N185	TI	pnp,AJ,ge	80	150	85	0.0025	25	150	6	6.5	–	2	
2N321	GE	pnp,AJ,ge	80	225	85	4	20	200	16	–	25	3	
2N527	SY	pnp,AJ,ge	80	225	85	3.7	45	500	10	–	–	3.3	TS
2N651	MO	pnp,AJ,ge	80	200	100	2.8	45	500	3	5	–	2	US, SY

150 mw

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2N2048 GERMANIUM SWITCH

FOR FULL NEWS ON THIS NEW TRANSISTOR

SEE PAGE 9

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A revolutionary equipment development patented by Philco. Provides unequalled control over all production phases. Results in an inherent reliability possible only through automated production. To you concerned with reliability this means a *constant* output of reliable transistors.

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A widely acclaimed 5 million dollar transistor reliability assurance program. Surveys quality and reliability from initial design to final release of the finished product. A key factor in this project is the most advanced test equipment found anywhere . . . eliminates all test variables induced by operator techniques or errors. To you concerned with reliability this means the constant checking and eliminating of the factors that result in unreliable transistors.

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TRANSISTOR CENTER U.S.A.

TRANSISTORS – 196

Audio

Type No.	Mfg.	Type	h_{fe} or h_{FE}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v
2N651A	MO	pnp,AJ,ge	80	200	100	2.8	45
2N654	MO	pnp,AJ,ge	80	200	100	2.8	30
2N780	TI	npn,DM,si	80	1w	175	–	45
2N1187	MO	pnp,AJ,ge	80	200	100	2.7	60
2N1370	TI	pnp,AJ,ge	80	150	85	.0025	25
2N1371	TI	pnp,AJ,ge	80	150	85	.0025	25
2N1374	TI	pnp,AJ,ge	80	250	100	3.3	25
2N1375	TI	pnp,AJ,ge	80	250	100	3.3	45
2N1382	TI	pnp,AJ,ge	80	200	85	–	25
2N1449	IND	pnp,AJ,ge	80	200	85	3.33	45
2N1731	TI	npn,DM,si	80	2w	175	–	60
2N1926	GE	pnp,AJ,ge	80	225	85	–	40
CK28A	RA	pnp,AJ,ge	80	80	85	–	12
OC55	AMP	pnp,AJ,ge	80	10	55	0.7	3
OC59	AMP	pnp,PADT,ge	80	10	55	–	7
TR-321	IND	pnp,AJ,ge	80	150	85	2.5	30
2N543A	TR	npn,DG,si	80-200	200	200	–	45
2N527	GE	pnp,AJ,ge	81	225	100	4	45
2N324	GE	pnp,AJ,ge	85	140	85	4	16
2N224	PH	pnp,AJ,ge	90	250	75	5.0	25
2N466	MO	pnp,AJ,ge	90	200	100	2.5	35
2N1706	TS	–	90	200	100	–	25
2N1707	TS	–	90	200	100	–	30
CK22	RA	pnp,FA,ge	90	80	85	–	20
CK66	RA	pnp,FA,ge	90	80	85	–	20
CK66A	RA	pnp,AJ,ge	90	80	85	–	20
OC75	AMP	pnp,PADT,ge	90	115	75	–	30
2N1376	TI	pnp,AJ,ge	95	250	100	3.3	45
2N1377	TI	pnp,AJ,ge	95	250	100	3.3	45
2N207	PH	pnp,AJ,ge	100	50	65	1.25	12
2N207A	PH	pnp,AJ,ge	100	50	65	1.25	12
2N207B	PH	pnp,AJ,ge	100	50	65	1.25	12
2N360	RA	pnp,AJ,ge	100	150	85	2.5	20
2N362	IND	pnp,AJ,ge	100	150	85	2.5	20
2N534	PH	pnp,AJ,ge	100	25	65	1.43	50
2N535	PH	pnp,AJ,ge	100	50	85	0.83	20
2N535A	PH	pnp,AJ,ge	100	50	85	0.83	20
2N535B	PH	pnp,AJ,ge	100	50	85	0.83	20
2N568	IND	pnp,AJ,ge	100	150	85	2.5	30
2N632	IND	pnp,AJ,ge	100	150	85	2.5	30
2N736	TI	npn,MS,si	100	1.0	175	–	80
2N740	TI	npn,DM,si	100	1w	175	–	125
2N1124	PH	pnp,AJ,ge	100	300	85	5.0	40
2N1380	TI	pnp,AJ,ge	100	250	100	3.3	12
2N1381	TI	pnp,AJ,ge	100	250	100	3.3	25
2N1574	TI	npn,DM,si	100	1.2w	175	–	125
TR383	IND	pnp,AJ,ge	100	150	85	3	25
2N213A	SY	npn,AJ,ge	100-250	150	85	2.5	40
2N1944	IND	npn,DM,si	100-300	600	175	4	20
2N1945	IND	npn,DM,si	100-300	600	175	4	30
2N1946	IND	npn,DM,si	100-300	600	175	4	40
2N1947	IND	npn,DM,si	100-300	600	175	4	20
2N1948	IND	npn,DM,si	100-300	600	175	4	30
2N1949	IND	npn,DM,si	100-300	600	175	4	40
CK67B	RA	pnp,AJ,ge	108	75	95	1.25	35
CK67C	RA	pnp,AJ,ge	108	75	85	1.25	35
CK261	RA	npn,AJ,ge	54	75	85	1.25	35
CK262	RA	npn,AJ,ge	54	75	85	1.25	35
2N223	PH	pnp,AJ,ge	110	250	75	5.0	18
2N265	GE	pnp,AJ,ge	110	75	85	2	25
2N1705	TS	–	110	200	100	–	18
GT-109	GI	pnp,AJ,ge	110	150	100	2	25
2N508	GE	pnp,AJ,ge	112	140	85	4	16
2N1018	RA	pnp,AJ,ge	120	80	85	–	8
2N1128	PH	pnp,AJ,ge	120	150	85	2.5	25
TR-508	IND	pnp,AJ,ge	125	150	85	2.5	16
2N652	MO	pnp,AJ,ge	130	200	100	2.7	45
2N652A	MO	pnp,AJ,ge	130	200	100	2.8	45
2N655	MO	pnp,AJ,ge	130	200	100	2.8	30
2N1130	PH	pnp,AJ,ge	130	150	85	2.5	30
2N1188	MO	pnp,AJ,ge	130	200	100	2.7	60
2N359	RA	pnp,AJ,ge	150	150	85	2.5	45

DATA CHART

(continued)

Characteristics				Remarks	Type No.
o	NF db	C_c μμf	$f_{\alpha e}$ mc		
	15	–	2.0		2N651A
	10	–	2.0	US	2N654
6	–	–	–		2N780
	5	–	2		2N1187
	6.5	–	2.0		2N1370
	6.5	–	2.0		2N1371
	6.5	–	2		2N1374
	6.5	–	2		2N1375
11	6.5	–	2		2N1382
	6	20	5		2N1449
5	–	–	–		2N1731
	–	–	–		2N1926
	–	14	17	micromin RF switch	CK28A
1	10	–	0.01	Hearing aid	OC55
5	–	–	2.2		OC59
5	–	20	3.1	2N321	TR-321
02	20	7	15	100% reliability assurance processed.	2N543A
	6	25	3.3	MD	2N527
	–	25	3	Driver	2N324
	–	125	0.51		2N224
	15	–	1	US, GI, RA, SY	2N466
	–	–	3		2N1706
	–	–	3		2N1707
	6.5	–	1.2		CK22
	22	–	1.2		CK66
	22	–	1.2	micromin	CK66A
	–	–	0.75		OC75
	5.5	40	2		2N1376
	5.5	–	2		2N1377
	5	–	2		2N207
	2	–	2		2N207A
	2	–	2		2N207B
	–	–	1.2	IND, US	2N360
0	–	–	–	RA, US	2N362
	–	–	–		2N534
	5	–	2		2N535
	2	–	2		2N535A
	2	–	2		2N535B
	12	20	1.5	US	2N568
	–	–	1	RA, US, GI	2N632
	20	5	50	TO-18, TR, FA, NA	2N736
	–	–	–	TR	2N740
	–	–	1.0		2N1124
	5.5	40	2		2N1380
	5.5	40	2		2N1381
	–	–	–	TR	2N1574
	–	50	1.8	2N383	TR383
	–	–	10		2N213A
1	–	–	–		2N1944
01	–	–	–		2N1945
1	–	–	–		2N1946
	–	–	–		2N1947
01	–	–	–		2N1948
01	–	–	–		2N1949
	–	–	–	Submin.	CK67B
	–	–	–	Submin.	CK67C
	–	–	–	Submin.	CK261
	–	–	–	Submin.	CK262
	–	90	0.6		2N223
	15	40	1.5	Driver	2N265
	–	–	4		2N1705
	16	35	–		GT-109
	–	25	3.5	Driver	2N508
	–	14	25	micromin RF switch KF	2N1018
	–	45	1		2N1128
	–	20	3.5	2N508	TR-508
	5	–	2.5	SY	2N652
	15	–	2.5		2N652A
	10	–	2.5	US	2N655
	–	125	0.75		2N1130
	5	–	2.5		2N1188
	–	–	1	IND, US	2N359

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Audio

Type No.	Mfg.	Type	h_{fe} or h_{FE}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I (m…
2N570	IND	pnp,AJ,ge	150	150	85	2.5	30	[illegible]
2N631	IND	pnp,AJ,ge	150	150	85	2.5	25	[illegible]
2N1008A	SY	pnp,AJ,ge	150	400	85	6.6	40	[illegible]
2N1471	IND	pnp,AJ,ge	150	200	85	3.33	12	[illegible]
2N1193	MO	pnp,AJ,ge	160	200	100	2.7	40	[illegible]
2N467	MO	pnp,AJ,ge	180	200	100	2.5	35	[illegible]
CK67	RA	pnp,FA,ge	180	80	85	–	15	[illegible]
CK67A	RA	pnp,AJ,ge	180	80	85	–	15	[illegible]
2N1129	PH	pnp,AJ,ge	190	150	85	2.5	25	[illegible]
2N467	GI	pnp,AJ,ge	200	120	85	2	35	[illegible]
2N572	IND	pnp,AJ,ge	200	150	85	2.5	30	[illegible]
2N1378	TI	pnp,AJ,ge	200	250	100	3.3	12	[illegible]
2N1379	TI	pnp,AJ,ge	200	250	100	3.3	25	[illegible]
2N1185	MO	pnp,AJ,ge	260	200	100	2.7	45	[illegible]
2N1194	MO	pnp,AJ,ge	280	200	100	2.7	40	[illegible]
OCP70	AMP	pnp,AJ,ge	–	25	65	2.5	7.5	[illegible]
2N461	MO	pnp,AJ,ge	–	200	100	2.8	45	

Abbreviation

AJ	Alloy Junction
DD	Double Diffused
DG	Grown Diffused
DJ	Diffused Junction
DM	Diffused Mesa
DP	Diffused Planar
Dr	Drift
Ep	Epitaxial
FA	Fused Alloy
FJ	Fused Junction
GD	Grown Diffused
Ge	Germanium
GJ	Grown Junction
GR	Grown Rate
MB	Meltback
MD	MADT
Ms	Mesa
RG	Rate Grown

(concluded)

Characteristics				Remarks	Type No.
I_{co} μa	NF db	C_c μμf	f_{ab} mc		
3	12	20	2		2N570
10	–	–	1.2	RA	2N631
500	–	–	25	BE	2N1008A
2.5	–	18	5		2N1471
2	10	–	2.5		2N1193
6	–	–	1.2	IND, SY	2N467
2	22	–	1.5		CK67
2	22	–	–	micromin	CK67A
25	–	125	0.75		2N1129
10	16	40	0.5	MO, RA, US	2N467
3	12	20	3		2N572
3	4	40	3		2N1378
3	4	40	3		2N1379
5	5	–	3		2N1185
2	10	–	3		2N1194
325	–	–	–	Relay photo-tr.	OCP70
10	20	–	0.7	USAF	2N461

of Terms

Si Silicon
SBT Surface Barrier
C_{oe} = Collector-to-emitter capacitance measured across the output terminals with the input ac open-circuited.
f_{ae} = Frequency at which the magnitude of the forward-current transfer ratio (small-signal) is 0.707 of its low-frequency value.
f_t = Frequency at which common emitter gain is unity.
h_{fe} = Common emitter-small signal forward current transfer ratio.
h_{FE} = Common emitter-static value of short-circuited forward current ratio.
I_{co} = Collector current when collector junction is reverse-biased and emitter is dc open-circuited.

TRANSISTORS — 1961

High Frequency

Type No.	Mfg.	Type	$f_{\alpha e}$	Maximum Ratings					Characteristics				Remarks
				W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	h_{fe}	I_{co} µa	NF db	C_c µµf	
2N444A	GI	npn,AJ,ge	1	150	100	2	40	–	25	2	12	14	
2N1024	SSD	pnp,AJ,si	1	150	150	1.2	15	100	9	25	–	7	NA
2N1025	SSD	pnp,AJ,si	1	150	150	1.2	35	100	9-22	25	–	–	NA
2N94	SY	npn,AJ,ge	2	50	75	1	20	50	50	50	–	–	
2N139	SY	pnp,AJ,ge	2(min.)	80	85	.75	20	15	22-110	50	–	–	
2N169A	SY	npn,AJ,ge	2	65	75	.8	25	20	36-220	5	–	–	
2N193	SY	npn,AJ,ge	2	50	75	1	18	50	9	50	–	–	
2N194	SY	npn,AJ,ge	2	50	75	1	18	50	10	50	–	–	Mixer
2N194A	SY	npn,AJ,ge	2	50	75	1	18	50	10	50	–	–	Converter
2N211	SY	npn,AJ,ge	2	50	70	1.1	10	50	5-15	20	–	–	
2N233A	SY	npn,AJ,ge	2	50	75	1	18	50	30	50	–	–	
2N413A	SY	pnp,AJ,ge	2	150	85	2.5	15	200	–	10	–	–	GI
2N445	CBS	npn,AJ,ge	2	100	85	1.67	15	–		6	–	12	
2N515	SY	npn,AJ,ge	2	50	75	1	18	10	25-50	50	–	–	
2N516	SY	npn,AJ,ge	2	50	75	1	18	10	5-15	50	–	–	
2N517	SY	npn,AJ,ge	2	50	75	1	18	10	10-60	50	–	–	
2N519A	GI	pnp,AJ,ge	2	150	100	2	25	–	25	1	12	14	IND, KF
2N1026	SSD	pnp,AJ,si	2	150	150	1.2	35	100	18-44	25	–	7	
2N1469	SSD	pnp,AJ,si	2	150	150	1.2	35	100	36	25	–	7	
2N413	RA	pnp,FA,ge	2.5	150	85	–	18	200	30	2.0	7	–	IND, US, KF, GI
CK13	RA	pnp,FA,ge	2.5	80	85	–	18	200	30	2.0	7	–	
GK13A	RA	pnp,AJ,ge	2.5	80	85	–	18	200	30	2.0	7	–	Micromin
2N356	CBS	pnp,AJ,ge	3	100	85	1.67	20	–	–	5	–	12	RCA, GI, SY
2N438	CBS	npn,AJ,ge	3	100	85	1.67	30	–	–	10	–	12	GI
2N438A	CBS	npn,AJ,ge	3	150	85	2.5	30	–	–	10	–	12	GI, RA
2N445A	GI	npn,AJ,ge	3	150	100	2	30	–	70	2	12	14	
2N481	RA	pnp,AJ,ge	3	200	85	3	30	20	50	3	–	14	
2N482	IND	pnp,AJ,ge	3.5	150	85	2.5	14	200	50	3	–	12	RA, US
TR-482	IND	pnp,AJ,ge	3.5	150	85	2.5	14	200	20	3	–	12	
2N212	SY	npn,AJ,ge	4	50	75	1	18	50	20	50	–	–	Converter
2N385	CBS	npn,AJ,ge	4	150	100	2.0	25	–	–	35	–	4	SY, GI
2N414A	SY	pnp,AJ,ge	4	150	85	2.5	15	200	–	20	–	–	KF, GI
2N528	WE	pnp,DG,ge	4	1	100	.5	40	50	25	10	–	–	US, MIL only
2N1027	SSD	pnp,AJ,si	4	150	150	1.2	15	100	18	25	–	7	
2N1058	SY	npn,AJ,ge	4	50	75	1	18	–	15	50	–	–	Converter
2N94A	SY	npn,AJ,ge	5	50	85	.8	20	50	19	50	–	–	
2N168A	SY	npn,AJ,ge	5	65	85	1.1	15	20	23-135	5	–	–	
2N292	SY	npn,AJ,ge	5	65	85	.9	15	20	6-44	5	–	–	GE
2N395	RA	pnp,AJ,ge	5	150	85	–	25	–	40	2.0	–	12	TO-5 RF Switch
2N438	RA	npn,AJ,ge	5	100	85	–	25	400	25	3	–	9	TO-5 RF Switch
2N439	CBS	npn,AJ,ge	5	100	85	1.67	30	–	–	10	–	12	GT, SY
2N439A	CBS	npn,AJ,ge	5	150	85	2.5	30	–	–	10	–	12	RA
2N446	CBS	npn,AJ,ge	5	100	85	1.67	15	–	–	6	–	12	
2N448	GE	npn,RG,ge	5	65	85	1.1	15	20	25	5	–	2.4	
2N520A	GI	pnp,AJ,ge	5	150	100	2	25	–	100	1	12	14	IND, KF
2N634	CBS	npn,AJ,ge	5	150	85	2.5	20	–	–	5	–	12	GE
2N1090	CBS	npn,AJ,ge	5	120	85	2	25	–	–	8	–	12	
2N1681	TS	–	5	180	100	–	30	200	75	3	–	–	
2N483	RA	pnp,FA,ge	5.5	150	85	–	12	20	60	3.0	–	–	IND, US
2N357	CBS	npn,AJ,ge	6	100	85	1.67	20	–	–	5	–	12	RCA, GI, SY
2N377	CBS	npn,AJ,ge	6	150	100	2.0	25	–	–	5	–	12	SY
2N446A	GI	npn,AJ,ge	6	150	100	2	30	–	120	2	12	14	
OC45	AMP	pnp,PADT,ge	6	83	75	–	15	10	100	0.5	–	–	
ST4150	TR	npn,DJ,si	6	5.0	200	45	60	–	25	15	–	80	
2N139	RCA	pnp,AJ,ge	6.8	80	85	1	16	15	48	6	8	–	SY
2N218	RCA	pnp,AJ,ge	6.8	80	85	–	16	15	48	6	–	–	
2N409	RCA	pnp,AJ,ge	6.8	80	85	–	13	15	48	10	–	–	SY
2N410	RCA	pnp,AJ,ge	6.8	80	85	–	13	15	75	10	–	–	
2N414	RA	pnp,FA,ge	7	150	85	–	15	200	60	2.0	6	–	IND, US, TS, GE, RCA, SY, GI
2N439	RA	npn,AJ,ge	7	100	85	–	20	400	45	3	–	9	TO-5 RF Switch GI
2N1090	RA	npn,AJ,ge	7	150	85	–	18	100	50	3	–	9	TO-5 RF Switch
CK14	RA	pnp,FA,ge	7	80	85	–	15	200	60	2.0	6	–	
ST903	TR	npn,GR,si	7	150	150	1.0	30	–	16	0.1	25	7	
2N485	IND	pnp,AJ,ge	7.5	200	85	3	30	20	50	3	–	12	RA, US
2N168A	GE	npn,RG,ge	8	65	85	1.1	15	20	40	5	–	2.4	
2N169	GE	npn,RG,ge	8	65	85	1.1	15	20	72	5	–	2.4	
2N293	GE	npn,RG,ge	8	65	85	1.1	15	20	25	5	–	2.4	
2N388	CBS	npn,AJ,ge	8	150	100	2.0	25	–	–	5	–	12	GI, SY
2N396	RA	pnp,AJ,ge	8	150	85	–	20	–	60	2.0	–	12	TS
2N449	GE	npn,RG,ge	8	65	85	1.1	15	20	72	5	–	2.4	
2N471A	TR	npn,GJ,si	8	200	200	–	30	25	10-25	.02	22	7	
2N472A	TR	npn,GJ,si	8	200	200	–	45	25	10-25	.02	22	7	
2N581	RA	pnp,AJ,ge	8	100	85	–	15	100	30	3	–	12	TO-5 RF Switch
2N1086	GE	npn,RG,ge	8	65	85	1.1	9	20	40	3	–	2.4	
2N1086A	GE	npn,RG,ge	8	65	85	1.1	9	20	40	3	–	2.4	

High Frequency (continued)

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c V	I_c ma	Characteristics h_{fe}	I_{co} μa	NF db	C_c μμf	Remarks
2N1087	GE	npn,RG,ge	8	65	85	1.1	9	20	40	3	–	2.4	
2N1121	GE	npn,RG,ge	8	65	85	1.1	15	20	72	5	–	2.4	
S500	SSD	pnp,AJ,si	8	150	150	1.2	25	100	9	25	–	7	
2N358	CBS	npn,AJ,ge	9	100	85	1.67	20	–	–	5	–	12	GI, SY
2N447	CBS	npn,AJ,ge	9	100	85	1.67	15	–	–	6	–	12	
2N521A	GI	pnp,AJ,ge	9	150	100	2	25	–	150	1	12	14	
ST904	TR	npn,GR,si	9	150	150	1.0	30	–	31	0.1	25	7	
2N140	RCA	pnp,AJ,ge	10	80	85	–	16	15	75	6	8	–	SY
2N219	RCA	pnp,AJ,ge	10	80	85	–	16	15	75	6	–	–	
2N411	RCA	pnp,AJ,ge	10	80	85	–	13	15	75	10	–	–	SY
2N414B	IND	pnp,AJ,ge	10	200	85	2.5	14	200	90	3	–	12	IND, KF
2N416	RA	pnp,FA,ge	10	150	85	–	12	200	80	2.0	4	–	IND, US, GI, TS, KF
2N440	CBS	npn,AJ,ge	10	100	85	1.67	30	–	–	10	–	12	GI, SY, RA
2N440A	CBS	npn,AJ,ge	10	150	85	2.5	30	–	–	10	–	12	GI, RA
2N447A	GI	npn,AJ,ge	10	150	100	2	30	–	150	2	12	14	
2N473	TR	npn,GR,si	10	200	200	–	15	25	20-50	.02	20	7	
2N474	TR	npn,GR,si	10	200	200	–	30	25	20-50	.02	20	7	
2N474A	TR	npn,GJ,si	10	200	200	–	30	25	20-50	.02	20	7	
2N475	TR	npn,GR,si	10	200	200	–	45	25	20-50	.02	20	7	
2N479A	TR	npn,GJ,si	11	200	200	–	30	25	40-100	.02	20	7	
2N484	RA	pnp,FA,ge	10	150	85	–	12	20	90	3.0	–	–	US
2N635	CBS	npn,AJ,ge	10	150	85	2.5	20	–	–	5	–	12	GE
2N1091	CBS	npn,AJ,ge	10	120	85	2	25	–	--	8	–	12	
CK16	RA	pnp,FA,ge	10	80	85	–	12	200	80	2.0	4	–	
GK16A	RA	pnp,AJ,ge	10	80	85	–	12	200	80	2.0	4	–	Micromin
ST905	TR	npn,GR,si	10	150	150	1.0	30	–	65	0.1	25	7	
2N118A	TR	npn,GR,si	11	150	175	–	30	25	19-90	0.1	27	7	JAN, TI
2N478	TR	npn,GR,si	11	200	200	–	15	25	40-100	0.2	20	7	
2N479	TR	npn,GR,si	11	200	200	–	30	25	40-100	.02	20	7	
2N480	TR	npn,GR,si	11	200	200	–	45	25	40-100	.02	20	7	
2N1417	TR	npn,GR,si	11	150	150	–	15	25	30-200	0.1	19	7	
2N1418	TR	npn,GR,si	11	150	150	–	30	25	30-200	0.1	19	7	
ST15	TR	npn,GR,si	11	200	200	–	15	25	10-100	.02	22	7	
ST35	TR	npn,GR,si	11	200	200	–	30	25	10-100	.02	22	7	2N332
ST45	TR	npn,GR,si	11	200	200	–	45	25	10-100	.02	22	7	
ST904A	TR	npn,GR,si	11	150	150	1.0	30	–	60	0.1	25	7	
ST910	TR	npn,GR,si	11	150	150	1.0	30	–	140	0.1	20	7	
2N397	RA	pnp,AJ,ge	12	150	85	–	15	–	80	2.0	–	12	TO-5, RF Switch, KF
2N486	IND	pnp,AJ,ge	12	–	85	3	30	20	100	3	–	12	RA, US
2N751	RA	npn,DJ,si	12	150	+175	0.75	20	50	4	0.01	–	6	
2N1390	RA	npn,DJ,si	12	300	+175	0.5	20	50	4	0.01	–	6	
2N541	TR	npn,GR,si	15	200	200	–	15	25	80-200	.02	20	7	NA
2N542	TR	npn,GR,si	15	200	200	–	30	25	80-200	.02	20	7	NA
2N542A	TR	npn,GJ,si	15	200	200	–	30	25	80-200	.02	20	7	
2N543	TR	npn,GR,si	15	200	200	–	45	25	80-200	.02	20	7	NA
2N636	CBS	npn,AJ,ge	15	150	85	2.5	20	–	–	5	–	12	GE
2N1091	RA	npn,AJ,ge	15	150	85	–	15	100	70	3	–	9	TO-5 RF switch
OC44	AMP	pnp,PADT,ge	15	83	75	–	15	10	100	0.5	–	–	
2N476	TR	npn,GJ,si	17	200	200	–	15	25	30-60	.02	19	8	
2N477	TR	npn,GJ,si	17	200	200	–	30	25	30-60	.02	19	8	
2N522A	GI	pnp,AJ,ge	17	150	100	2	25	–	200	1	12	14	KF
2N582	RA	pnp,AJ,ge	18	100	85	–	14	100	60	3	–	12	TO-5 RF switch
2N1118	PH	pnp,SAT,si	18	150	140	1.3	25	50	20	.002	–	6	SPR
2N1118A	PH	pnp,SAT,si	18	150	140	1.3	25	50	25	1.0	–	6	SPR
2N232	PH	pnp,SBT,ge	20	9	55	0.9	.5	3	39	6	–	6	SPR
2N417	RA	pnp,FA,ge	20	150	85	–	10	200	140	2.0	4	–	IND, US, GI, TS
2N602	GI	pnp,Dr,ge	20	120	85	2	20	–	–	3	14	4	
CK17	RA	pnp,FA,ge	20	80	85	–	10	200	140	2.0	4	–	
CK17A	RA	pnp,AJ,ge	20	80	85	–	10	200	140	2.0	4	–	micromin
2N495	PH	pnp,SA,si	21	150	140	1.3	25	50	20	.002	–	7	
2N523A	GI	pnp,AJ,ge	23	150	100	2	20	–	300	1	12	14	IND
2N1428	PH	pnp,SAT,si	23	100	140	0.86	6	50	45	.001	–	7	
2N1429	PH	pnp,SAT,si	23	100	140	0.86	6	50	45	.001	–	7	
2N1065	GI	pnp,Dr,ge	25	120	85	2	40	–	–	4	12	3	
2N1900	PSI	npn,DM,si	25	125w	150	1000	140	5a	10	20ma	–	0.1	hi freq., hi pwr.
2N1901	PSI	npn,DM,si	25	125w	150	1000	140	5	19	20ma	–	1	hi freq., hi pwr.
2N274	RCA	pnp,Dr,ge	30	80	85	–	35	10	60	16	–	–	
2N370	RCA	pnp,Dr,ge	30	80	85	–	20	10	60	20	–	–	SY
2N371	RCA	pnp,Dr,ge	30	80	85	–	20	10	–	20	–	–	SY
2N372	RCA	pnp,Dr,ge	30	80	85	–	20	10	60	20	–	–	Mixer, SY
2N373	RCA	pnp,Dr,ge	30	80	85	–	25	10	60	8	–	–	SY
2N374	RCA	pnp,Dr,ge	30	80	85	–	25	10	60	8	–	–	converter, SY
2N1109	TI	pnp,GD,ge	30	30	85	.5	16	5	–	5	–	1.5	
2N1224	SY	pnp,DD,ge	30	120	100	1.6	40	10	20-175	12	–	–	
2N1224	RCA	pnp,Dr,ge	30	120	85	–	40	10	60	12	–	–	
2N1226	RCA	pnp,Dr,ge	30	120	85	–	60	10	60	16	–	–	

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High Frequency (continued)

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics h_{fe}	I_{co} μa	NF db	C_c μμf	Remarks
2N1395	RCA	pnp,Dr,ge	30	120	85	–	40	10	90	16	–	–	
2N1750	PH	pnp,SBT,ge	30	15	75	0.5	14	5	–	2	–	6	
2N1425	RCA	pnp,Dr,ge	33	80	71	–	24	10	50	12	–	–	
2N1426	RCA	pnp,Dr,ge	33	80	71	–	24	10	130	12	–	–	
2N1524	RCA	pnp,Dr,ge	33	80	71	0.4	24	10	60	16	–	2	
2N1525	RCA	pnp,Dr,ge	33	80	71	0.4	24	10	60	16	–	2	
2N1526	RCA	pnp,Dr,ge	33	80	71	0.4	24	10	130	16	–	–	
2N1527	RCA	pnp,Dr,ge	33	80	71	0.4	24	10	130	16	–	–	
2N1108	TI	pnp,GD,ge	35	30	85	0.5	16	5	–	5	–	1.5	
2N1110	TI	pnp,GD,ge	35	30	85	0.5	16	5	–	5	–	1	
2N1111	TI	pnp,GD,ge	35	30	85	0.5	20	5	–	5	–	1.5	
2N1111A	TI	pnp,GD,ge	35	30	85	0.5	20	5	–	5	–	1.5	
2N1111B	TI	pnp,GD,ge	35	30	85	0.5	20	5	–	5	–	1.5	
2N603	GI	pnp,Dr,ge	40	120	85	2	30	–	–	3	14	3	
2N750	RA	npn,DJ,si	40	150	175	0.75	50	50	7	10	–	6	
2N1107	TI	pnp,GD,ge	40	30	85	0.5	16	5	–	5	–	1.5	
2N1389	RA	npn,DJ,si	40	300	175	0.5	50	50	7	10	–	6	
2N1633	RCA	pnp,Dr,ge	40	80	71	0.4	34	10	75	16	–	–	
2N1634	RCA	pnp,Dr,ge	40	80	71	0.4	34	10	75	16	–	–	
2N1638	RCA	pnp,Dr,ge	40	80	71	0.4	34	10	75	7	–	2	
2N3746	RCA	pnp,Dr,ge	40	80	71	–	34	20	.985	16	–	3.8	
2N640	RCA	pnp,Dr,ge	42	80	85	0.75	34	10	60	5	–	–	
2N641	RCA	pnp,Dr,ge	42	80	85	0.75	34	10	60	7	–	–	
2N642	RCA	pnp,Dr,ge	42	80	85	0.75	34	10	60	7	–	–	
2N754	TR	npn,DJ,si	44	300	175	–	60	50	20-80	1	–	8	
2N755	TR	npn,DJ,si	44	300	175	–	100	50	20-80	1	–	8	
2N839	TR	npn,DJ,si	44	300	175	–	45	25	20-45	0.1	15	–	TMT839 (150mw)
2N840	TR	npn,DJ,si	44	300	175	–	45	25	40-90	0.1	15	8	TMT840 (150mw)
TMT842	TR	npn,DJ,si	44	150	175	–	45	25	20	0.1	–	6	
2N1196	HU	pnp,MS,si	45	385	200	2	70	.25	–	4	–	4	
2N1631	RCA	pnp,Dr,ge	45	80	71	0.4	34	10	80	16	–	2	
2N1632	RCA	pnp,Dr,ge	45	80	71	0.4	34	10	80	16	–	2	
2N1635	RCA	pnp,Dr,ge	45	80	71	0.4	34	10	75	16	–	–	
2N1636	RCA	pnp,Dr,ge	45	80	71	0.4	34	10	75	16	–	–	
2N1637	RCA	pnp,Dr,ge	45	80	71	0.4	34	10	80	5	–	–	
2N1639	RCA	pnp,Dr,ge	45	80	71	0.4	34	10	75	7	–	2	
2N248	TI	pnp, GD,ge	50	30	75	0.6	25	5	20	5	–	1.2	
2N344	PH	pnp,SB,ge	50	20	55	1.33	5	5	22	0.7	–	3	SPR
2N345	PH	pnp,SA,ge	50	20	55	1.33	5	5	35	0.7	–	3	SPR
2N393	PH	pnp,MA,ge	50	25	100	0.63	6	50	155	5	–	2	SPR,GI
2N604	GI	pnp,Dr,ge	50	120	85	2	30	–	–	4	14	3	
2N1899	PSI	npn,DM,si	50	125w	150	1000	140	10a	10	10ma	–	6	hi freq., hi pwr
3N36	GE	npn,MB,ge	50	30	85	0.5	6	20	2.2	3	–	2	tetrode
PT900	PSI	npn,DM,si	50	125w	150	1000	80	10a	3	10ma	–	1	hi freq. hi powr.
PT901	PSI	npn,Ms,si	50	125w	150	1000	140	10a	10	30	–	1	Hi frequency, high power
2N1197	HU	pnp,Ms,si	55	385	200	2	70	–	–	–	–	4	
2N128	PH	pnp,SB,ge	60	25	85	0.4	10	5	40	0.6	10	2.5	SPR
2N749	RA	npn,DJ,si	60	150	175	0.75	45	50	10	10	–	6	
2N1388	RA	npn,DJ,si	60	300	175	0.5	45	50	10	10	–	6	
2N841	TR	npn,DJ,si	64	300	175	–	45	25	80-330	0.1	15	8	TMT841 (150 mw)
TMT843	TR	npn,DJ,si	64	150	175	–	45	25	40	0.1	–	6	
2N1516	AMP	pnp,PADT,ge	70*	83	–	1.7	20	10	100	–	–	–	*f_T, RF-IF
2N1517A	AMP	pnp,PADT,ge	70*	100	–	1.7	40	10	150	–	–	–	*f_T,
PADT20	AMP	pnp,PADT,ge	70*	83	–	1.7	20	10	150	–	–	–	*f_T, RF amp
PADT21	AMP	pnp,PADT,ge	70*	83	–	1.7	20	10	150	–	–	–	*f_T, Converter
PADT22	AMP	pnp,PADT,ge	70*	83	–	1.7	20	10	150	–	–	–	*f_T, IF amp
PADT23	AMP	pnp,PADT,ge	70*	100	–	1.7	35	10	150	–	–	–	*f_T, RF amp
PADT24	AMP	pnp,PADT,ge	70*	100	–	1.7	35	10	150	–	–	–	*f_T, IF amp
PADT25	AMP	pnp,PADT,ge	70*	–	–	– –	–	–	–	–	–	–	*f_T, IF amp
PADT26	AMP	pnp,PADT,ge	70*	–	–	–	–	–	–	–	–	–	*f_T, RF amp
PADT27	AMP	pnp,PADT,ge	70*	100	–	1.7	35	10	150	–	–	–	*f_T, osc
PADT31	AMP	pnp,PADT,ge	70*	100	–	1.7	35	10	–	–	–	–	*f_T, Mixer osc.
2N346	PH	pnp,SB,ge	75	20	55	1.3	5	5	35	0.7	–	3	SPR
2N696	FA	npn,DP,si	80	2w	175	13.3	40	–	40	0.1	–	18	RH, PSI, HO, TR, TI, IND, SY, SSD, NA
2N698	FA	npn,DP,si	80	2w	175	13.3	80	–	30	0.1	–	12	RH, IND, TR, NA
2N699	FA	npn,DP,si	80	2w	175	13.3	80	–	65	.01	–	12	RH, NA
2N706	FA	npn,DP,si	80	1w	175	6.7	28	–	12	.005	–	5	RH, NA
2N1252	FA	npn,DP,si	80	2w	175	13.3	20	–	35	0.1	–	30	RH, TR
2N844	TR	npn,DJ,si	86	300	175	–	60	50	40-120	1	–	8	
2N845	TR	npn,DJ,si	86	300	175	–	100	50	40-120	1	–	8	
3N37	GE	npn,MB,ge	90	30	85	0.5	6	20	1.1	3	–	1.5	tetrode
2N384	RCA	pnp,Dr,ge	100	80	85	–	30	10	60	16	–	–	
2N697	FA	npn,DP,si	100	2w	175	13.3	40	–	75	.01	–	18	RH, PSI, HO, TR, SSD, SY, NA

DATA CHART

High Frequency (continued)

Type No.	Mfg.	Type	$f_{\alpha e}$	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics h_{fe}	I_{co} μa	NF db	C_c μμf	Remarks
2N1180	RCA	pnp,Dr,ge	100	80	71	–	30	10	80	12	–	–	
2N1225	RCA	pnp,Dr,ge	100	120	85	–	40	10	60	12	–	–	
2N1253	FA	npn,DP,si	100	2w	175	13.3	20	–	45	0.1	–	30	RH
2N1396	RCA	pnp,Dr,ge	100	120	85	–	40	10	90	16	–	–	
2N1420	FA	npn,DP,si	100	2w	175	13.3	30	–	130	0.1	–	20	RH, NA
2N1613	FA	npn,DP,si	100	3w	200	17.2	50	–	80	.0004	–	18	RH
2N1748	PH	pnp,MD,ge	100	60	100	.8	25	–	45	1.5		1.3	
2N1748A	PH	pnp,MD,ge	100	60	100	.8	25	50	70	1.5	–	1.3	
2N1749	PH	pnp,MD,ge	100	75	100	1	40	10	45	1.5	–	1.3	
3N34	TI	npn,GD,si	100	125	150	1	30	20	4	0.4	20	–	tetrode
OC171	AMP	pnp,DJ,ge	100	60	75	2	20	5	–	2	–	–	
2N1752	PH	pnp,MD,ge	106	60	100	.8	12	50	250	0.8	–	1	
2N497	RH	npn,MS,si	120	4w	175	26.5	60	500	25	0.1	–	20	NA, GE
2N498	RH	npn,MS,si	120	4w	175	26.5	100	500	25	0.1	–	20	NA, GE
2N656	RH	npn,MS, si	120	4w	175	26.5	60	500	60	0.1	–	20	NA, GE
2N657	RH	npn,MS, si	120	4w	175	26.5	100	500	60	0.1	–	20	NA, GE
2N1023	RCA	pnp,Dr,ge	120	120	85	–	40	10	60	12	–	–	
2N1066	RCA	pnp,Dr,ge	120	120	85	–	40	10	60	12	–	–	
2N1397	RCA	pnp,Dr,Ge	120	120	85	–	40	10	90	16	–	–	
2N1409	RH	npn,MS,si	120	2.8w	150	22.5	30	500	30	0.1	–	20	PSI
2N1410	RH	npn,MS,si	120	2.8w	150	22.5	30	500	50	0.1	–	20	PSI
2N1420	RH	npn,DD,si	120	2w	175	13.2	60	500	200	.003	–	20	PSI, TR, GI
2N1507	RH	npn,DD,si	120	2w	175	13.2	60	500	200	.003	–	20	TI
PT600	PSI	npn,DM,si	120	13w	175	86.7	60	–	12	1		40	hi freq, hi pwr.
PT601	PSI	npn,DM,si	120	13w	175	86.7	60	–	14	1	–	40	hi freq. hi pwr,
RT5001	RH	npn,MS,si	120	3w	175	20	60	1000	40	0.1	–	30	
RT5002	RH	npn,MS,si	120	3w	175	20	60	1000	60	0.1	–	30	
RT5003	RH	npn,MS,si	120	3w	175	20	100	1000	40	0.1	–	30	
RT5004	RH	npn,MS,si	120	3w	175	20	100	1000	60	0.1	–	30	
2N715	TI	npn,MS,si	125	1.2w	175	8	50	–	1	.001	–	3	h_{FE} 10–50, NA
2N716	TI	npn,MS,si	125	1.2w	175	8	70	–	1	.001	–	3	h_{FE} 10–50, NA
2N1785	PH	pnp,MD,ge	125	45	85	.75	10	50	–	2	–	1.5	
2N1786	PH	pnp,MD,ge	125	45	85	.75	10	50	–	2	–	1.7	
2N1787	PH	pnp,MD,ge	125	45	85	.75	15	50		1.5	–	1.5	
2N1864	PH	pnp,MD,ge	125	60	100	.8	20	50	60	1.5	–	1.6	
2N1177	RCA	pnp,Dr,ge	140	80	71	–	30	10	100	12	–	–	
2N1178	RCA	pnp,Dr,ge	140	80	71	–	30	10	40	12	–	–	
2N1179	RCA	pnp,Dr,ge	140	80	71	–	30	10	80	12			
2N728	TR	npn,JD,si	150	300	175	–	15	25	20	.25	–	8	
2N729	TR	npn,DJ,si	150	300	175	–	30	25	20	.25	–	8	
2N1505	PSI	npn,MS,si	150	3w	175	0.2	50	–	7	–	–	1.5	high freq., high power
2N1726	PH	pnp,MD,ge	150	60	100	0.8	20	50	–	1.5	–	1.5	
2N1727	PH	pnp,MD,ge	150	60	100	0.8	20	50	–	1.5	–	1.5	
2N1728	PH	pnp,MD,ge	150	60	100	0.8	20	50	–	1.5	–	1.5	
2N1788	PH	pnp,MD,ge	150	60	100	0.8	35	50	–	1.5	–	1.5	
2N1789	PH	pnp,MD,ge	150	60	100	0.8	35	50	–	1.5	–	1.5	
2N1790	PH	pnp,MD,ge	150	60	100	0.8	35	50	–	1.5	–	1.5	
3N35	TI	npn,GD,si	150	125	150	1	30	20	4	0.4	14	–	Tetrode
2N1335	PSI	npn,MS,si	170	2.8w	150	24	120	75	13	8	–	4	High freq., high power
2N1336	PSI	npn,MS,si	170	2.8w	150	24	120	75	13	8	–	4	High freq., high power
2N1337	PSI	npn,MS,si	170	2.8w	150	24	120	75	13	8	–	4	High freq., high power
PADT30	AMP	pnp,PADT,ge	200*	83	–	1.7	25	10	–	–	–	–	*fT
2N1506	PSI	npn,MS,si	210	3w	175	.2	60	9	–	–	–	8	High frequency, high power
2N1339	PSI	npn,MS,si	220	2.8w	150	24	120	75	–	8	–	4	High freq., hogh power
PADT28	AMP	pnp,PADT,ge	220*	100	–	1.7	35	10	120	–	–	–	*fT, RF amp
2N1746	PH	pnp,MD,ge	235	60	100	.8	20	50	–	2	–	3	
2N1709	PSI	npn,DM,si	240	13w	175	86.7	75	1.2a	–		–	40	Hi freq., hi pwr.
2N1710	PSI	npn,DM,si	240	13w	175	86.7	60	1.2a	–	50	–	40	Hi freq., hi pwr.
2N588	PH	npn,MD,ge	250	30	85	0.75	15	50	–	1.8	3.8	–	SPR, GI
2N710	MO	pnp,MS,ge	250	300	100	4	15	50	40	.2	–	–	TI
2N1340	PSI	npn,MS,si	250	28w	2.8w	24	120	75	–	8	–	4	High freq., high power
2N1491	RCA	npn,MS,si	250	3w	175	20	30	50	50	10	–	–	
2N1837	PSI	npn,DM,si	250	2w	175	13.3	80	–	9	.001	–	11	Hi freq., hi power
2N1837A	PSI	npn,DM,si	250	2.8w	175	18.6	80	–	9	.001	–	11	Hi freq., hi power
2N1838	PSI	npn,DM,si	250	2w	175	13.3	45	–	9	0.1	–	9	Hi freq., hi power
2N1838A	PSI	npn,DM,si	250	2.8w	175	18.6	45	–	9	0.1	–	9	Hi freq., hi pwr.
2N1839	PSI	npn,DM,si	250	2w	175	13.3	45	–	9	0.1	–	9	Hi freq., hi pwr.
2N1839A	PSI	npn,DM,si	250	2.8w	175	18.6	45	–	9	0.1	–	9	Hi freq., hi pwr.
2N502A	PH	pnp,MD,ge	260	75	100	1.0	30	–	–	1.3	6	1.0	
2N502	PH	pnp,MD,ge	260	60	85	1.0	20	–	–	1	–	1.0	
2N1492	RCA	npn,MS,si	275	3w	175	20	60	50	50	10	–	–	
2N1341	PSI	npn,MS,si	280	2.8w	150	24	120	75	–	8	–	4	High freq., high power
2N695	MO	pnp,DM,ge	300	75	100	1	15	50	40	0.2	–	3.5	GE
2N1493	RCA	npn,MS,si	300	3w	175	20	100	50	50	10	–	–	

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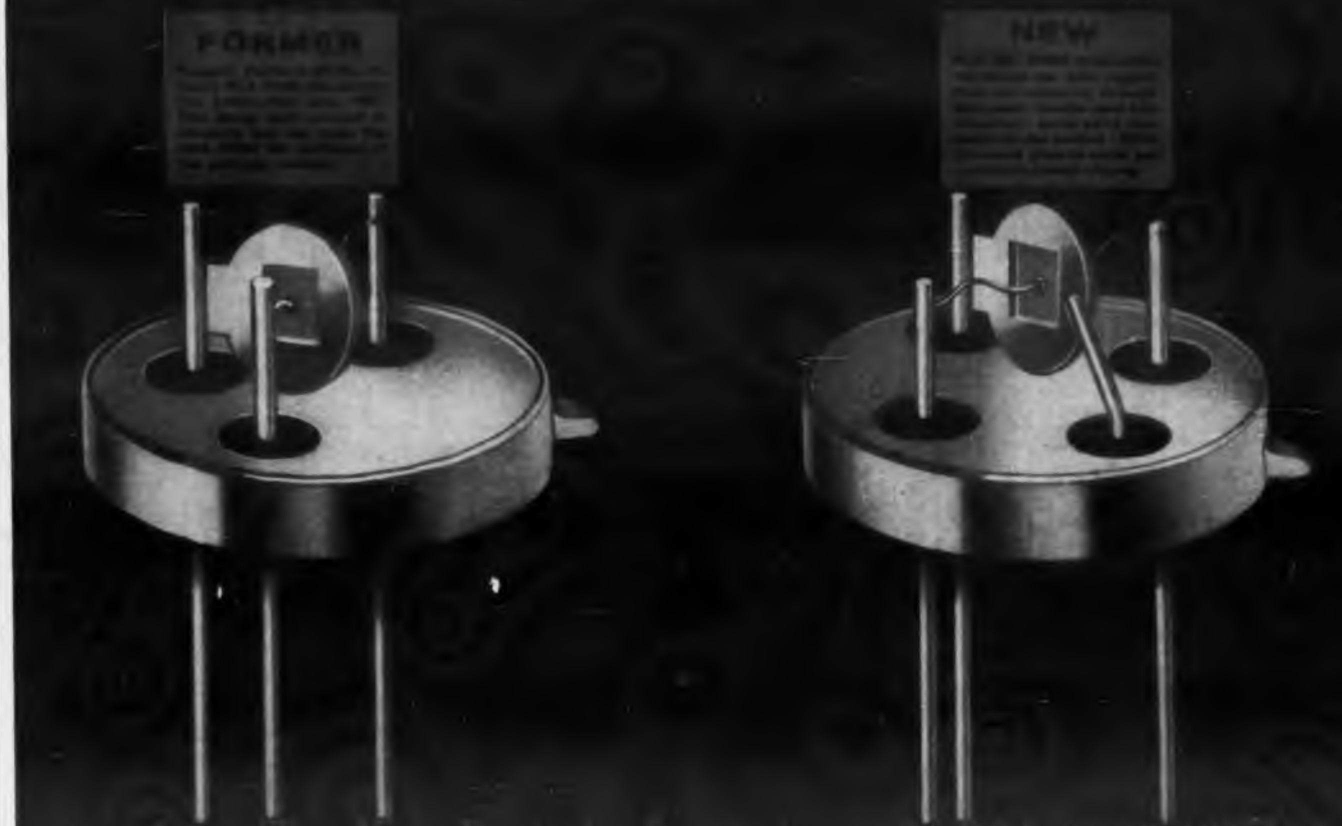

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COLLECTOR-TO-BASE-VOLTAGE	−25 MAX
COLLECTOR-TO-EMITTER VOLTAGE with $V_{EB} = -1v$	−24 MAX
EMITTER-TO-BASE VOLTAGE	−12 MAX
COLLECTOR CURRENT	−200 MAX
EMITTER CURRENT	200 MAX
TRANSISTOR DISSIPATION: At ambient temperature of: 25°C 55°C 71°C	 150 MAX 75 MAX 35 MAX
AMBIENT TEMPERATURE RANGE: Operating Storage	 −65 to +85°C −65 to +100°C
LEAD TEMPERATURE: For immersion in molten solder for 10 seconds max.	255 MAX °C

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TRANSISTORS – 1961

High Frequency (continued)

Type No.	Mfg.	Type	fαe	Maximum Ratings P_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics h_{fe}	I_{co} μa	NF db	C_c μμf	Remarks
2N503	PH	pnp,MD,ge	320	25	85	0.63	20	50	4.2	3	–	1.0	
2N499	PH	pnp,MD,ge	340	30	85	0.75	30	50	8.5	1.0	–	1.3	GI
2N741	MO	pnp,MS,ge	360	300	100	4	15	100	25	.2	7	6	Amp VHF
2N741A	MO	pnp,DM,ge	360	300	100	4	20	100	25	0.2	7	6	
2N1407	TI	pnp,MS,ge	375	75	100	1	30	50	6	2	7	–	
2N919	PSI	npn,DM,si	400	1.2w	100	6.7	25	220	4	.005	–	5	
2N920	PSI	npn,DM,si	400	1.2w	200	6.7	25	220	4	.005	–	5	
2N921	PSI	npn,DM,si	400	1.2w	200	6.7	50	200	4	.005	–	4	
2N922	PSI	npn,DM,si	400	1.2w	200	6.7	50	200	4	.005	–	4	
2N1405	TI	pnp,MS,ge	450	75	100	1	30	50	8	2	5	–	
2N1406	TI	pnp,MS,ge	450	75	100	1	30	50	8	2	6	–	
2N1143	TI	pnp,DB,ge	480	750	100	10	25	100	8	.7	–	1.5	PG=22db @ 200mc
2N1562	MO	pnp,MS,ge	500	3w	100	40	25	500	10db	1.5	–	7	High freq., high power
2N1561	MO	pnp,MS,ge	500	3w	100	40	25	500	10db	1.5	–	7	High freq., high power
2N700	MO	pnp,DM,ge	600	75	100	1	25	50	10db	0.4	6	1.1	UHF Amp.
2N700A	MO	pnp,DM,ge	600	75	100	1	25	50	5db200mc	0.4	6	1.1	MIL
2N1142	TI	pnp,DB,ge	600	750	100	10	30	100	10	0.7	–	1.5	PG=26db @ 200mc
2N1645	WE	pnp,DJ,ge	700	–	100	12.5	35	0.3	50	.0015	–	10	
2N537	WE	pnp,DG,ge	750	250	100	.3	–	100	10	2	–	2.8	U.S. MIL only
2N1094	WE	pnp,DM,ge	750	150	100	0.3	–	40	13	1.2	–	4	U.S., MIL only
2N1141	TI	pnp,DB,ge	750	750	100	10	35	100	12	0.7	–	1.5	PG=30db @ 200mc
2N1195	WE	pnp,DM,ge	750	250	100	0.3	30	40	13	1.2	–	4	HO
2N218	SY	pnp,AJ,ge	–	80	85	1.3	20	–	22-110	50	–	–	
2N231	PH	pnp,SBT,ge	—	9	55	0.9	4.5	3	66	3	–	–	SPR
2N233	SY	npn,AJ,ge	–	50	75	1	10	50	10	50	–	–	
2N247	SY	pnp,Dr,ge	–	.080	100	1	40	10	20-175	50	–	–	
2N312	CBS	npn,AJ,ge	–	75	85	–	15	–	–	60	–	12	SY, GI
2N410	SY	pnp,AJ,ge	–	50	75	1	20	–	22-110	5	–	–	
2N504	SPR	pnp,MD,ge	–	30	85	–	35	50	16	100	–	–	
2N544	SY	pnp,DJ,ge	–	80	85	1.3	18	10	20-175	4	–	–	
2N624	SY	pnp,DJ,ge	–	100	100	1.3	20	–	20	30	–	–	
2N706C	SY	npn,DM,si	–	360	200	2	40	50	20-60	.025	–	–	
2N743	SY	npn,MS,si	–	300	175	2	20	200	20-60	1	–	–	Epitaxial
2N744	SY	npn,MS,si	–	300	175	2	20	200	40-120	1	–	–	Epitaxial
2N753	PSI	npn,MS,si	–	1w	175	6.7	25	50	–	0.5	–	5	
2N768	SPR	pnp,MD,ge	–	35	100	–	12	100	40	1	–	–	PH
2N769	SPR	pnp,MD,ge	–	35	100	–	12	100	55	0.3	–	–	PH
2N773	PH	npn,SA,si	–	150	150	1.2	20	100	11	0.1	–	1.3	
2N774	PH	npn,SA,si	–	150	150	1.2	20	100	20	0.1	–	1.3	
2N775	PH	npn,SA,si	–	150	150	1.2	20	100	50	0.1	–	1.3	
2N776	PH	npn,SA,si	–	150	150	1.2	20	100	11	0.1	–	1.3	
2N777	PH	npn,SA,si	–	150	150	1.2	20	100	20	0.1	–	1.3	
2N778	PH	npn,SA,si	–	150	150	1.2	20	100	50	0.1	–	1.3	
2N781	SY	pnp,MS,ge	–	150	100	2	15	200	25	3	–	–	Epitaxial
2N782	SY	pnp,MS,ge	–	150	100	2	12	200	20	3	–	–	Epitaxial
2N783	SY	npn,MS,si	–	300	175	2	40	200	20-60	.25	–	–	Epitaxial
2N784	SY	npn,MS,si	–	300	175	2	30	200	25	.25	–	–	
2N1158	PH	pnp,MD,ge	–	60	100	0.8	20	100	50	5	–	3	
2N1158A	PH	pnp,MD,ge	–	75	100	1	20	100	50	5	–	2.8	
2N1204	SPR	pnp,MD,ge	–	200	100	–	20	500	40	7	–	–	PH
2N1264	SY	pnp,DD,ge	–	50	75	1	20	10	15	50	–	–	
2N1266	SY	pnp,AJ,ge	–	80	85	1.3	10	–	10	100	–	–	
2N1267	PH	npn,SADT,si	–	150	150	0.8	20	100	11	.01	–	1.5	
2N1268	PH	npn,SADT,si	–	150	150	0.8	20	100	20	.01	–	1.5	
2N1269	PH	npn,SADT,si	–	150	150	0.8	20	100	50	.01	–	1.5	
2N1270	PH	npn,SADT,si	–	150	150	0.8	20	100	11	10	–	1.5	
2N1271	PH	npn,SADT,si	–	150	150	0.8	20	100	20	.01	–	1.5	
2N1272	PH	npn,SADT,si	–	150	150	0.8	20	100	50	.01	–	1.5	
2N1398	TI	pnp,MS,ge	–	50	85	–	30	10	2.3	10	5	–	
2N1399	TI	pnp,MS,si	–	50	85	–	30	10	2.3	10	6	–	
2N1400	TI	pnp,MS,ge	–	50	85	–	30	10	1.6	10	–	–	
2N1401	TI	pnp,MS,ge	–	50	85	–	30	10	2	10	–	–	
2N1401A	TI	pnp,MS,ge	–	50	85	–	30	10	2	10	–	–	
2N1402	TI	pnp,MS,ge	–	50	85	–	30	10	2.2	10	–	–	
2N1450	SY	pnp,AJ,ge	–	120	100	1.6	30	100	20	10	–	–	
2N1494	SPR	pnp,MD,ge	–	400	100	–	20	500	15	7	–	–	PH
2N1515	AMP	pnp,PADT,ge	–	83	75	–	20	10	60	–	–	–	OC169
2N1646	SY	pnp,MS,ge	–	150	100	2	15	50	20	3	–	–	
2N1676	PH	pnp,SAT,si	–	100	140	–	4.5	50	10.5	.001	–	–	SPR, chopper
2N1677	PH	pnp,SAT,si	–	100	140	–	4.5	50	50	.001	–	–	SPR, chopper
2N1684	SY	pnp,AJ,ge	–	100	100	1.3	25	100	–	5	–	–	
2N1742	PH	pnp,MD,si	–	60	100	0.8	20	–	–	0.8	4.9	–	
2N1743	PH	pnp,MD,ge	–	60	100	0.8	20	–	–	0.8	10	–	

High Frequency (concluded)

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics h_{fe}	I_{co} μa	NF db	C_c μμf	Remarks
2N1744	PH	pnp,MD,ge	–	60	100	0.8	20	–	–	1	–	–	
2N1745	PH	pnp,MD,ge	–	60	100	0.8	20	50	–	2.5	–	–	
2N1747	PH	pnp,MD,ge	–	60	100	0.8	20	50	–	2	–	–	
2N1782	SY	pnp,AJ,ge	–	100	100	1.3	30	100	30-150	6	–	–	
2N1783	SY	pnp,AJ,ge	–	100	100	1.3	30	100	30-90	5	–	–	
2N1784	SY	pnp,AJ,ge	–	100	100	1.3	30	100	20	4	–	–	
2N1840	PSI	npn,DM,si	–	2w	175	13.3	24	–	9	–	–	11	hi freq., hi pwr.
2N1840A	PSI	npn,DM,si	–	2.8	175	18.6	25	–	9	–	–	11	hi freq., hi pwr.
2N1841	WE	npn,DM,si	–	15.4	150	75	2	35	.005	100 mc	–	–	
2N1865	PH	pnp,MD,ge	–	60	100	0.8	20	50	–	2	–	–	
2N1866	PH	pnp,MD,ge	–	60	100	0.8	35	50	–	2	–	–	
2N1867	PH	pnp,MD,ge	–	60	100	0.8	35	50	–	2	–	–	
2N1868	PH	pnp,MD,ge	–	60	100	0.8	20	50	–	2.5	–	–	
2N1958	SY	npn,MS,si	–	600	175	4	60	500	20-60	0.5	–	18	Epitaxial
2N1959	SY	npn,MS,si	–	600	175	4	60	500	40-120	0.5	–	18	Epitaxial
2N1960	SY	pnp,MS,ge	–	150	100	2	15	200	25	3	–	–	Epitaxial
2N1961	SY	pnp,MS,ge	–	150	100	2	12	200	20	3	–	–	Epitaxial
2N1962	SY	npn,MS,si	–	400	175	2.6	40	200	20-60	.25	–	3	Epitaxial
2N1963	SY	npn,MS,si	–	400	175	2.6	30	200	25	.25	–	3.5	Epitaxial
2N1964	SY	npn,MS,si	–	400	175	2.6	60	500	20-60	0.5	–	18	Epitaxial
2N1965	SY	npn,MS,si	–	400	175	2.6	60	500	40-120	0.5	–	18	Epitaxial
2N1969	SY	pnp,AJ,ge	–	150	100	2	30	400	50-200	5	–	20	
GT1665	GI	pnp,AJ,ge	–	150	100	2	100	–	25	4	–	–	Drift
MA-1	SPR	pnp,MAT,ge	–	25	75	–	6	50	40	10	–	–	
MA-2	SPR	pnp,MAT,ge	–	20	75	–	3	50	40	10	–	–	
PT850	PSI	npn,DM,si	–	2w	175	13.3	120	–	2	2	–	–	hi freq., hi pwr.
PT850A	PSI	npn,DM,si	–	2.8w	175	18.6	120	–	2	2	–	–	hi freq., hi pwr.
SO-1	SPR	pnp,SBT,ge	–	20	65	–	5	5	10	10	–	–	
SO-2	SPR	pnp,SBT,ge	–	15	65	–	3	5	10	10	–	–	
SO-3	SPR	pnp,SBT,ge	–	20	65	–	5	5	10	10	–	–	
ST3031	TR	npn,DJ,si	–	150	175	–	–	–	–	–	–	–	

Abbreviation of Terms

AJ	Alloy Junction	**FJ**	Fused Junction
DD	Double Diffused	**GD**	Grown Diffused
DG	Grown Diffused	**Ge**	Germanium
DJ	Diffused Junction	**GJ**	Grown Junction
DM	Diffused Mesa	**GR**	Grown Rate
DP	Diffused Planar	**MB**	Meltback
Dr	Drift	**MD**	MADT
Ep	Epitaxial	**Ms**	Mesa
FA	Fused Alloy	**RG**	Rate Grown

Si Silicon

SBT Surface Barrier

C_{oe} = Collector-to-emitter capacitance measured across the output terminals with the input ac open-circuited.

f_{ae} = Frequency at which the magnitude of the forward-current transfer ratio (small-signal) is 0.707 of its low-frequency value.

f_t = Frequency at which common emitter gain is unity.

h_{fe} = Common emitter-small signal forward current transfer ratio.

h_{FE} = Common emitter-static value of short-circuited forward current ratio.

I_{co} = Collector current when collector junction is reverse-biased and emitter is dc open-circuited.

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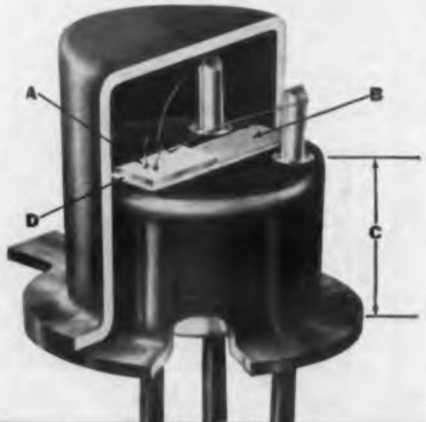
- **A** *Rugged, mechanically reliable eutectic solder joints*
- **B** *Flat bed attachment for good heat dissipation*
- **C** *Long path prevents weld contamination of transistor*
- **D** *Gold doped for high speed*
- • *Extremely high cut-off frequency*
- • *High Beta* • *Low resistivity germanium*



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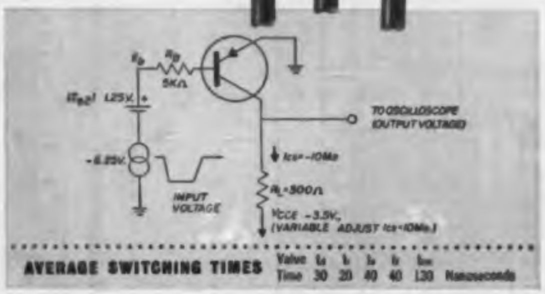

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TRANSISTORS—1961

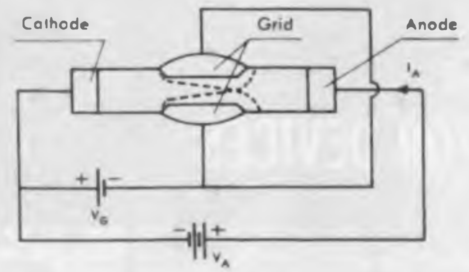
Power

Type No.	Mfg.	Type	W_c w	Max. Ratings: w/c	T_j c	V_c v	I_c amp	Characteristics: h_{fe}	I_{co} ma	f_{ae} kc	Powr. Gain db	Powr. Out. w	Remarks
2N339	TI	npn,GR,si	1.0	0.008	150	55	.06	9-90	.001	6	30	–	TR
2N340	TI	npn,GR,si	1.0	0.008	150	85	.06	9-90	.001	6	30	–	TR
2N341	TI	npn,GR,si	1.0	0.008	150	125	.06	9-90	.001	6	30	–	TR
2N341A	TR	npn,DJ,si	1	0.008	200	125	.1	15-90	.001	–	–	–	
2N342	TI	npn,GR,si	1.0	0.008	150	60	.06	9-32	.001	6	30	–	TR
2N342A	TI	npn,GR,si	1.0	0.008	150	85	..06	9-32	.001	6	30	–	TR
2N343	TI	npn,GR,si	1.0	0.008	150	60	.06	28-90	.001	8	30	–	TR
2N343A	TR	npn,DJ,si	1	.008	150	85	–	29-90	.001	–	–	–	TR
2N1206	TR	npn,GR,si	1.0	10	200	60	–	15-19	1	–	–	–	
2N1207	TR	npn,GR,si	1.0	10	200	125	–	15-90	1	–	–	–	
2N1566	TI	npn,MS,si	1.2	–	175	80	50	100	1	50	–	–	TR,NA
2N1335	PSI	npn,MS,si	2.8	0.024	150	.120	.075	13	.008	170mc	–	–	high freq. high pwr.
2N1336	PSI	npn,MS,si	2.8	0.024	150	120	.075	13	.008	170mc	–	–	high freq., high pwr.
2N1339	PSI	npn,MS,si	2.8	0.024	150	120	.075	–	.008	220 mc			high freq., high pwr.
2N1340	PSI	npn,MS,si	2.8	0.024	150	120	.075	–	.008	250 mc	–	–	high freq., high pwr.
2N1341	PSI	npn,MS,si	2.8	0.024	150	120	.075	–	.008	280 mc			high freq., high pwr.
2N1505	PSI	npn,MS,si	3	0.2	175	50	–	7	–	150 mc	–	–	high freq., high pwr.
2N1506	PSI	npn,MS,si	3	0.2	175	60	–	9	–	210 mc	–	–	high freq., high pwr.
2N1561	MO	pnp,MS,si	3	.04	100	25	.25	10	.0015	500 mc	–	–	high freq., high pwr.
2N1562	MO	pnp,MS,ge	3	.04	100	25	.25	10	.0015	450 mc	–	–	high freq., high pwr.
2N1692	MO	pnp,MS,ge	3	.04	100	25	.25	10 db	.0015	500 mc	6	0.5	
2N1693	MO	pnp,MS,ge	3	.04	100	25	.25	10 db	.0015	–	6	.4	
OC30	AMP	pnp,PADT,ge	3.6	–	75	32	1.4	35	.012	–	–	–	
2N497	TI	npn,DJ,si	4.0	.023	200	60	200	12-36	10	9 mc	–	–	TR, RH, FA, NA, RCA
2N498	TI	npn,DJ,si	4.0	.023	200	100	200	12-36	10	9 mc	–	–	TR, RH, FA, NA
2N656	TI	npn,DJ,si	4.0	.023	200	60	200	30-90	10	8 mc	–	–	TR, RH, FA, NA, RCA, GE
2N657	TI	npn,DJ,si	4.0	.023	200	100	200	30-90	10	8 mc	–	–	TR, RH, FA, NA, GE
2N1479	RCA	npn,DJ,si	4	–	175	60	1.5	50	10	1.5 mc	–	–	
2N1480	RCA	npn,DJ,si	4	–	175	100	1.5	50	10	1.5 mc	–	–	
2N1481	RCA	npn,DJ,si	4	–	175	60	1.5	50	10	1.5 mc	–	–	
2N1482	RCA	npn,DJ,si	4	–	175	100	1.5	50	10	1.5 mc	–	–	
2N1067	STC	npn,DJ,si	5	28.6	175	60	0.5	35	5	1.5	–	–	RCA
2N1218	SY	npn,AJ,ge	6	0.1	85	45	2	40-100	3	7	–	–	
ST4201	TR	npn,DJ,si	6	.03	200	45	0.5	12-36	.001	–	–	–	
ST4202	TR	npn,DJ,si	6	.03	200	75	0.5	12-36	.001	–	–	–	
ST4203	TR	npn,DJ,si	6	.03	200	45	0.5	30-90	.001	–	–	–	
ST4204	TR	npn,DJ,si	6	.03	200	75	0.5	30-90	.001	–	–	–	
2N326	SY	npn,AJ,ge	7	0.11	85	35	2	45	3	150	–	–	
2N1172	DE	pnp,AJ,ge	7.5	.1	100	40	1.5	–	0.01	17	34	–	driver
2N1183	RCA	pnp,AJ,ge	7.5	–	100	45	3	20	.03	500	–	–	
2N1183A	RCA	pnp,AJ,ge	7.5	–	100	60	3	20	.03	500	–	–	
2N1183B	RCA	pnp,AJ,ge	7.5	–	100	80	3	20	.03	500	–	–	
2N1184	RCA	pnp,AJ,ge	7.5	–	100	45	3	40	.03	500	–	–	
2N1184A	RCA	pnp,AJ,ge	7.5	–	100	60	3	40	.03	500	–	–	
2N1184B	RCA	pnp,AJ,ge	7.5	–	100	80	3	40	.03	500	–	–	
2N122	TI	npn,GR,si	8.75	.070	150	120	140	3	10	1	28	–	
2N176	SY	pnp,AJ,ge	10	0.15	90	30	3	4.5	0.3	–	35.5	–	RCA, MO, BE
2N350	SY	pnp,AJ,ge	10	0.13	100	40	3	40	–	5	32	–	MO
2N351	RCA	pnp,AJ,ge	10	1	90	40	3	65	3	–	33.5	4	MO, SY
2N376	RCA	pnp,AJ,ge	10	1	90	40	3	78	3	–	35	4	MO
2N669	MO	pnp,AJ,ge	10	1.5	90	30	3	90	0.3	5	40	2	
2N1068	IND	npn,AJ,si	10	0.133	175	60	1.5	38	0.5	–	–	–	STC,RCA
2N1714	TI	npn,MS,si	10	.134	175	60	1	–	.002	20 mc	–	–	
2N1715	TI	npn,MS,si	10	.134	175	100	1	–	.002	20 mc	–	–	
2N1716	TI	npn,MS,si	10	.134	175	60	1	–	.002	20 mc	–	–	
2N1717	TI	npn,MS,si	10	.134	175	100	1	–	.002	20 mc	–	–	
2N1718	TI	npn,MS,si	10	.134	175	60	1	–	.002	20 mc	–	–	
2N1719	TI	npn,MS,si	10	.134	175	100	1	–	.002	20 mc	–	–	
2N1720	TI	npn,MS,si	10	.134	175	60	1	–	.002	20 mc	–	–	
2N1721	TI	npn,MS,si	10	.134	175	100	1	–	.002	20 mc	–	–	
2N1755	CL	pnp,AJ,ge	10	2.5	95	40	3	–	7	15	30-75	–	
2N1756	CL	pnp,AJ,ge	10	2.5	95	60	3	–	7	15	30-75	–	
2N1757	CL	pnp,AJ,ge	10	2.5	95	80	3	–	7	8	30-75	–	
2N1758	CL	pnp,AJ,ge	10	2.5	95	100	3	–	7	8	30-75	–	
2N1759	CL	pnp,AJ,ge	10	2.5	95	40	3	–	7	10	60-150	–	
2N1760	CL	pnp,AJ,ge	10	2.5	95	60	3	–	7	10	60-150	–	
2N1761	CL	pnp,AJ,ge	10	2.5	95	80	3	–	7	6	60-150	–	
2N1762	CL	pnp,AJ,ge	10	2.5	95	100	3	–	7	6	60-150	–	
CDT1310	CL	pnp,AJ,ge	10	1.5	95	40	5	–	15	5	40-120	–	
CDT1311	CL	pnp,AJ,ge	10	1.5	95	60	5	–	15	5	40-120	–	
CDT1312	CL	pnp,AJ,ge	10	1.5	95	80	5	–	15	5	40-120	–	
CDT1313	CL	pnp,AJ,ge	10	1.5	95	100	5	–	15	5	40-120	–	

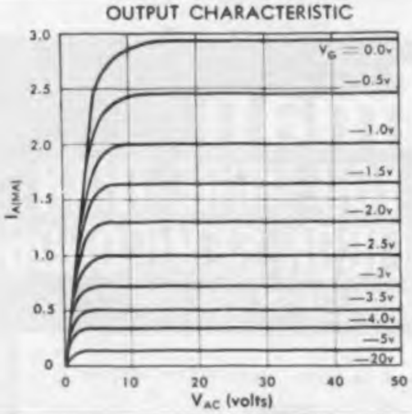
Power (continued)

Type No.	Mfg.	Type	W_c w	Max. Ratings w/c	T_j c	V_c v	I_c amp	Characteristics h_{fe}	I_{co} ma	$f_{\alpha e}$ kc	Powr. Gain db	Powr. Out. w	Remarks
CST1740	CL	pnp,AJ,ge	10	2.5	95	40	3	–	3	7	28-33	–	
CST1741	CL	pnp,AJ,ge	10	2.5	95	40	3	–	3	7	32-35	–	
CST1742	CL	pnp,AJ,ge	10	2.5	95	40	3	–	3	7	34-37	–	
CST1743	CL	pnp,AJ,ge	10	2.5	95	40	3	–	3	7	36-39	–	
CST-1744	CL	pnp,AJ,ge	10	2.5	95	80	3	–	3	7	28-37	–	
CST1745	CL	pnp,AJ,ge	10	2.5	95	80	3	–	3	7	28-33	–	
CST1746	CL	pnp,AJ,ge	10	2.5	95	80	3	–	3	7	32-37	–	
CTP1104	CL	pnp,AJ,ge	10	2.0	85	40	3	–	2	4	28	1.2	
CTP1105	CL	pnp,AJ,ge	10	2.0	85	40	3	–	2	5	30	1.2	
CTP1108	CL	pnp,AJ,ge	10	2.0	85	20	3	–	2	4	27	0.6	
CTP1109	CL	pnp,AJ,ge	10	2.0	90	20	3	–	2	6	35	0.6	
CTP1111	CL	pnp,AJ,ge	10	2.0	90	80	3	–	5	4	29	1.2	
CST1739	CL	pnp,AJ,ge	10	2.5	95	40	3	–	3	7	28-39	–	
2N301	RCA	pnp,AJ,ge	11	–	91	40	3	70	0.1	–	–	–	
2N301A	SY	pnp,AJ,ge	12	0.2	85	60	2	–	5	5	35	–	CL, RCA, BE, CBS
2N1314/ OC26	AMP	pnp,PADT,ge	11	–	90	32	3.5	33	<0.1	150	–	–	
2N1315/ OC27	AMP	pnp,PADT,ge	12.5	–	90	32	7.5	75	<0.1	300	–	–	OC27
2N1709	PSI	npn,DM,si	13	86.7	175	75	1.2a	–	10 max	240 mc	10 db	–	hi freq., hi pwr.
2N1710	PSI	npn,DM,si	13	86.7	175	60	1.2a	–	10 max	240 mc	8 db	–	hi freq., hi pwr.
2N307	BE	pnp,AJ,ge	15	2.0	75	35	1.0	–	.35	–	–	–	2N234A
2N1658	MH	pnp,AJ,ge	15	0.2	100	80	1	50	0.5	700	–	–	
2N1659	MH	pnp,AJ,ge	15	0.2	100	60	1	50	0.5	700	–	–	
2N307A	SY	pnp,AJ,ge	17	0.34	75	35	2	25	–	5	33	–	BE
2N155	CBS	pnp,AJ,ge	20	.33	85	30	3	20	2	5	–	2	CL, BE
2N156	CBS	pnp,AJ,ge	20	0.33	85	30	3	20	1	5	–	2	
2N157	CBS	pnp,AJ,ge	20	0.33	85	60	3	20	1	5	–	2	
2N157A	CBS	pnp,AJ,ge	20	0.33	85	100	3	20	1	5	–	2	
2N158	CBS	pnp,AJ,ge	20	0.33	85	60	3	20	1	5	–	2	
2N158A	CBS	pnp,AJ,ge	20	0.33	85	80	3	20	1	5	–	2	
2N255	BE	pnp,AJ,ge	20	2.0	85	15	3	–	1.0	–	–	19-26	2N234A, CL
2N255A	CBS	pnp,AJ,ge	20	0.5	85	15	3	–	1.0	5	25	2	
2N256	BE	pnp,AJ,ge	20	2.0	85	30	3	–	1.0	–	–	22-29	2N234A, CL
2N256A	CBS	pnp,AJ,ge	20	0.5	85	25	3	–	1	5	25	2	
2N401	BE	pnp,AJ,ge	20	1.2	90	40	3	–	1.3	–	30	5	
2N500	EM	–	20	.18	95	30	3	30 (min)	2	7	25	20w	
2N1042	TI	pnp,AJ,ge	20	.27	100	40	3	20-60	0.75	–	–	–	TR
2N1043	TI	pnp,AJ,ge	20	.27	100	60	3	20-60	0.75	–	–	–	TR
2N1044	TI	pnp,AJ,ge	20	.27	100	80	3	20-60	0.75	–	–	–	TR
2N1045	TI	pnp,AJ,ge	20	.27	100	100	3	20-60	0.75	–	–	–	TR
2N1078	CBS	pnp,AJ,ge	20	0.33	85	60	3	30 min	0.5	5	–	2	
2N1291	CBS	pnp,AJ,ge	20	0.33	85	30	3	30 min	0.5	5	–	2	
2N1292	CBS	pnp,AJ,ge	20	0.33	85	30	3	30 min	0.5	5	–	2	
2N1293	CBS	pnp,AJ,ge	20	0.33	85	60	3	30 min	0.5	5	–	2	
2N1294	CBS	npn,AJ,ge	20	0.33	85	60	3	30 min	0.5	5	–	2	SY
2N1295	CBS	pnp,AJ,ge	20	0.33	85	80	3	30 min	0.5	5	–	2	SY
2N1296	CBS	npn,AJ,ge	20	0.33	85	80	3	30 min	0.5	5	–	2	
2N1297	CBS	pnp,AJ,ge	20	0.33	85	100	3	30 min	0.5	5	–	2	
2N1298	CBS	npn,AJ,ge	20	0.33	85	100	3	30 min	0.5	5	–	2	
2N1320	CBS	pnp,AJ,ge	20	0.33	85	30	3	30 min	0.5	5	–	2	TO-10
2N1321	CBS	npn,AJ,ge	20	0.33	85	30	3	30 min	0.5	5	–	2	TO-10
2N1322	CBS	pnp,AJ,ge	20	0.33	85	60	3	30 min	0.5	5	–	2	TO-10
2N1323	CBS	npn,AJ,ge	20	0.33	85	60	3	30 min	0.5	5	–	2	TO-10
2N1324	CBS	pnp,AJ,ge	20	0.33	85	80	3	30 min	0.5	5	–	2	TO-10
2N1325	CBS	npn,AJ,ge	20	0.33	85	80	3	30 min	0.5	5	–	2	TO-10
2N1326	CBS	pnp,AJ,ge	20	0.33	85	100	3	30 min	0.5	5	–	2	TO-10
2N1327	CBS	npn,AJ,ge	20	0.33	85	100	3	30 min	0.5	5	–	2	TO-10
2N1328	CBS	pnp,AJ,ge	20	0.33	85	30	3	30 min	0.5	5	–	2	TO-13
2N1329	CBS	npn,AJ,ge	20	0.33	85	30	3	30 min	0.5	5	–	2	TO-13
2N1330	CBS	npn,AJ,ge	20	0.33	85	60	3	30 min	0.5	5	–	2	TO-13
2N1331	CBS	pnp,AJ,ge	20	0.33	85	80	3	30 min	0.5	5	–	2	TO-13
2N1332	CBS	npn,AJ,ge	20	0.33	85	80	3	30 min	0.5	5	–	2	TO-13
2N1333	CBS	pnp,AJ,ge	20	0.33	85	100	3	30 min	0.5	5	–	2	TO-13
2N1334	CBS	npn,AJ,ge	20	0.33	85	100	3	30 min	0.5	5	–	2	TO-13
2N1437	CBS	pnp,AJ,ge	20	0.33	85	100	3	20 min	0.5	5	–	2	TO-13
2N1438	CBS	pnp,AJ,ge	20	0.33	85	100	3	20 min	0.5	5	–	2	TO-10
2N1465	CBS	pnp,AJ,ge	20	0.33	85	120	3	20 min	0.5	5	–	2	TO-13
2N1466	CBS	pnp,AJ,ge	20	0.33	85	120	3	20 min	0.5	5	–	2	TO-10
2N1504	CBS	pnp,AJ,ge	20	0.33	85	80	3	20 min	0.5	5	–	2	
CDT1319	CL	pnp,AJ,ge	20	1.5	100	40	5	20-60	15	5	–	–	
CDT1320	CL	pnp,AJ,ge	20	1.5	100	60	5	20-60	15	5	–	–	
CDT1321	CL	pnp,AJ,ge	20	1.5	100	80	5	20-60	15	5	–	–	
CDT1322	CL	pnp,AJ,ge	20	1.5	100	100	5	20-60	15	5	–	–	
LT-11	CBS	pnp,AJ,ge	20	0.33	85	80	3	–	1	5	–	–	

PHYSICAL CONSTRUCTION OF THE FIELD-EFFECT TRANSISTOR



OUTPUT CHARACTERISTIC



Silicon Field-effect Transistors

- *Almost infinite input impedance (1000 MΩ)*
- *Almost infinite power gain*
- *Extremely low noise figures (0.5 dB maximum)*
- *Negligible offset voltage (less than 1μ V)*
- *Unprecedented gain stability*

The silicon field-effect transistors from Crystalonics combine almost all advantages of vacuum tubes and conventional transistors. They are silicon majority carrier devices presently available in the TO-5 package, and have three terminals; anode, cathode, and grid. The transistor action takes place entirely within the bulk of the silicon material and completely away from the surface, giving rise to an unprecedented gain stability of the unit. The radiation resistance of the field-effect transistors exceeds that of the conventional units approximately ten times.

The new devices are recommended as first stages to high input, low noise amplifiers, low level switching circuits such as choppers, analog multipliers, and electronically variable resistors.

Low Noise Amplifiers:

Field-effect transistors are inherently low noise devices and have noise figures considerably below that of the best selected low noise transistors and tubes. Unlike the conventional bipolar transistor, the field-effect unit does not pass any working current through the junctions, and it does not rely for its operation on minority carriers which eventually recombine to produce base current of the conventional unit. Both processes, the passing of current through emitter and collector junctions and carrier recombination are inherently noisy, and are completely eliminated in the new device. The result is a transistor series (C620) with maximum noise figures of 0.5 dB with 1 MΩ generator impedance. To obtain optimum performance for the low noise field-effect transistors, the grid bias should be kept at zero and the anode potential at approximately 3 volts.

High Input Impedance Amplifiers:

The input impedance of the field-effect transistor is effectively equivalent to a reverse biased silicon diode and is of the order of 1000 MΩ. The output characteristics of the C613 field-effect transistor is shown below. They are identical with those of a thermionic pentode. In fact, the field-effect transistor can be used in a manner analogous to vacuum pentodes and, therefore, no new circuit techniques are required.

Low Level Switching:

Unlike the conventional transistor which is a normally "off" switch, the field-effect unit is a normally "on" switch. In the "on" condition, the unit, therefore, is merely a passive silicon resistor without any "offset" voltage. The only equivalent of "offset voltage" in the field-effect transistors is the noise generated by this silicon resistor, and is of the order of .1μ Volt. No matching of units is therefore required, and only one device has to be used instead of the usual two.

ORDER NOW FROM STOCK

Silicon Field-effect Transistors

Crystalonics Inc. Types

C610	C611	C612	C613	C614
C615	C650	C651	C652	C653

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Phone: VA 5-7820

TRANSISTORS—1961

Power

Type No.	Mfg.	Type	W_c w	Max. Ratings w/c	T_j c	V_c v	I_c amp
LT-12	CBS	pnp,AJ,ge	20	0.33	85	100	3
LT-13	CBS	pnp,AJ,ge	20	0.33	85	120	3
LT-14	CBS	pnp,AJ,ge	20	0.33	85	150	3
LT-15	CBS	pnp,AJ,ge	20	0.33	85	200	3
2N234A	BE	pnp,AJ,ge	25	1.2	90	30	3
2N235A	BE	pnp,AJ,ge	25	1.2	90	40	3
2N235B	BE	pnp,AJ,ge	25	1.2	90	40	3
2N236A	BE	pnp,AJ,ge	25	1.2	95	40	3
2N285A	BE	pnp,AJ,ge	25	1.2	95	40	3
2N296	SY	pnp,AJ,ge	25	0.33	100	60	2
2N399	BE	pnp,AJ,ge	25	1.2	90	40	3
2N400	BE	pnp,AJ,ge	25	1.2	95	40	3
2N1146	CL	pnp,AJ,ge	25	0.7	95	40	15
2N1146A	CL	pnp,AJ,ge	25	0.7	95	60	15
2N1146B	CL	pnp,AJ,ge	25	0.7	95	80	15
2N1146C	CL	pnp,AJ,ge	25	0.7	95	100	15
2N1147	CL	pnp,AJ,ge	25	0.7	95	40	15
2N1147A	CL	pnp,AJ,ge	25	–	95	60	15
2N1147B	CL	pnp,AJ,ge	25	–	95	80	15
2N1147C	CL	pnp,AJ,ge	25	–	95	100	15
2N1245	CBS	pnp,AJ,ge	25	0.5	85	25	3
2N1246	CBS	pnp,AJ,ge	25	0.5	85	25	3
2N1483	RCA	npn,DJ,si	25	–	200	60	3
2N1484	RCA	npn,DJ,si	25	–	200	100	3
2N1485	RCA	npn,DJ,si	25	–	200	60	3
2N1486	RCA	npn,DJ,si	25	–	200	100	3
B-177	BE	pnp,AJ,ge	25	1.2	90	30	3
B-178	BE	pnp,AJ,ge	25	1.2	90	30	3
B-179	BE	pnp,AJ,ge	25	1.2	90	40	3
CTP1500	CL	pnp,AJ,ge	25	1.0	95	100	15
CTP1503	CL	pnp,AJ,ge	25	1.0	95	80	15
CTP1504	CL	pnp,AJ,ge	25	1.0	95	60	15
CTP1508	CL	pnp,AJ,ge	25	1.0	95	40	15
CTP1544	CL	pnp,AJ,ge	25	1.0	95	60	25
CTP1545	CL	pnp,AJ,ge	25	1.0	95	80	25
CTP1552	CL	pnp,AJ,ge	25	1.0	95	40	25
CTP1553	CL	pnp,AJ,ge	25	1.0	95	100	25
2N236B	CBS	pnp,AJ,ge	30	–	85	40	3
2N242	SY	pnp,AJ,ge	30	0.33	100	45	2.0
2N257	BE	pnp,AJ,ge	30	2.0	90	40	3
2N268	BE	pnp,AJ,ge	30	2.0	90	–	3
2N538	MH	pnp,AJ,ge	32	0.45	95	80	3
2N539	MH	pnp,AJ,ge	32	0.45	95	80	3.0
2N540	MH	pnp,AJ,ge	32	0.45	95	80	3.0
2N1202	MH	pnp,AJ,ge	32	0.45	95	80	3
2N1203	MH	pnp,AJ,ge	32	0.45	95	120	3
2N1261	MH	pnp,AJ,ge	32	0.45	95	80	3
2N1262	MH	pnp,AJ,ge	32	0.45	95	80	3
2N1263	MH	pnp,AJ,ge	32	0.45	95	80	3
2N1501	MH	pnp,AJ,ge	32	0.45	95	60	3
2N1502	MH	pnp,AJ,ge	32	0.45	95	40	3
2N463	WE	npn,AJ,ge	35	–	–	60	5
2N1011	BE	pnp,AJ,ge	35	0.2	95	–	3
2N178	MO	pnp,AJ,ge	40	1.4	90	40	3
2N554	MO	pnp,AJ,ge	40	1.4	90	15	3
2N555	MO	pnp,AJ,ge	40	1.4	90	30	3
2N1047	STC	npn,AJ,si	40	0.2	200	80	2
2N1047A	TI	npn,MS,si	40	.228	200	80	0.5
2N1048	STC	npn,DJ,si	40	0.2	200	120	2
2N1048A	TI	npn,MSI,si	40	.228	200	120	0.5
2N1049	STC	npn,DJ,si	40	0.2	200	80	2
2N1049A	TI	npn,MS,si	40	.228	200	80	0.5
2N1050	STC	npn,DJ,si	40	0.2	200	120	2
2N1050A	TI	npn,MS,si	40	.228	200	120	5
2N1453	CBS	pnp,AJ,ge	40	0.66	85	30	5
2N1454	CBS	pnp,AJ,ge	40	0.66	85	30	5
2N1455	CBS	pnp,AJ,ge	40	0.66	85	60	5
2N1456	CBS	pnp,AJ,ge	40	0.66	85	60	5
2N1457	CBS	pnp,AJ,ge	40	0.66	85	80	5
2N1458	CBS	pnp,AJ,ge	40	0.66	85	80	5
2N1461	CBS	pnp,AJ,ge	40	0.66	85	30	5
2N1462	CBS	pnp,AJ,ge	40	0.66	85	30	5
2N1463	CBS	pnp,AJ,ge	40	0.66	85	60	5
2N1464	CBS	pnp,AJ,ge	40	0.66	85	60	5
2N1647	TR	npn,DJ,si	40	.27	175	80	3

◄ CIRCLE 49 ON READER-SERVICE CARD

DATA CHART

(continued)

Characteristics					Remarks	Type No.
h_{fe}	I_{co} ma	$f_{\alpha e}$ kc	Powr Gain db	Powr Out. w		
–	1	5	–	–		LT-12
–	1	5	–	–		LT-13
–	1	5	–	–		LT-14
–	1	5	–	–		LT-15
–	1	–	–	34	CBS	2N234A
–	1.0	–	–	36	CBS, CL	2N235A
–	1.0	–	–	38		2N235B
–	1.0	–	–	35		2N236A
–	1.0	–	–	39	hFE 20 min.	2N285A
20	2.0	4	–	–		2N296
–	1.5	–	33	–		2N399
–	1.3	–	35	6		2N400
–	25	4	–	–		2N1146
–	25	4	–	–		2N1146A
–	25	4	–	–		2N1146B
–	25	4	–	–		2N1146C
–	25	4	–	–	solder lugs	2N1147
–	25	4	–	–	solder lugs	2N1147A
–	25	4	–	–	solder lugs	2N1147B
–	25	4	–	–	solder lugs	2N1147C
–	1	5	–	–		2N1245
–	1	5	–	–		2N1246
45	15	1.25 mc	–	–	STC, SE	2N1483
45	15	1.25 mc	–	–	STC, SE	2N1484
45	15	1.25 mc	–	–	STC, SE	2N1485
45	15	1.25 mc	–	–	STC, SE	2N1486
–	1.0	–	36	–		B-177
–	1.0	–	30-36	–		B-178
–	1.0	–	25-30	–		B-179
30-75	8	–	–	–		CTP1500
30-75	8	–	–	–		CTP1503
30-75	8	–	–	–		CTP1504
30-75	8	–	–	–		CTP1508
25-75	15	3	–	–		CTP1544
25-75	15	3	–	–		CTP1545
25-75	15	3	–	–		CTP1552
25-75	15	3	–	–		CTP1553
–	1.0	5	37	4	BE	2N236B
–	3.0	–	36	–	CL, BE, TS	2N242
–	–	–	–	33	CL	2N257
–	2	–	–	35	SY, CL	2N268
30	2	200	–	–		2N538
43	2	200	–	–		2N539
64	2	200	–	–		2N540
86	2	200	–	–		2N1202
37	2	200	–	–		2N1203
30	2	200	–	–		2N1261
43	2	200	–	–		2N1262
64	2	200	–	–		2N1263
45	2	200	–	–		2N1501
45	2	200	–	–	Sat. volt = 0.15v	2N1502
60	100	15	–	–	U.S. MIL only	2N463
30-75	15	–	–	–	MIL	2N1011
50	–	6	30	–		2N178
50	–	6	35	–		2N554
50	–	6	35	–		2N555
12-36	.015	–	–	–	TR	2N1047
12-36	.0015	8 mc	–	–	TR	2N1047A
12-36	.015	–	–	–	TR	2N1048
12-36	.0015	8 mc	–	–	TR	2N1048A
30-90	.015	–	–	–	TR	2N1049
30-90	.0015	7 mc	–	–	TR	2N1049A
30-90	.015	–	–	–	TR	2N1050
30-90	7 mc	–	–	–	TR	2N1050A
50	1.0	5	–	4	TO-13	2N1453
100	1.0	5	–	4	TO-13	2N1454
50	1.0	5	–	4	TO-13	2N1455
100	1.0	5	–	4	TO-13	2N1456
50	1.0	5	–	4	TO-13	2N1457
100	1.0	5	–	2	TO-13	2N1458
50	1.0	5	–	4	TO-10	2N1461
100	1.0	5	–	4	TO-10	2N1462
50	1.0	5	–	4	TO-10	2N1463
100	1.0	5	–	4	TO-10	2N1464
15-45	.025	10 mc	–	–		2N1647

CIRCLE 50 ON READER-SERVICE CARD ➤

TRANSISTORS — 1961

Power (continued)

Type No.	Mfg.	Type	W_c w	Max. Ratings w/c	T_j c	V_c v	I_c amp	Characteristics h_{fe}	I_{co} ma	$f_{\alpha e}$ kc	Powr. Gain db	Powr. Out. w	Remarks
2N1648	TR	npn,DJ,si	40	.27	175	120	3	15-45	.025	10 mc	–	–	
2N1649	TR	npn,DJ,si	40	.27	175	80	3	30-90	.025	10 mc	–	–	
2N1650	TR	npn,DJ,si	40	.27	175	120	3	30-90	.025	10 mc	–	–	
2N1886	TR	npn,DJ,si	40	.27	175	60	5	20-80	.35	8 mc	–	–	
2N2018	TR	npn,DJ,si	40	.27	175	150	–	20-60	.01	10 mc	–	–	
2N2019	TR	npn,DJ,si	40	.27	175	200	–	20-60	.01	10 mc	–	–	
2N2020	TR	npn,DJ,si	40	.27	175	150	–	40-120	.01	10 mc	–	–	
2N2021	TR	npn,DJ,si	40	.27	175	200	–	40-120	.01	10 mc	–	–	
2N1120	BE	pnp,AJ,ge	45	1.0	95	80	15	20-50	15	–	–	–	MO
2N250	TI	pnp,AJ,ge	50	.27	100	30	5	60	2	–	30	–	CL
2N251	TI	pnp,AJ,ge	50	.27	100	60	5	60	2	–	30	–	
2N553	DE	pnp,AJ,ge	50	1.5	100	80	5	–	0.02	25	–	–	
2N665	DE	pnp,AJ,ge	50	1.5	100	80	5	–	0.02	25	–	–	JAN2N665
2N1014	RCA	pnp,AJ,ge	50	1.0	100	100	10	75	0.1	–	26	30	
2N1069	STC	npn,DJ,si	50	.29	175	60	4	20	1	1	–	–	RCA
2N1070	STC	npn,DJ,si	50	.29	175	60	4	20	1	1	–	–	RCA
2N1722	TI	npn,MS,si	50	.67	175	80	7.5	–	1	20 mc	–	–	
2N1724	TI	npn,MS,si	50	.67	175	80	7.5	–	1	20 mc	–	–	
2N1905	RCA	pnp,Dr,ge	50	0.7	–	60	10	90	.15	–	–	–	
2N1906	RCA	pnp,Dr,ge	50	0.7	–	100	10	125	.15	–	–	–	
2N1470	RA	npn,DJ,si	55	3.0	200	60	2	50	10	10	–	–	Diamond Package
2N1657	RA	npn,DB,si	55	.33	200	60	2	50	10	10 mc	–	–	
2N419	BE	pnp,AJ,ge	60	1.2	95	45	3	–	0.5	–	–	5	
2N639	BE	pnp,AJ,ge	60	1.2	100	40	5	15-30	1.0	–	–	–	
2N639A	BE	pnp,AJ,ge	60	1.2	100	70	5	15-30	1.0	–	–	–	
2N639B	BE	pnp,AJ,ge	60	1.2	100	80	5	15-30	2.2	–	–	–	
2N1073	BE	pnp,AJ,ge	60	1.0	100	40	10	20-6	2.0	1.5	–	–	
2N1073A	BE	pnp,AJ,ge	60	1.0	100	80	10	20-6	1.5	–	–	–	
2N1073B	BE	pnp,AJ,ge	60	1.0	100	120	10	20-6	2.0	1.5	–	–	
2N1136	BE	pnp,AJ,ge	60	1.2	100	40	6	–	0.5	–	–	–	
2N1136A	BE	pnp,AJ,ge	60	1.2	100	70	6	–	2	–	–	–	
2N1136B	BE	pnp,AJ,ge	60	1.2	100	80	6	–	2	–	–	–	
2N1137	BE	pnp,AJ,ge	60	1.2	100	40	6	–	0.5	–	–	–	
2N1137A	BE	pnp,AJ,ge	60	1.2	100	70	6	–	2	–	–	–	
2N1137B	BE	pnp,AJ,ge	60	1.2	100	80	6	–	2	–	–	–	
2N1138	BE	pnp,AJ,ge	60	1.2	100	40	6	–	0.5	–	–	–	
2N1138A	BE	pnp,AJ,ge	60	1.2	100	70	6	–	2.0	–	–	–	
2N1138B	BE	pnp,AJ,ge	60	1.2	100	80	6	–	2	–	–	–	
2N1210	TR	npn,DJ,si	60	.27	175	60	5	15-75	50	15 mc	–	–	STC
2N1211	TR	npn,DJ,si	60	.27	175	70	5	15-75	50	15 mc	–	–	STC
2N1487	RCA	npn,DJ,si	60	–	175	60	6	30	25	1 mc	–	–	STC, SE
2N1488	RCA	npn,DJ,si	60	–	175	100	6	30	25	1 mc	–	–	STC, SE
2N1489	RCA	npn,DJ,si	60	–	175	60	6	30	25	1 mc	–	–	STC, SE
2N1490	RCA	npn,DJ,si	60	–	175	100	6	30	25	1.25mc	–	–	STC, SE
2N1616	TR	npn,DJ,si	60	.27	175	60	5	15-75	50	15 mc	–	–	
2N1617	TR	npn,DJ,si	60	.27	175	70	5	15-75	50	15 mc	–	–	
2N1618	TR	npn,DJ,si	60	.27	175	80	5	15-75	50	15 mc	–	–	
ST440	TR	npn,DJ,si	60	.27	150	60	5	10	1	–	–	–	SE
ST450	TR	npn,DJ,si	60	.27	150	60	5	10	1	–	–	–	
2N174A	TS	pnp,AJ,ge	75	–	95	80	15	37	8	18	–	–	MO
3N45	MH	pnp,AJ,ge	75	1.0	100	60	10	50	3.0	750	–	–	Sat. volt=0.15v
3N46	MH	pnp,AJ,ge	75	1.0	100	80	10	40	3.0	450	–	–	Sat. volt=0.15v
3N47	MH	pnp,AJ,ge	75	1.0	100	40	10	50	3	750	–	–	Sat. volt=0.15v
3N48	MH	pnp,AJ,ge	75	1.0	100	60	10	40	3	450	–	–	Sat. volt=0.15v
2N389	TI	npn,DJ,si	85	.48	200	60	2	12-60	10	7 mc	–	–	STC, TR, RA
2N424	TI	npn,DJ,si	85	.48	200	80	2	12-60	10	6 mc	–	–	STC, TR, RA SE
2N1619	TR	npn,DJ,si	85	.27	200	80	5	30	0.1	15 mc	–	–	
2N1660	RA	npn,DB,si	85	0.5	200	60	2	90	10	40 mc	–	–	
2N1661	RA	npn,DB,si	85	0.5	200	80	2	90	10	40 mc	–	–	
2N1662	RA	npn,DB,si	85	0.5	200	100	2	90	10	40 mc	–	–	
2N1894	RA	npn,DB,si	85	0.5	200	60	2	30	.01	–	–	–	
2N1895	RA	npn,DB,si	85	0.5	200	80	2	30	.01	–	–	–	
2N1896	RA	npn,DB,si	85	0.5	200	60	2	90	.01	–	–	–	
2N1897	RA	npn,DB,si	85	0.5	200	80	2	90	.01	–	–	–	
2N1898	RA	npn,DB,si	85	0.5	200	100	2	90	.01	–	–	–	
STC1101	STC	npn,DJ,si	85	–	200	60	6	10-50	.025	1 mc	–	–	
STC1102	STC	npn,DJ,si	85	–	200	100	6	10-50	.025	1 mc	–	–	
STC1103	STC	npn,DJ,si	85	–	200	60	6	25-75	.025	1 mc	–	–	
STC1104	STC	npn,DJ,si	85	–	200	100	6	25-75	.025	1 mc	–	–	
2N297A	MO	pnp,AJ,ge	90	1.2	100	80	3	40-100	3	5	–	–	DE, BE
2N350A	MO	pnp,AJ,ge	90	1.4	100	50	3	30	3	5	33	–	
2N351A	MO	pnp,AJ,ge	90	1.4	100	50	4	45	3	5	33	–	
2N376A	MO	pnp,AJ,ge	90	1.4	100	50	5	60	3	5	35	–	
2N627	MO	pnp,AJ,ge	90	1.2	100	40	10	10-30	4	5	38	–	
2N628	MO	pnp,AJ,ge	90	1.2	100	60	10	10-30	4	5	38	–	

DATA CHART

Power (continued)

Type No.	Mfg.	Type	W_c w	Max. Ratings				Characteristics					Remarks
				w/c	T_j c	V_c v	I_c amp	h_{fe}	I_{co} ma	$f_{\alpha e}$ kc	Powr. Gain db	Powr. Out. w	
2N629	MO	pnp,AJ,ge	90	1.2	100	80	10	10-30	4	5	38	–	
2N630	MO	pnp,AJ,ge	90	1.2	100	100	10	10-30	4	5	38	–	
2N677	BE	pnp,AJ,ge	90	1.2	100	50	15	45	1	–	–	–	
2N677A	BE	pnp,AJ,ge	90	1.2	100	60	15	45	1	–	–	–	
2N677B	BE	pnp,AJ,ge	90	1.2	100	90	15	45	1	–	–	–	
2N677C	BE	pnp,AJ,ge	90	1.2	100	100	15	45	1	–	–	–	
2N678	BE	pnp,AJ,ge	90	1.2	100	150	15	75	1	–	–	–	
2N678A	BE	pnp,AJ,ge	90	1.2	100	60	15	75	1	–	–	–	
2N678B	BE	pnp,AJ,ge	90	1.2	100	90	15	75	1	–	–	–	
2N678C	BE	pnp,AJ,ge	90	1.2	100	100	15	75	1	–	–	–	
2N1031	BE	pnp,AJ,ge	90	0.8	100	30	15	20-60	1.0	–	–	–	
2N1031A	BE	pnp,AJ,ge	90	0.8	100	40	15	20-60	1.0	–	–	–	
2N1031B	BE	pnp,AJ,ge	90	0.8	100	70	15	20-60	1.0	–	–	–	
2N1031C	BE	pnp,AJ,ge	90	0.8	100	80	15	20-60	2.0	–	–	–	
2N1032	BE	pnp,AJ,ge	90	0.8	100	30	15	50-100	1.0	–	–	–	
2N1032A	BE	pnp,AJ,ge	90	0.8	100	40	15	50-100	1.0	–	–	–	
2N1032B	BE	pnp,AJ,ge	90	0.8	100	70	15	50-100	2.0	–	–	–	
2N1032C	BE	pnp,AJ,ge	90	0.8	100	80	15	50-100	2	–	–	–	
2N1162	MO	pnp,AJ,ge	90	1.2	100	50	25	15-65	3	4	–	–	
2N1162A	MO	pnp,AJ,ge	90	1.2	100	50	25	15-65	15	4	–	–	
2N1163	MO	pnp,AJ,ge	90	1.2	100	50	25	15-65	3	4	–	–	
2N1163A	MO	pnp,AJ,ge	90	1.2	100	50	25	15-65	15	4	–	–	
2N1164	MO	pnp,AJ,ge	90	1.2	100	80	25	15-65	3	4	–	–	
2N1164A	MO	pnp,AJ,ge	90	1.2	100	80	25	15-65	15	4	–	–	
2N1165	MO	pnp,AJ,ge	90	1.2	100	80	25	15-65	3	4	–	–	
2N1165A	MO	pnp,AJ,ge	90	1.2	100	80	25	15-65	15	4	–	–	
2N1166	MO	pnp,AJ,ge	90	1.2	100	80	25	15-65	3	4	–	–	
2N1166A	MO	pnp,AJ,ge	90	1.2	100	100	25	15-65	15	4	–	–	
2N1167	MO	pnp,AJ,ge	90	1.2	100	100	25	15-65	3	4	–	–	
2N1167A	MO	pnp,AJ,ge	90	1.2	100	100	25	15-65	15	4	–	–	
2N1359	MO	pnp,AJ,ge	90	1.2	100	50	3	35-90	3	7	–	–	
2N1360	MO	pnp,AJ,ge	90	1.2	100	50	3	60-140	3	5	–	–	
2N1362	MO	pnp,AJ,ge	90	1.2	100	100	3	35-90	3	7	–	–	
2N1363	MO	pnp,AJ,ge	90	1.2	100	100	3	60-140	3	5	–	–	
2N1364	MO	pnp,AJ,ge	90	1.2	100	120	3	35-90	3	7	–	–	
2N1365	MO	pnp,AJ,ge	90	1.2	100	120	3	60-140	3	5	–	–	
2N1529	MO	pnp,AJ,ge	90	1.2	100	40	5	20-40	2	10	–	–	
2N1529A	MO	pnp,AJ,ge	90	1.2	100	40	5	20-40	2	10	–	–	
2N1530	MO	pnp,AJ,ge	90	1.2	100	40	5	20-40	2	10	–	–	
2N1530A	MO	pnp,AJ,ge	90	1.2	100	60	5	20-40	2	10	–	–	
2N1531	MO	pnp,AJ,ge	90	1.2	100	80	5	20-40	2	10	–	–	
2N1531A	MO	pnp,AJ,ge	90	1.2	100	80	5	20-40	2	10	–	–	
2N1532	MO	pnp,AJ,ge	90	1.2	100	100	5	20-40	2	10	–	–	
2N1532A	MO	pnp,AJ,ge	90	1.2	100	100	5	20-40	2	10	–	–	
2N1533	MO	pnp,AJ,ge	90	1.2	100	120	5	20-40	2	10	–	–	TR
2N1534	MO	pnp,AJ,ge	90	1.2	100	40	5	35-70	2	8.5	–	–	
2N1534A	MO	pnp,AJ,ge	90	1.2	100	40	5	35-70	2	8.5	–	–	
2N1535	MO	pnp,AJ,ge	90	1.2	100	60	5	35-70	2	8.5	–	–	
2N1535A	MO	pnp,AJ,ge	90	1.2	100	60	5	35-70	2	8.5	–	–	
2N1536	MO	pnp,AJ,ge	90	1.2	100	80	5	35-70	2	8.5	–	–	
2N1536A	MO	pnp,AJ,ge	90	1.2	100	80	5	35-70	2	8.5	–	–	
2N1537	MO	pnp,AJ,ge	90	1.2	100	100	5	35-70	2	8.5	–	–	
2N1537A	MO	pnp,AJ,ge	90	1.2	100	100	5	35-70	2	8.5	–	–	
2N1538	MO	pnp,AJ,ge	90	1.2	100	120	5	35/70	2	8.5	–	–	
2N1539	MO	pnp,AJ,ge	90	1.2	100	40	5	50-100	2	4	–	–	
2N1539A	MO	pnp,AJ,ge	90	1.2	100	40	5	50-100	2	4	–	–	
2N1540	MO	pnp,AJ,ge	90	1.2	100	60	5	50-100	2	4	–	–	
2N1540A	MO	pnp,AJ,ge	90	1.2	100	60	5	50-100	2	4	–	–	
2N1541	MO	pnp,AJ,ge	90	1.2	100	80	5	50-100	2	4	–	–	
2N1541A	MO	pnp,AJ,ge	90	1.2	100	80	5	50-100	2	4	–	–	
2N1542	MO	pnp,AJ,ge	90	1.2	100	100	5	50-100	2	4	–	–	
2N1542A	MO	pnp,AJ,ge	90	1.2	100	100	5	50-100	2	4	–	–	
2N1543	MO	pnp,AJ,ge	90	1.2	100	120	5	50-100	2	4	–	–	
2N1544	MO	pnp,AJ,ge	90	1.2	100	40	5	75-150	2	4	–	–	
2N1544A	MO	pnp,AJ,ge	90	1.2	100	40	5	75-150	2	4	–	–	
2N1545	MO	pnp,AJ,ge	90	1.2	100	60	5	75-150	2	4	–	–	
2N1545A	MO	pnp,AJ,ge	90	1.2	100	60	5	75-150	2	4	–	–	
2N1546	MO	pnp,AJ,ge	90	1.2	100	80	5	75-150	2	4	–	–	
2N1546A	MO	pnp,AJ,ge	90	1.2	100	80	5	75-150	2	4	–	–	
2N1547	MO	pnp,AJ,ge	90	1.2	100	100	5	75-150	2	4	–	–	
2N1547A	MO	pnp,AJ,ge	90	1.2	100	100	5	75-100	2	4	–	–	
2N1548	MO	pnp,AJ,ge	90	1.2	100	120	5	75-150	2	4	–	–	
2N1549	MO	pnp,AJ,ge	90	1.2	100	40	15	10-30	3	10	–	–	
2N1549A	MO	pnp,AJ,ge	90	1.2	100	40	15	10-30	3	10	–	–	
2N1550	MO	pnp,AJ,ge	90	1.2	100	60	15	10-30	3	10	–	–	

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Power (continued)

Type No.	Mfg.	Type	W_c w	Max. Ratings w/c	T_j c	V_c v	I_c amp	Characteristics h_{fe}	I_{co} ma	$f_{\alpha e}$ kc	Powr. Gain db	Powr. Out. w	Remarks
2N1550A	MO	pnp,AJ,ge	90	1.2	100	60	15	10-30	3	10	–	–	
2N1551	MO	pnp,AJ,ge	90	1.2	100	80	15	10-30	2	10	–	–	
2N1551A	MO	pnp,AJ,ge	90	1.2	100	80	15	10-30	3	10	–	–	
2N1552	MO	pnp,AJ,ge	90	1.2	100	100	15	10-30	2	10	–	–	
2N1552A	MO	pnp,AJ,ge	90	1.2	100	100	15	10-30	3	10	–	–	
2N1553	MO	pnp,AJ,ge	90	1.2	100	40	15	30-60	2	6	–	–	
2N1553A	MO	pnp,AJ,ge	90	1.2	100	40	15	30-60	3	6	–	–	
2N1554	MO	pnp,AJ,ge	90	1.2	100	60	15	30-60	2	6	–	–	
2N1554A	MO	pnp,AJ,ge	90	1.2	100	60	15	30-60	3	6	–	–	
2N1555	MO	pnp,AJ,ge	90	1.2	100	80	15	30-60	3	6	–	–	
2N1555A	MO	pnp,AJ,ge	90	1.2	100	80	15	30-60	3	6	–	–	
2N1556	MO	pnp,AJ,ge	90	1.2	100	100	15	30-60	3	6	–	–	
2N1556A	MO	pnp,AJ,ge	90	1.2	100	100	15	30-60	3	6	–	–	
2N1557	MO	pnp,AJ,ge	90	1.2	100	40	15	50-100	3	6	–	–	
2N1557A	MO	pnp,AJ,ge	90	1.2	100	40	15	50-100	3	6	–	–	
2N1558	MO	pnp,AJ,ge	90	1.2	100	60	15	50-100	3	5	–	–	
2N1558A	MO	pnp,AJ,ge	90	1.2	100	60	15	50-100	3	5	–	–	
2N1559	MO	pnp,AJ,ge	90	1.2	100	80	15	50-100	3	5	–	–	
2N1559A	MO	pnp,AJ,ge	90	1.2	100	80	15	50-100	3	5	–	–	
2N1560	MO	pnp,AJ,ge	90	1.2	100	100	15	50-100	3	5	–	–	
2N1560A	MO	pnp,AJ,ge	90	1.2	100	100	15	50-100	3	5	–	–	
2N392	DE	pnp,AJ,ge	94	.8	100	60	5	–	0.065	6	–	–	
2N669	DE	pnp,AJ,ge	94	1.2	100	40	3	–	0.065	10	–	–	
2N1159	DE	pnp,AJ,ge	94	0.8	100	80	5	–	0.065	10	–	–	
2N1160	DE	pnp,AJ,ge	94	0.8	100	80	7	–	0.065	10	–	–	
2N1168	DE	pnp,AJ,ge	94	0.8	100	50	5	–	0.065	10	–	–	
3N49	MH	pnp,AJ,ge	94	1.25	100	60	10	50	3	750	–	–	Sat. volt = 0.15v
3N50	MH	pnp,AJ,ge	94	1.25	100	80	10	40	3	450	–	–	Sat. volt = 0.15v
3N51	MH	pnp,AJ,ge	94	1.25	100	40	10	50	3	750	–	–	Sat. volt = 0.15v
3N52	MH	pnp,AJ,ge	94	1.25	100	60	10	40	3	450	–	–	Sat. volt = 0.15v
2N574	MH	pnp,AJ,ge	100	1.43	95	60	15	14	7	75	–	–	
2N574A	MH	pnp,AJ,ge	100	1.43	95	80	15	14	20	75	–	–	
2N575	MH	pnp,AJ,ge	100	1.43	95	60	30	25	7	75	–	–	
2N575A	MH	pnp,AJ,ge	100	1.43	95	80	30	25	20	75	–	–	
2N1157	MH	pnp,AJ,ge	100	1.43	95	60	30	50	7	75	–	–	
2N1157A	MH	pnp,AJ,ge	100	1.43	95	80	30	50	20	75	–	–	
2N1651	BE	pnp,DJ,ge	100	1.2	110	60	25	30	2.0	–	–	–	Sat. volt = 1.0v
2N1652	BE	pnp,DJ,ge	100	1.2	110	100	25	30	2.0	–	–	–	Sat. volt = 0.5v
2N1653	BE	pnp,DJ,ge	100	1.2	110	120	25	30	2.0	–	–	–	Sat. volt = 0.5v
2N1936	TI	npn,MS,si	100	1.34	175	60	15	–	20	7 mc	–	–	
2N1937	TI	npn,MS,si	100	1.34	175	80	15	–	20	7 mc	–	–	
PT900	PSI	npn,DM,si	125	1	150	80	10	3	10	50 mc	10	100	hi freq., hi power
PT901	PSI	npn,MS,si	125	1	150	140	10	10	30	50 mc	–	–	hi freq., hi power
2N1899	PSI	npn,DM,si	125	1	150	140	10	10	20	50 mc	10	100	hi freq., hi power
2N1900	PSI	npn,DM,si	125	1	150	140	5	10	20	25 mc	–	–	hi freq., hi power
2N1901	PSI	npn,DM,si	125	1	150	140	5	10	20	25 mc	–	–	hi freq., hi pwr.
2N173	DE	pnp,AJ,ge	150	0.5	100	60	0.5	–	0.1	10	–	20	MO, TS, TI, RCA
2N174	DE	pnp,AJ,ge	150	0.5	100	80	15	–	0.1	10	–	40	TS, MO, TI, RCA
2N277	DE	pnp,AJ,ge	150	0.5	100	40	15	–	0.1	10	–	20	MO, TS, TI, RCA
2N278	DE	pnp,AJ,ge	150	0.5	100	50	15	–	0.1	10	–	20	MO, TS, TI, RCA
2N441	DE	pnp,AJ,ge	150	0.5	100	40	15	–	0.1	10	–	20	MO, TS, TI, RCA
2N442	DE	pnp,AJ,ge	150	0.5	100	50	15	–	0.1	10	–	20	MO, TS, TI, RCA
2N443	DE	pnp,AJ,ge	150	0.5	100	60	15	–	0.1	10	–	20	MO, TS, TI, RCA
2N511	TI	pnp,AJ,ge	150	2	100	40	25	20-60	5	–	–	–	Sat. volt = 0.2v
2N511A	TI	pnp,AJ,ge	150	2	100	60	25	20-60	5	–	–	–	Sat. volt = 0.02v
2N511B	TI	pnp,AJ,ge	150	2	100	80	25	20-60	5	–	–	–	
2N512	TI	pnp,AJ,ge	150	2	100	40	25	20-60	5	–	–	–	
2N512A	TI	pnp,AJ,ge	150	2	100	60	25	20-60	5	–	–	–	
2N512B	TI	pnp,AJ,ge	150	2	100	80	25	20-60	5	–	–	–	
2N513	TI	pnp,AJ,ge	150	2	100	40	25	20-60	5	–	–	–	Sat. volt = 0.4v
2N513A	TI	pnp,AJ,ge	150	2	100	60	25	20-60	5	–	–	–	Sat. volt = 0.4v
2N513B	TI	pnp,AJ,ge	150	2	100	80	25	20-60	5	–	–	–	Sat. volt = 0.4v
2N514	TI	pnp,AJ,ge	150	2	100	40	25	20-60	5	–	–	–	Sat. volt = 0.5v
2N514A	TI	pnp,AJ,ge	150	2	100	60	25	20-60	5	–	–	–	Sat. volt = 0.5v
2N514B	TI	pnp,AJ,ge	150	2	100	80	25	20-60	5	–	–	–	Sat. volt = 0.5v
2N1021	TI	pnp,AJ,ge	150	2	100	100	10	30-90	2	–	–	–	TR
2N1022	TI	pnp,AJ,ge	150	2	100	120	10	30-90	2	–	–	–	TR
2N1099	DE	pnp,AJ,ge	150	0.5	100	80	15	–	0.1	10	–	40	TS, MO, TI, RCA
2N1100	DE	pnp,AJ,ge	150	0.5	100	100	15	–	0.1	10	–	40	TS, MO, RCA
2N1907	TI	pnp,AD,ge	150	2	100	100	20	10	10	–	–	–	
2N1908	TI	pnp,AD,ge	150	2	100	130	20	10	10	–	–	–	
2N1980	TI	pnp,AJ,ge	150	2	100	50	15	50	6	–	–	–	
2N1981	TI	pnp,AJ,si	150	2	100	70	15	50	6	–	–	–	
2N1982	TI	pnp,AJ,si	150	2	100	90	15	50	6	–	–	–	
WX118UA	WH	npn,F,si	150	2	150	50	10	1000	10	11	–	–	

Power (concluded)

Type No.	Mfg.	Type	W_c w	Max. Ratings w/c	T_j c	V_c v	I_c amp	Characteristics h_{fe}	I_{co} ma	$f_{\alpha e}$ kc	Powr. Gain db	Powr. Out. w	Remarks
WX118UB	WH	npn,F,si	150	2	150	100	10	1000	10	11	–	–	
WX118UC	WH	npn,F,si	150	2	150	150	10	1000	10	11	–	–	
WX118XA	WH	npn,F,si	150	2	150	50	10	1200	10	11	–	–	
WX118XB	WH	npn,F,si	150	2	150	100	10	1200	10	11	–	–	
WX118XC	WH	npn,F,si	150	2	150	150	10	1200	10	11	–	–	
WX115UA	WH	npn,AJ,si	250	2.22	150	50	30	30	15	17	–	–	
WX115UB	WH	npn,AJ,si	250	2.22	150	100	30	30	15	17	–	–	
WX115UC	WH	npn,AJ,si	250	2.22	150	150	30	30	15	17	–	–	
WX115UD	WH	npn,AJ,si	250	2.22	150	200	30	30	15	17	–	–	
WX115WA	WH	npn,AJ,si	250	2.22	150	50	30	23	15	18	–	–	
WX115WB	WH	npn,AJ,si	250	2.22	150	100	30	23	15	18	–	–	
WX115WC	WH	npn,AJ,si	250	2.22	150	150	30	23	15	18	–	–	
WX115WD	WH	npn,AJ,si	250	2.22	150	200	30	23	15	18	–	–	
WX115WD	WH	npn,AJ,si	250	2.22	150	200	30	23	15	18	–	–	
WX115XA	WH	npn,AJ,si	250	2.22	150	50	30	27	15	19	–	–	
WX115XB	WH	npn,AJ,si	250	2.2	150	100	30	27	15	19	–	–	
WX115XC	WH	npn,AJ,si	250	2.22	150	150	30	27	15	19	–	–	
WX115XD	WH	npn,AJ,si	250	2.22	150	200	15	27	15	19	–	–	

Special Types

Type No.	Mfg.	Type	$f_{\alpha e}$	Max. Ratings W_c w	T_j °C	mw/c	V_c v	I_c amp	Characteristics h_{fe}	I_{co} ma	NF	C_{toe}	Remarks
2N469A	GI	pnp,AJ,ge	1.8 mc	50	85	0.83	20	–	75	5	16	30	photo
2N1311	GI	npn,AJ,ge	1.5 mc	120	100	1.5	75	–	25	3	10	11	high voltage
2N1312	GI	npn,AJ,ge	2 mc	120	100	1.5	50	–	30	3	10	11	high voltage
2N1392	GI	pnp,AJ,ge	1 mc	50	85	0.83	20	–	40	5	16	30	photo
2N1310	GI	npn,AJ,ge	1.0 mc	120	100	1.5	90	–	30	3	10	11	high voltage
2N1393	GI	pnp,AJ,ge	3.4 mc	50	85	0.83	20	–	160	5	16	30	photo
2N1394	GI	pnp,AJ,ge	1 mc	50	85	0.83	10	–	50	5	16	30	photo
GT1624	GI	npn,AJ,ge	3	150	100	2	40	–	75	4	–	–	high voltage
GT1200	GI	npn,AJ,ge	–	120	85	2	90	–	–	4	20	–	driver
2N1408	GI	pnp,AJ,ge	–	150	100	2	50	–	20	3	10	35	high voltage

Type No.	Mfg.	Type	w(mw)	T	mw/c	V	I(ma)	gm	Remarks
C650	CT	pnp,AJ,si	250	160	2	45	50	–	field effect
C651	CT	pnp,AJ,si	250	160	2	35	50	–	field effect
C652	CT	pnp,AJ,si	250	160	2	25	50	–	field effect
C653	CT	pnp,AJ,si	250	160	2	15	50	–	field effect
C610	CT	pnp,AJ,si	250	160	2	40	50	250	field effect
C611	CT	pnp,AJ,si	250	160	2	40	50	400	field effect
C612	CT	pnp,AJ,si	250	160	2	40	50	650	field effect
C613	CT	pnp,AJ,si	250	160	2	40	50	1000	field effect
C614	CT	pnp,AJ,si	250	160	2	40	50	250	field effect
C615	CT	pnp,AJ,si	250	160	2	40	50	750	field effect
2N1671	GE	pn,si	450	140	–	–	–	–	unijunction
2N1671A	GE	pn,si	450	140	–	–	–	–	unijunction
2N1671B	GE	pn,si	450	140	–	–	–	–	unijunction
2N1510	GE	npn,RJ,ge	75	85	–	70	20	–	

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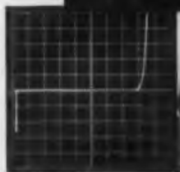
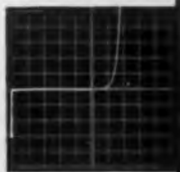
In-process testing of silicon diodes with a Type 575

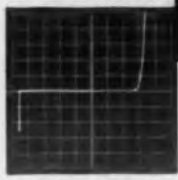
TEKTRONIX TRANSISTOR-CURVE TRACER



BEFORE SEALING



DURING SEALING



AFTER SEALING

INVALUABLE TOOL FOR EVALUATING SEMICONDUCTOR DEVICES

. . . in research and development

The Type 575 is a versatile precision tool for in-process testing of semiconductor diodes—as illustrated above in the Semiconductor-Device Development Lab of Tektronix' Research Division. Viewing the display on a Type 575, a technician can easily determine the forward conduction characteristics as well as the reverse breakdown-and-leakage of a semiconductor diode prior to sealing, during sealing, and after sealing.

NOTE: Double-exposure waveform photos of the case-sealing operation were taken with control settings at 1 ma/div (v) and 0.2 v/div (h)—forward direction, upper right—and 20μa/div (v) and 20 v/div (h)—reverse direction, lower left.

. . . in other applications

The Type 575 provides 20-ampere collector displays (10-ampere average supply current), two ranges of collector supply (0 to 20 volts, 0 to 200 volts), and 2.4-ampere base supply (positive or negative base stepping).

With a Type 575, you can plot and measure 7 different transistor characteristics. You can display 4 to 12 curves per family—with input current from 1 microampere/step to 200 milliamperes/step or input voltage from 10 millivolts/step to 200 millivolts/step—in repetitive or single-family presentations. You can select either common-emitter or common-base configurations.

Add a Type 175 Adapter and you extend the range of collector displays 10 times and the range of base supply 5 times.

. . . in production runs

The Type 575—used by itself or with a Type 175 Adapter for increased current capability—is a convenient Quality Control tool for production testing of both PNP and NPN transistors—a simple procedure with Test-Setup Charts of front-panel layout available from your Tektronix Field Engineer. Using a Test-Setup Chart, with control settings marked with arrows, display limits drawn on the graticule, other time-saving techniques devised by a QC Engineer clearly noted, a production worker can easily change from one test procedure to another, accurately compare the characteristic curves displayed on the 5-inch crt of the Type 575 with charted standards, and speedily accept or reject the transistor under test.

Type 575 Calibrated Displays

Vertical Axis—Collector Current, 16 steps from 0.01 ma/div to 1000 ma/div. Pushbuttons are provided for multiplying each current step by 2 and dividing by 10, increasing the current range to 0.001 to 2000 ma/div.

Horizontal Axis—Collector Voltage, 11 steps from 0.01 v/div to 20 v/div.

Both Axes—Base Voltage, 6 steps from 0.01 v/div to 0.5 v/div. Base Current, 17 steps from 0.001 ma/div to 200 ma/div. Base Source Voltage, 5 steps from 0.01 v/div to 0.2 v/div.

Type 575 Transistor-Curve Tracer $975
(price f.o.b. factory)

HIGH-CURRENT ADAPTER AVAILABLE

For measuring high-powered semiconductor devices which exceed the current capabilities of a Type 575, ask your Tektronix Field Engineer about the Type 175 High-Current Adapter. Not intended for separate use, the Type 175 depends upon the circuitry and crt of a Type 575 to provide *200-ampere collector displays, three ranges of collector supply, and 12-ampere base supply*—for calibrated displays with Collector Current on the Vertical Axis and either Collector Voltage or Base Voltage on the Horizontal Axis.

Type 175 Transistor-Curve Tracer High-Current Adapter . . . $1425

HIGH-VOLTAGE TYPE 575 AVAILABLE

Supplied on order from your Tektronix Field Engineer is a special model of the Type 575 Transistor-Curve Tracer. Although similar to the Type 575, the special model provides much higher diode breakdown test voltage (*variable from zero to 1500 volts* at a maximum current of 1 milliampere) and also much higher Collector Supply (*up to 400 volts*, at 0.5 ampere).

For complete specifications of this special model—call your Tektronix Field Engineer.

Type 575 Mod 122C $1175
(prices f.o.b. factory)

. . . for more information about evaluating semiconductor devices with a Type 575 or other Tektronix test equipment, call your Tektronix Field Engineer. He will be glad to assist you.

Tektronix, Inc. P. O. Box 500 • Beaverton, Oregon • Phone Mitchell 4-0161 • TWX—BEAV 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albuquerque, N. Mex. • Atlanta, Ga. • Baltimore (Towson) Md • Boston (Lexington) Mass. • Buffalo, N.Y. • Chicago (Park Ridge) Ill. • Cleveland, Ohio • Dallas, Texas • Dayton, Ohio Denver, Colo. • Detroit (Lathrup Village) Mich. • Endicott (Endwell) N.Y. • Greensboro, N.C. • Houston, Texas • Indianapolis, Ind. • Kansas City (Mission) Kan. • Los Angeles, Calif. Area (East Los Angeles, Encino • West Los Angeles) • Minneapolis, Minn. • Montreal, Quebec, Canada • New York City Area (Albertson, L.I., N.Y. • Stamford, Conn. • Union, N.J.) • Orlando, Fla. • Philadelphia, Pa. • Phoenix (Scottsdale) Ariz. Poughkeepsie, N.Y. • San Diego, Calif. • San Francisco, Calif. Area (Lafayette, Palo Alto) • St. Petersburg, Fla. • Syracuse, N.Y. • Toronto (Willowdale) Ont., Canada • Washington, D.C. (Annandale, Va.).

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations.

In Europe please contact Tektronix International A.G., Terrassenweg 1A, Zug, Switzerland, Phone (042) 4-[illegible], for the address of the Tektronix Representative in your country.

CIRCLE 54 ON READER-SERVICE CARD

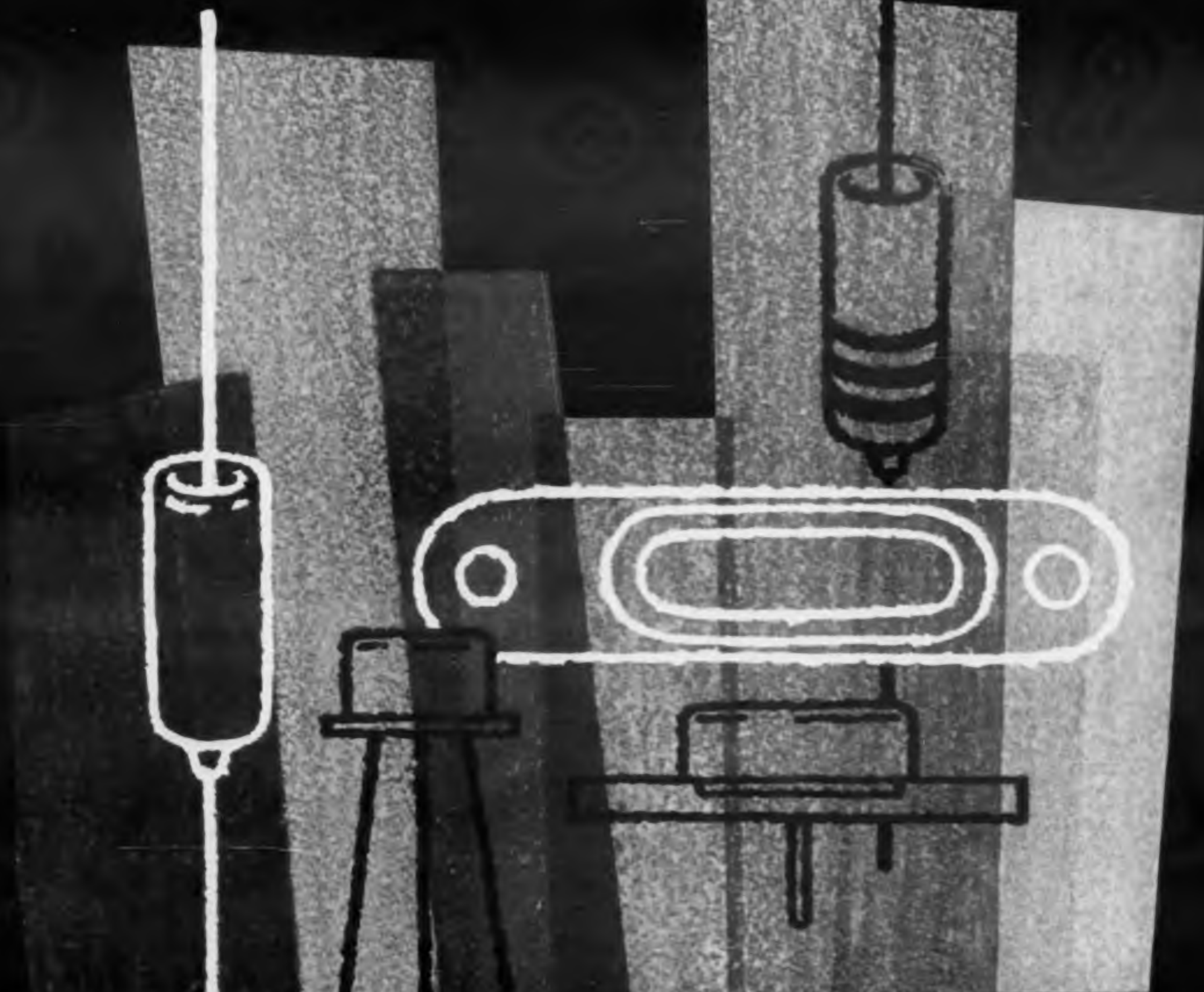
***CAREER OPPORTUNITIES** now exist at Tektronix in the following fields: Instrument design, Circuit design and engineering, Cathode-ray tubes, Electron physics, Solid state and semiconductor devices. For information write to . . Irving Smith, Professional Placement.*

CIRCLE 53 ON READER-SERVICE CARD

TRANSISTORS — 1961

Type No.	Mfg.	Type	f_{ae} kc	Maximum Ratings W_c (w)	T_j (c)	w/c	V_c v	I_c a	Characteristics h_{fe}	I_{co} ma	Powr. Gain db	Powr. Out w	Switching Rise Time μsec	Stor. Time μsec	Sat. Volt	Leak Cur	Remarks
2N1238	HU	pnp,FJ,si	0.8	1.0	200	–	15	0.5	14	0.1	–	–	–	–	–	–	
2N1239	HU	pnp,FJ,si	0.8	1.0	200	–	15	0.5	32	0.1	–	–	–	–	–	–	
2N1240	HU	pnp,FJ,si	1.0	1.0	200	–	35	0.5	14	0.1	–	–	–	–	–	–	
2N1241	HU	pnp,FJ,si	1.0	1.0	200	–	35	0.5	24	0.1	–	–	–	–	–	–	
2N1242	HU	pnp,FJ,si	1.0	1.0	200	–	65	0.5	14	0.1	–	–	–	–	–	–	
2N1243	HU	pnp,FJ,si	1.0	1.0	200	–	65	0.5	24	0.1	–	–	–	–	–	–	
2N1244	HU	pnp,FJ,si	1.2	1.0	200	–	110	0.5	14	0.1	–	–	–	–	–	–	
2N1073	BE	pnp,DJ,ge	1.5	35	100	1.5	40	10	20-6	2.0	–	–	–	–	1.0	–	
2N1073A	BE	pnp,DJ,ge	1.5	35	100	1.5	80	10	20-6	2.0	–	–	–	–	1.0	–	
2N1073B	BE	pnp,DJ,ge	1.5	35	100	1.5	120	10	20-6	2.0	–	–	–	–	1.0	–	
B-1085	BE	pnp,DJ,ge	1.5	60	100	1.0	120	10	5a	2.0	–	–	–	–	0.75	–	
OC22	AMP	pnp,PADT,ge	2.5	10	75	–	32	1	150	30	–	–	–	–	–	–	
OC23	AMP	pnp,PADT,ge	2.5	10	75	–	40	1	150	30	–	–	–	–	–	–	
OC24	AMP	pnp,PADT,ge	2.5	10	75	–	32	1	150	30	–	–	–	–	–	–	
2N1518	DE	pnp,AJ,ge	4	70	100	1.2	50	25	–	100	–	40	20	7	0.3	–	
2N1519	DE	pnp,AJ,ge	4	70	100	1.2	80	25	–	100	–	40	20	7	0.3	–	Min. gain of 12 at 25a
2N1520	DE	pnp,AJ,ge	4	70	100	1.2	50	35	–	100	–	40	20	7	0.3	–	Min. gain of 12 at 35a
2N1521	DE	pnp,AJ,ge	4	70	100	1.2	80	35	–	100	–	40	20	7	0.3	–	Min. gain of 12 at 35a
2N1522	DE	pnp,AJ,ge	4	70	100	1.2	50	50	–	100	–	40	20	7	0.3	–	Min. gain of 12 50a
2N1523	DE	pnp,AJ,ge	4	70	100	1.2	80	50	–	100	–	40	20	7	0.3	–	Min. gain of 12 at 50a
2N297	BE	pnp,AJ,ge	5	35	90	1.5	50	5	–	3	–	–	–	–	1.02	–	
2N297A	CL	pnp,AJ,ge	5	12	95	2.0	60	5	–	3	–	–	–	–	1.0	–	BE, DE, MO
2N618	CL	pnp,AJ,ge	5	14	90	1.5	80	3	–	3	–	–	–	–	0.8	80	MO
2N375	CL	pnp,AJ,ge	7	–	95	–	80	3	–	3	–	–	–	–	1.0	–	MO
2N378	TS	pnp,AJ,ge	7	50	100	1.2	20	5	30	0.5	–	–	–	–	–	–	
2N379	CL	pnp,AJ,ge	7	5	85	0.3	80	3	–	5	–	–	–	–	1	15	TS
2N380	TS	pnp,AJ,ge	7	50	100	0.8	30	5	–	0.5	–	–	–	–	–	50	
2N458	TI	pnp,AJ,ge	7	50	95	0.72	80	5	–	1	–	–	12	12.5	0.24	30	CL
2N459	TS	pnp,AJ,ge	7	50	100	0.8	60	5	–	0.5	–	–	–	–	–	30	
2N1011	DE	pnp,AJ,ge	7	70	100	0.1	80	5	–	100	–	–	5	2	0.3	–	2N1011 Sig. C., MO
2N456A	DE	pnp,AJ,ge	10	94	100	1.2	40	7	–	0.065	–	–	10	5	–	–	TI
2N457A	DE	pnp,AJ,ge	10	94	100	1.2	60	0.065	–	0.065	–	–	10	5	–	–	TI
2N458A	DE	pnp,AJ,ge	10	94	100	1.2	80	7	–	0.065	–	–	10	5	–	–	TI
2N1038	TI	pnp,AJ,ge	10	20	100	0.27	40	3	33	50	–	–	–	–	–	–	
2N1039	TI	pnp,AJ,ge	10	20	100	0.27	60	3	33	50	–	–	–	–	–	–	
2N1040	TI	pnp,AJ,ge	10	20	100	0.27	80	3	33	50	–	–	–	–	–	–	
2N1358	DE	pnp,AJ,ge	10	150	100	2	80	15	–	0.1	–	40	15	5	0.3	–	TS, TI, RCA, MO
2N1412	DE	pnp,AJ,ge	10	150	100	2	100	15	–	100	–	40	15	5	0.3	–	TS, RCA, MO
2N1970	DE	pnp,AJ,ge	10	150	100	2	100	15	–	0.1	–	–	10	5	–	–	
2N387	PH	pnp,AJ,ge	12	12.5	100	0.5	80	3	–	1.0	33	5	–	–	0.35	–	
2N386	PH	pnp,AJ,ge	14	12.5	100	0.5	60	3	–	0.1	33	5	–	–	–	–	
2N1046	TI	pnp,AD,ge	15	150	100	2	100	10	40	10	–	–	–	–	1.0	–	
2N1046A	TI	pnp,AD,ge	15	150	100	2	130	10	20	10	–	–	–	–	–	–	
2N1046B	TI	pnp,AD,ge	15	150	100	2	130	10	10	10	–	–	–	–	–	–	
2N1609	DE	pnp,AJ,ge	17	7.5	100	0.1	80	1.5	–	10	–	0.4w	3	1	0.3	–	
2N1610	DE	pnp,AJ,ge	17	7.5	100	0.1	80	1.5	–	10	–	0.4w	3	1	0.3	–	
2N1611	DE	pnp,AJ,ge	17	7.5	100	0.1	60	1.5	–	10	–	0.4w	3	1	0.3	–	
2N1612	DE	pnp,AJ,ge	17	7.5	100	0.1	60	1.5	–	10	–	0.4w	3	1	0.3	–	
2N1971	DE	pnp,AJ,ge	25	50	100	0.7	80	4	–	0.02	–	–	5	2	–	–	
2N1015	WH	npn,FJ,si	25	150	150	1.4	30	7.5	8	10	–	–	5	1	1.5	8	SE
2N1015A	WH	npn,FJ,si	25	150	150	1.4	60	7.5	8	10	–	–	5	1	1.5	8	SE
2N1015B	WH	npn,FJ,si	25	150	150	1.4	100	7.5	8	10	–	–	5	1	1.5	8	
2N1015C	WH	npn,FJ,si	25	150	150	1.4	150	7.5	8	10	–	–	5	1	1.5	8	
2N1015D	WH	npn,FJ,si	25	150	150	1.4	200	7.5	8	10	–	–	5	1	1.5	8	
2N1016	WH	npn,FJ,si	25	150	150	1.4	30	7.5	8	10	–	–	5	1	2.5	8	SE
2N1016A	WH	npn,FJ,si	25	150	150	1.4	60	7.5	8	10	–	–	5	1	2.5	8	SE
2N1016B	WH	npn,FJ,si	25	150	150	1.4	100	7.5	8	10	–	–	5	1	2.5	8	
2N1016C	WH	npn,FJ,si	25	150	158	1.4	150	7.5	8	10	–	–	5	1	2.5	8	
2N1016D	WH	npn,FJ,si	25	150	150	1.4	200	7.5	8	10	–	–	5	1	2.5	8	
2N1667	AMP	pnp,PADT,ge	200	30	90	–	–	6	90	0.1	–	–	–	–	–	–	
2N1668	AMP	pnp,PADT,ge	200	30	90	–	–	6	50	0.1	–	–	–	–	–	–	
2N1669	AMP	pnp,PADT,ge	200	30	90	–	–	–	70	0.1	–	–	–	–	–	–	
OC28	AMP	pnp,PADT,ge	200	13	90	–	80	6	32	<100	–	–	–	–	–	–	
OC29	AMP	pnp,PADT,ge	200	13	90	–	60	6	90	<100	–	–	–	–	–	–	
OC35	AMP	pnp,PADT,ge	200	13	90	–	60	6	50	<100	–	–	–	–	–	–	
OC36	AMP	pnp,PADT,ge	200	13	90	–	80	6	70	<100	–	–	–	–	–	–	
2N418	BE	pnp,AJ,ge	400	60	100	1.2	100	4	60	1.0	–	–	–	–	0.5	–	
2N420	BE	pnp,AJ,ge	400	60	100	1.2	65	4	60	1.0	–	–	15	–	1.7	–	
2N420A	BE	pnp,AJ,ge	400	60	100	1.2	90	15	60	1.0	–	–	–	–	0.5	–	
2N637	BE	pnp,AJ,ge	400	60	100	1.2	60	6	45	1.0	–	–	–	–	0.7	–	

CIRCLE 56 ON READER-SERVICE CARD ➤



How to select power transistors

by RICHARD F. MOREY, JR.

Manager, Applications Engineering, Clevite Transistor Division of Clevite Corporation

A basic understanding of the interrelationship of transistor design parameters facilitates selection of the most advantageous unit for a given application.

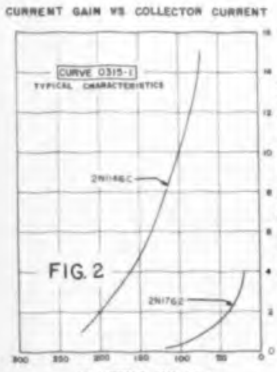
Transistor characteristics depend upon each other. Consequently, a design change in the manufacture of a transistor directly affects a number of its electrical characteristics.

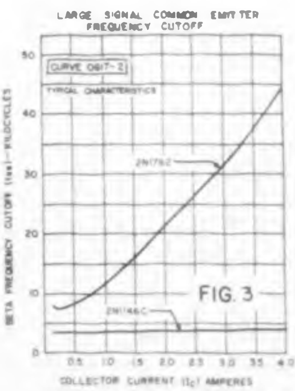
As a guide to users of power transistors, several of the important design elements and the electrical characteristics they influence have been summarized in chart form (fig. 1).

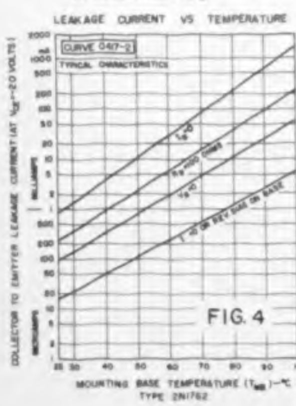
The curves (figs. 2-5), show typical characteristics for two power transistors of quite different design. Clevite's 2N1762, for example, is a 3 ampere unit having the following design parameters: Small junction area; high resistivity germanium; moderate germanium lifetime; average wafer thickness and no emitter doping.

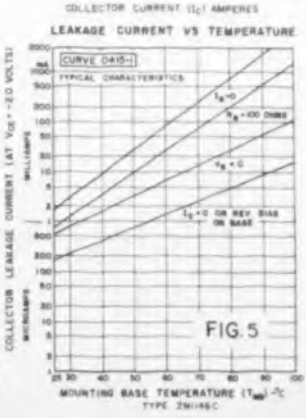
In contrast, Clevite's 2N1146C is a 15 ampere power transistor which has several quite different parameters based upon a higher current and power requirement; large junction area several times the size of the 3 ampere unit; identical base width and resistivity but longer germanium lifetime and thicker wafer plus aluminum doping to increase emitter efficiency.

Working with the chart in figure 1 and the table, figure 6, we see that the comparative design elements of









Effect of Transistor Design on Characteristics

DESIGN PARAMETER	Addition of Emitter Doping	Increase in Wafer Thickness	Reduction in GE material lifetime	Increase in GE material resistivity	Reduction in Base Width	Increase in Junction Area
THERMAL RESISTANCE R_T	—	—	—	—	—	decrease
COLLECTOR LEAKAGE CURRENT I_{CBO}	—	decrease	increase	increase	—	increase
COLLECTOR BASE VOLTAGE V_{CB}	—	—	—	increase	—	decrease slightly
COLLECTOR EMITTER VOLTAGE V_{CE}	decrease	—	increase	increase	decrease	decrease slightly
D.C. CURRENT GAIN h_{FE}	increase	—	decrease	—	increase	—
LINEARITY OF h_{FE}	better	—	—	—	—	better
SATURATION VOLTAGE $V_{CE(SAT)}$	decrease	decrease	increase	increase	decrease	decrease
BETA CUTOFF FREQUENCY f_{ae}	decrease	—	increase	—	increase	decrease
PUNCH THROUGH VOLTAGE V_{PT}	—	—	—	decrease	decrease	—
SECONDARY BREAKDOWN CURRENT I_{SB}	increase	increase	—	decrease	—	increase

Figure 1.

the two transistors result in the 15 ampere unit exhibiting:

- — lower thermal resistance and higher leakage currents because of its large junction area.
- — slightly lower collector to base voltage.
- — higher gain because of the emitter doping and higher lifetime.
- — very linear current gain out to high currents because of its large area and special emitter doping.
- — lower collector to emitter breakdown voltages because of its higher gain and lower collector to base voltage.
- — much lower saturation voltage and base input voltage because of its high gain and thicker wafer and larger area.
- — low common emitter frequency response because of its high gain and large area.

Comparison of Characteristics — Two different designs

Characteristic	2N1762 Typical Value 3 Amp. Device	2N1146C Typical Value 15 Amp. Device	Units
Thermal Resistance	1.4	0.5	°C/watt
I_{CBO} at 100V at 85°C	3	15	mA
I_{CBO} at 100V at 25°C	1	4	mA
BV_{CBO}	130	120	Volts
$V_{CEO(sus)}$	70	50	Volts
Current Gain at I_C = 1 Amp.	60	220	
Current Gain at I_C = 5 Amps.	15	140	
Current Gain at I_C = 15 Amps.	—	75	
Saturation Voltage at 3 Amps.	0.3	0.2	Volts
Saturation Voltage at 15 Amps.	—	0.4	Volts
Saturation Resistance	100	26	Milliohms
Frequency Cutoff at 1 Amp.	18	4	kc.

Figure 6

In order for circuit designers and users of power transistors to obtain the best combination of electrical characteristics, the requirements for the application must be well known and be matched to the transistors available on the market. Therefore, an elementary knowledge of the existing relationships between transistor characteristics is a useful design tool. A tabular summary of characteristics for Clevite's complete line of power transistors is available. Ask for Bulletin 61-A.

CLEVITE TRANSISTOR
Waltham, Massachusetts

DATA CHART

Abbreviation of Terms

AJ	Alloy Junction
DD	Double Diffused
DG	Grown Diffused
DJ	Diffused Junction
DM	Diffused Mesa
DP	Diffused Planar
Dr	Drift
Ep	Epitaxial
FA	Fused Alloy
FJ	Fused Junction
GD	Grown Diffused
Ge	Germanium
GJ	Grown Junction
GR	Grown Rate
MB	Meltback
MD	MADT
Ms	Mesa
RG	Rate Grown
Si	Silicon
SBT	Surface Barrier
C_{oe}	= Collector-to-emitter capacitance measured across the output terminals with the input ac open-circuited.
f_{ae}	= Frequency at which the magnitude of the forward-current transfer ratio (small-signal) is 0.707 of its low-frequency value.
f_T	= Frequency at which common emitter gain is unity.
h_{fe}	= Common emitter-small signal forward current transfer ratio.
h_{FE}	= Common emitter-static value of short-circuited forward current ratio.
I_{CO}	= Collector current when collector junction is reverse-biased and emitter is dc open-circuited.

If you would like an additional copy of the Transistor Data Chart Section circle 251 on the Reader-Service Card (Quantity prices on request)

High Level (continued)

Type No.	Mfg.	Type	$f_{\alpha e}$	Max. Ratings: W_c (w)	T_j c	w/c	V_c v	I_c a	Characteristics: h_{fe}	I_{co} ma	Powr. Gain db	Powr. out w	Switching: Rise Time μsec	Stor Time μsec	Sat. Volt	Leak Out	Remarks
2N637A	BE	pnp,AJ,ge	400	60	100	1.2	90	6	45	1.0	–	–	–	–	0.7	–	
2N637B	BE	pnp,AJ,ge	400	60	100	1.2	100	6	45	1.0	–	–	–	–	0.7	–	CL
2N638	BE	pnp,AJ,ge	400	60	100	1.2	60	6	30	1.0	–	–	–	–	0.7	–	
2N638A	BE	pnp,AJ,ge	400	60	100	1.2	90	6	30	1.0	–	–	–	–	0.7	–	
2N638B	BE	pnp,AJ,ge	400	60	100	1.2	100	6	30	1.0	–	–	–	–	0.7	–	
2N675	PH	pnp,AJ,ge	400	1	85	16.7	75	2	40	100	–	–	–	–	0.35	–	Infinite heat sink
2N456	TI	pnp,AJ,ge	430	50	100	0.67	40	5	30-90	0.2	–	–	12	12.5	0.24	30	RCA
2N457	TI	pnp,AJ,ge	430	50	100	0.67	60	5	30-90	0.6	–	–	12	12.5	0.24	30	RCA
2N671	PH	pnp,AJ,ge	700	1	85	0.017	40	2	100	20	–	–	–	–	–	–	Infinite heat sink
STC1103	STC	npn,DJ,si	1mc	85	200	0.425	60	6	25-75	0.025	–	–	–	–	–	–	
STC1104	STC	npn,DJ,si	1mc	85	200	0.425	100	6	25-75	0.025	–	–	–	–	–	–	
2N673	PH	pnp,AJ,ge	1.1mc	0.3	85	5	75	2	160	40	–	–	0.5	0.4	0.2	–	Infinite heat sink
2N424A	STC	npn,DM,si	2mc	85	200	0.4	60	3	12-60	10	–	–	–	–	–	–	SE
2N1701	STC	npn,DM,si	2mc	25	200	0.125	60	2.5	20-80	0.1	–	–	–	–	–	–	
2N1702	STC	npn,DM,si	2mc	75	200	0.375	60	5	15-60	0.2	–	–	–	–	–	–	
2N1768	STC	npn,DM,si	2	40	200	0.2	80	3	35-100	.015	–	–	–	–	–	–	
2N1769	STC	npn,DM,si	2	40	200	0.2	100	3	35-100	.015	–	–	–	–	–	–	
2N1620	STC	npn,DM,si	2mc	85	200	0.425	100	5	15-75	1	–	–	–	–	–	–	
2N551	TR	npn,DJ,si	3mc	3	200	0.5	60	–	20-80	1.2	–	–	1.2	0.3	0.9	–	
2N552	TR	npn,DJ,si	3mc	3	200	0.5	30	–	20-80	1.2	–	–	1.2	0.3	0.9	–	
2N1055	TR	npn,DJ,si	3	3	200	0.045	100	–	20-80	0.001	–	–	–	–	–	–	
2N547	TR	npn,DJ,si	4mc	5	200	0.5	60	–	20-80	1.2	–	–	0.7	0.2	3.0	–	
2N548	TR	npn,DJ,si	4mc	5	200	0.5	30	–	20-80	0.5	–	–	0.7	0.2	2.0	–	
2N549	TR	npn,DJ,si	4mc	5	200	0.5	60	–	20-80	0.5	–	–	0.7	0.2	1.5	–	
2N550	TR	npn,DJ,si	4mc	5	200	0.5	30	–	20-80	0.5	–	–	0.7	0.2	1.5	–	
2N1117	TR	npn,DJ,si	4mc	5	200	0.5	60	–	40	0.04	–	–	0.7	0.2	1.5	–	
2N1116	TR	npn,DJ,si	6mc	5	200	0.5	60	–	40	1.2	–	–	0.7	0.2	3.0	–	
2N1173	WE	npn,AJ,ge	6mc	–	100	3.33	35	0.2	80	0.004	–	–	–	–	–	–	
ST402	TR	npn,DJ,si	6mc	50	200	0.33	60	3	30	20	–	–	0.25	0.5	6	–	
ST403	TR	npn,DJ,si	6mc	50	200	0.33	45	3	30	20	–	–	0.25	0.5	5	–	
2N1174	WE	pnp,AJ,ge	7mc	–	100	3.33	35	0.2	85	0.005	–	–	–	–	–	–	
2N545	TR	npn,DJ,si	8mc	5	200	0.5	60	–	15	1.2	–	–	0.3	0.15	3.0	25	
2N546	TR	npn,DJ,si	8mc	5	200	0.5	30	–	15	0.5	–	–	0.3	-0.15	2.0	–	
2N1062	TR	npn,DJ,si	8mc	5	200	.045	60	–	15	0.001	–	–	–	–	–	–	
2N1212	TR	npn,DJ,si	10mc	85	200	0.27	60	3000	12-60	1000	–	–	–	–	3.5	–	
2N1054	TR	npn,DJ,si	12mc	5	200	.045	125	–	20-80	.0004	–	–	–	–	–	–	
2N1208	TR	npn,DJ,si	12mc	85	200	0.27	60	5	15	1.0	–	–	0.25	–	3	–	
2N1209	TR	npn,DJ,si	12mc	85	200	0.27	45	5	20	2.0	–	–	0.25	–	3	–	
2N1250	TR	npn,DJ,si	12mc	85	200	0.27	60	5	15	1.0	–	–	0.25	–	3	–	SE
ST401	TR	npn,DJ,si	12mc	85	200	0.27	45	5	20	2.0	–	–	0.25	–	3	–	
2N1072	WE	npn,DD,si	30mc	12	150	65	75	1	13	0.1	–	–	0.05	0.05	–	–	US, MIL only
2N1041	TI	npn,AJ,ge	33	20	100	0.27	100	3	33.	50	–	–	–	–	–	–	
RT497M	RH	npn,DD,si	50	3	175	0.02	60	0.5	20	–	–	–	–	–	–	–	Microbloc TO-46
RT498M	RH	npn,DD,si	50	3	175	0.02	100	0.5	20	–	–	–	–	–	–	–	Microbloc
2N912	FA	npn,DP,si	60*	1.8	200	0.01	80	–	30	0.005μa	–	–	–	–	–	–	*f_T
2N1975	FA	npn,DP,si	60*	3	200	0.017	80	–	30	0.005μa	–	–	–	–	–	–	*f_T
2N1978	FA	npn,DP,si	60*	30	200	0.17	40	–	40	0.001μa	–	–	–	–	–	–	*f_T
2N1985	FA	npn,DM,si	60*	2	150	0.0016	35	–	30	–	–	–	–	–	–	–	*f_T
2N1989	FA	npn,DM,si	60*	2	150	0.0016	60	–	40	–	–	–	–	–	–	–	*f_T
RT656M	RH	npn,DD,si	60	3	175	0.02	60	0.5	60	–	–	–	–	–	–	–	Microbloc
RT657M	RH	npn,DD,si	60	3	175	0.02	100	0.5	60	–	–	–	–	–	–	–	Microbloc
RT5202	RH	npn,DD,si	60	5	175	0.033	175	0.5	50	0.001	–	–	–	–	–	–	
RT5230	RH	npn,DD,si	60	2	175	0.013	30	0.5	50	–	–	–	–	–	–	–	
2N721	FA	pnp,DP,si	70*	1.5	175	0.01	50	–	35	0.01μa	–	–	–	–	–	–	*f_T
2N1131	FA	pnp,DP,si	70*mc	2	175	13.3	50	–	35	0.01	–	–	0.08	–	–	–	*f_T HU, TI, TR
2N1987	FA	npn,DM,si	70*	2	150	0.0016	40	–	50	–	–	–	–	–	–	–	*f_T
2N696	FA	npn,DP,si	80(f_T)	2	175	13.3	40	–	40	–	–	–	0.08	0.03	–	–	SSD, TR, SY, NA, TI.
2N698	FA	npn,DP,si	80(f_T)	2	175	13.3	80	–	30	0.01	–	–	0.08	–	–	–	RH, TR, NA, GI, SSD, IND, PSI, TI
2N717	FA	npn,DP,si	80(f_T)	1.5	175	10	80	–	30	0.01	–	–	0.08	–	–	–	GI. HO, PSI, RH, NA
2N719	FA	npn,DP,si	80(f_T)	1.5	175	10	80	–	30	0.01	–	–	0.08	–	–	–	PSI, RH, GI
2N1252	FA	npn,DP,si	80(f_T)	2	175	13.3	20	–	35	0.1	–	–	0.08	0.05	–	–	TR, GI, IND, PSI, TI, RH
2N719A	FA	npn,DP,si	80*	1.8	200	0.01	80	–	45	0.0004μa	–	–	–	–	–	–	*f_T GI
2N870	FA	npn,DP,si	80*	1.8	200	0.01	80	–	80	0.0004μa	–	–	–	–	–	–	*f_T
2N911	FA	npn,DP,si	80*	1.8	200	0.01	80	–	70	.0005 μa	–	–	–	–	–	–	*f_T
2N1613	FA	npn,DP,si	80*mc	3	200	17.2	50	–	80	0.0004	17	–	0.08	–	–	–	*f_T RH
2N1889	FA	npn,DP,si	80*	3	200	0.017	80	–	80	0.0004μa	–	–	–	–	–	–	*f_T
2N1893	FA	npn,DP,si	80*	3	200	0.017	100	–	80	0.0004	–	–	–	–	–	–	*f_T
2N1974	FA	npn,DP,si	80*	3	200	0.017	80	–	70	0.005μa	–	–	–	–	–	–	*f_T
2N1984	FA	npn,DM,si	80*	2	150	0.0016	35	–	70	–	–	–	–	–	–	–	*f_T
2N1991	FA	pnp,DM,si	80*	1	175	0.0057	20	–	45	0.005μa	–	–	–	–	–	–	*f_T
RT482	RH	npn,DD,si	80	2	175	0.0134	20	0.5	50	0.02	–	–	–	–	–	–	
RT483	RH	npn,DD,si	80	2	175	0.0134	40	0.5	40	0.02	–	–	–	–	–	–	
RT484	RH	npn,DD,si	80	2	175	0.0134	40	0.5	70	0.02	–	–	–	–	–	–	
RT696M	RH	npn,DD,si	80	3	175	0.02	60	0.5	40	0.003	–	–	–	–	–	–	Microbloc

High Level

Type No.	Mfg.	Type	Max. Ratings: $f_{\alpha e}$	W_c (w)	T_j c	w/c	V_c v	I_c a
RT698M	RH	npn,DD,si	80	3	175	0.02	120	0.5
RT5151	RH	npn,DD,si	80	2	175	0.013	45	0.5
RT5152	RH	npn,DD,si	80	2	175	0.013	45	0.5
RT5203	RH	npn,DD,si	80	2	175	0.013	40	0.5
RT5204	RH	npn,DD,si	80	2	175	0.013	30	0.5
RT5212	RH	npn,DD,si	80	2	175	0.013	60	0.5
2N722	FA	pnp,DP,si	90*	1.5	175	0.01	50	–
2N1988	FA	npn,DM,si	90*	2	150	0.0016	60	–
2N697	FA	npn,DP,si	100(f_T)	2	175	13.3	40	–
2N699	FA	npn,DP,si	100(f_T)	2	175	13.3	80	–
2N718	FA	npn,DP,si	100(f_T)	1.5	175	10	40	–
2N718A	FA	npn,DP,si	100*	1.8	200	0.01	50	–
2N720	FA	npn,DP,si	100(f_T)	1.5	175	10	80	–
2N720A	FA	npn,DP,si	100*	1.8	200	0.01	100	–
2N730	TI	npn,MS,si	100mc	1.5	175	0.01	60	–
2N731	TI	npn,MS,si	100mc	1.5	175	0.01	60	–
2N871	FA	npn,DP,si	100*	1.8	200	0.01	80	–
2N909	FA	npn,DM,si	100*	1.5	175	0.01	30	–
2N910	FA	npn,DP,si	100*	1.8	200	0.01	80	–
2N1060	WE	npn,MS,si	100mc	–	150	2	40	0.05
2N1132	FA	pnp,DP,si	100(f_T)	2	175	13.3	50	–
2N1253	FA	npn,DP,si	100(f_T)	2	175	13.3	20	–
2N1420	FA	npn,DP,si	100*	2	175	0.013	30	–
2N1444	WE	npn,DM,si	100mc	–	150	4	60	0.25
2N1711	FA	npn,DP,si	100*	3	200	0.017	50	–
2N1890	FA	npn,DP,si	100*	3	200	0.017	80	–
2N1972	FA	npn,DM,si	100*	2	175	0.013	30	–
2N1973	FA	npn,DP,si	100*	3	200	0.017	80	–
2N1983	FA	npn,DM,si	100*	2	150	0.0016	35	–
2N1986	FA	npn,DM,si	100*	2w	150	0.0016	40	–
RT409	RH	npnDD,si	100	3	175	0.02	60	0.5
RT696AM	RH	npn,DD,si	100	3	175	0.02	60	5
RT697M	RH	npn,DD,si	100	3	175	0.02	60	0.5
RT697AM	RH	npn,DD,si	100	3	175	0.02	60	0.5
RT699M	RH	npn,DD,si	100	3	175	0.02	120	0.5
RT1613M	RH	npn,DD,si	100	3	175	0.02	75	0.5
RT5001	RH	npn,MESA,si	120 mc	3	175	20	60	100
RT5002	RH	npn,MESA,si	120 mc	3	175	20	60	100
RT5003	RH	npn,MESA,si	120 mc	3	175	20	100	100
RT5004	RH	npn,MESA,si	120 mc	3	175	20	100	100
RT1420M	RH	npn,DD,si	130	3	175	0.02	60	0.5
2N869	FA	pnp,DP,si	150*	1.2	200	0.007	25	–
2N1409	PSI	npn,MS,si	175	2.8	150	0.024	30	0.5
2N1409A	PSI	npn,DM,si	250	2.8mc	175	0.186	30	0.5
2N1410	PSI	npn,MS,si	175	2.8	150	0.024	45	0.5
2N1410A	PSI	npn,DM,si	250	2.8 w	175	0.186	45	0.5
2N708	FA	npn,DP,si	400*	1.2	200	0.007	20	–
2N915	FA	npn,DP,si	400*	1.2	200	0.007	60	–
2N916	FA	npn,DP,si	400*	1.2	200	0.007	35	–
2N914	FA	npn,DP,si	450*	1.2	200	0.007	20	–
2N268A	CL	pnp,AJ,ge	–	14	90	1.5	80	3
2N497A	GE	npn,MS,si	–	1	200	–	60	–
2N498A	GE	npn,DM,si	–	1	200	–	100	–
2N656A	GE	npn,DM,si	–	1	200	–	60	–
2N657A	GE	npn,DM,si	–	1	200	–	100	–
2N1990	FA	npn,DM,si	–	2	150	0.0016	–	–
PADT50	AMP	pnp,PADT,ge	–	16.5	75	–	75	0.75
PADT40	AMP	pnp,PADT,ge	2	94	75	–	–	–

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DATA CHART

(concluded)

Characteristics				Switching				
h_{fe}	I_{co} ma	Powr. Gain db	Powr. Out w	Rise Time µsec	Stor. Time µsec	Sat. Volt	Leak Out	Remarks
40	0.01	–	–	–	–	–	–	Microbloc
60	–	–	–	–	–	–	–	
60	–	–	–	–	–	–	–	
–	–	–	–	–	–	–	–	
70	–	–	–	–	–	–	–	
70	–	–	–	–	–	–	–	
50	0.01µa	–	–	–	–	–	–	*fT
70	–	–	–	–	–	–	–	*fT
75	–	18	0.08	0.03	–	–	–	SSD, SY, NA, GI, TI, IND, PSI, HO, RH, TR
65	0.01	–	–	0.08	–	–	–	NA, TR, SSD, GI, PSI, TI, RH
75	0.01	–	–	0.08	–	–	–	NA, GI, HO, PSI, RH
80	0.0004µa	–	–	–	–	–	–	*fT GI
65	0.01	–	–	0.08	–	–	–	PSI, RH, NA, GI
80	0.0004µa	–	–	–	–	–	–	*fT GI
30	0.01	–	–	0.11	0.14	0.9	–	FA
60	0.01	–	–	0.11	0.14	0.9	–	FA
130	0.0004	–	–	–	–	–	–	*fT
150	0.01 µa	–	–	–	–	–	–	*fT
100	0.005	–	–	–	–	–	–	*fT
40	0.001µa	–	–	–	–	–	–	
50	0.01	–	–	0.08	–	–	–	HU, TI, TR
45	0.01	–	–	0.08	0.05	–	–	TR, IND, GI, PSI, TI, RH
130	0.01	–	–	–	–	–	–	*fT
25	0.002µa	–	–	–	–	–	–	
130	0.0004µa	–	–	–	–	–	–	*fT
130	0.0004	–	–	–	–	–	–	*fT
150	0.01 µa	–	–	–	–	–	–	*fT
100	0.005µa	–	–	–	–	–	–	*fT
140	–	–	–	–	–	–	–	*fT
120	–	–	–	–	–	–	–	*fT
40	0.003	–	–	–	–	–	–	
40	0.001	–	–	–	–	–	–	Microbloc
70	0.003	–	–	–	–	–	–	Microbloc
70	0.001	–	–	–	–	–	–	Microbloc
65	0.01	–	–	–	–	–	–	Microbloc
45	0.001	–	–	–	–	–	–	Microbloc
40	0.1	–	–	0.01	0.15	1.3	–	
60	0.1	–	–	0.1	0.2	1.3	–	
40	0.1	–	–	0.1	0.15	1.3	–	
60	0.1	–	–	0.1	0.2	1.3	–	
175	0.003	–	–	–	–	–	–	Microbloc
45	0.0008µa	–	–	–	–	–	–	*fT
30	10	7	1	0.06	0.1	0.8	–	Power gain F=70mcRH
10	0.05	10	1	0.032	0.1	–	–	
60	10	7	1	0.042	0.17	0.8	–	RH
6.5	0.003	–	–	0.04	0.17	–	–	
50	0.0004µa	–	–	–	–	–	–	*fT, GI
70	0.0003	–	–	–	–	–	–	*fT
80	0.0002µa	–	–	–	–	–	–	*fT
50	0.0004	–	–	–	–	–	–	*fT, Epitaxial
–	2	–	–	–	–	–	50	BE, 2N639A
12	10	–	–	–	–	–	–	
12	10	–	–	–	–	–	–	
30	10	–	–	–	–	–	–	
30	10	–	–	–	–	–	–	
40	–	–	–	–	–	–	–	
–	–	–	–	–	–	–	–	
50	–	–	–	–	–	–	–	

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TRANSISTORS – 1961

Low Level

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings					Characteristics			Switching				Remarks
				W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	h_{fe} h_{FE}	I_{co} μa	C_{coe} μμf	Rise Time	Stor Time	Sat Volt	Leak Cur	
2N327	CT	pnp,AJ,si	0.2	250	160	3	40	50	15	.005	70	–	–	–	–	
2N1034	RA	pnp,FA,si	0.2	250	160	–	40	50	15	5	70	–	–	–	–	SSD, NA
2N1275	RA	pnp,FA,si	0.2	250	160	.54	80	100	15	.005	60	–	–	–	–	
2N1037	RA	pnp,FA,ge	0.25	250	160	–	35	50	30	5	70	–	–	–	–	SSD, NA
2N328	CT	pnp,AJ,si	0.3	250	160	3	35	50	28	.005	70	–	–	–	–	
2N1035	RA	pnp.FA,si	0.3	250	160	–	35	50	30	5	70	–	–	–	–	SSD, NA
2N1036	RA	pnp,FA,si	0.4	250	160	–	30	50	60	5	70	–	–	–	–	SSD, NA
2N1640	CT	pnp,AJ,si	0.4	250	160	2	20	50	11	.001	50	–	–	–	–	
C101	CT	pnp,AJ,si	0.4	250	160	2	20	50	11	5	50	–	–	–	–	
C301	CT	pnp,AJ,si	0.4	250	160	2	70	50	4	5	50	–	–	–	–	
2N329	CT	pnp,AJ,si	0.5	250	160	3	30	50	60	.005	70	–	–	–	–	
2N329A	RA	pnp,FA,si	0.5	385	160	–	30	50	60	.005	70	–	–	.5	–	
2N1057	GE	pnp,AJ,ge	0.5	240	100	4	45	300	–	300	40	–	–	0.08	58	
2N327A	WT	pnp,AJ,si	0.7	–	200	3	.3	200	15	100	70	–	–	–	–	RA
2N670	PH	pnp,AJ,ge	0.7	300	85	5.0	40	2a	200	20	–	–	–	0.3	–	Pulse Amp.
2N1234	HU	pnp,AJ,si	0.8	400	160	3	110	100	21	10	95	–	–	–	–	TO-5 Package
2N1244	HU	pnp,AJ,si	0.8	1000	160	7.4	110	200	20	10	95	–	–	–	–	Coaxial package
2N1641	CT	pnp,AJ,si	0.8	250	160	2	10	50	15	.001	50	–	–	–	–	
C102	CT	pnp,AJ,si	0.8	250	160	2	15	50	15	5	50	–	–	–	–	
C302	CT	pnp,AJ,si	0.8	250	160	2	8	50	12	.2	50	–	–	–	–	
2N327A	HU	pnp,AJ,si	1.0	385	160	3	50	100	14	10	95	–	–	–	–	RA, SSD
2N328A	HU	pnp,AJ,si	1.0	385	160	3	50	100	25	10	95	–	–	–	–	WT, RA SSD, JA
2N329A	HU	pnp,AJ,si	1.0	385	160	3	50	100	50	10	95	–	–	–	–	WT, RA, SSD, NA
2N331	RCA	pnp,AJ,ge	1.0	200	85	3	30	200	–	16	–	–	–	–	–	BE, US, MO
2N1056	GE	pnp,AJ,ge	1.0	240	100	4	50	300	25	25	40	–	–	0.09	32	Neon indicator
2N674	PH	pnp,AJ,ge	1.1	300	85	5.0	75	2a	–	40	–	–	–	0.35	–	
2N1228	HU	pnp,AJ,si	1.2	400	160	3	15	100	20	10	95	–	–	–	–	WT
2N1229	HU	pnp,AJ,si	1.2	400	160	3	15	100	36	10	95	–	–	–	–	WT, NA
2N1230	HU	pnp,FJ,si	1.2	250	200	–	35	500	14	50	100	–	–	–	–	WT, NA
2N1231	HU	pnp,FJ,si	1.2	250	200	–	35	500	24	50	100	–	–	–	–	WT, NA
2N1232	HU	pnp,FJ,si	1.2	250	200	–	65	500	14	50	100	–	–	–	–	WT, NA
2N1233	HU	pnp,FJ,si	1.2	250	200	–	65	500	24	50	100	–	–	–	–	WT, NA
2N1234	HU	pnp,FJ,si	1.2	250	200	–	110	500	14	50	100	–	–	–	–	WT, NA
2N1238	HU	pnp,AJ,si	1.2	1w	160	7.4	15	200	20	10	95	–	–	–	–	Coaxial package
2N1239	HU	pnp,AJ,si	1.2	1w	160	7.4	15	200	36	10	95	–	–	–	–	Coaxial package
2N1239	HU	pnp,AJ,si	1.2	1w	160	–	15	–	28-65	.1	–	–	–	–	–	
2N1240	HU	pnp,AJ,si	1.2	1000	160	7.4	35	200	20	10	95	–	–	–	–	Coaxial package
2N1241	HU	pnp,AJ,si	1.2	1000	160	7.4	35	200	36	10	95	–	–	–	–	Coaxial package
2N1242	HU	pnp,AJ,si	1.2	1w	160	7.4	65	200	20	10	95	–	–	–	–	Coaxial package
2N1243	HU	pnp,AJ,si	1.2	1w	160	7.4	65	200	36	10	95	–	–	–	–	Coaxial package
2N1642	CT	pnp,AJ,si	1.2	250	160	2	6	50	23	.005		–	–	–	–	
C103	CT	pnp,AJ,si	1.2	250	160	2	10	50	23	5	50	–	–	–	–	Field effect
C106	CT	pnp,AJ,si	1.2	250	160	2	10	50	50	50	50	–	–	–	–	Field effect
2N312	SY	npn,AJ,ge	1.5	100	85	1.66	15	200	–	15	–	1.5	2	0.075	50	
2N519	IND	pnp,AJ,ge	1.5	150	85	2.5	15	200	25	2	14	–	–	–	–	US, KF
2N519A	IND	pnp,AJ,ge	1.5	150	85	2.5	25	200	25	1	14	1.3	0.7	–	35	US
B1154	BE	pnp,AJ,ge	1.5	400	100	.15	40	300	-	10	20	1.5	–	.25	–	
B1154A	BE	pnp,AJ,ge	1.5	400	100	.15	60	300	–	15	20	1.5	–	.25	–	
2N328A	SSD	pnp,FA,si	2	385	160	2.85	40	50	14	5	70	–	–	–	–	
2N536	PH	pnp,AJ,ge	2.0	50	85	0.83	20	30	–	4.0	–	–	–	0.07	150	
2N679	SY	npn,AJ,ge	2	150	85	2.5	20	200	–	25	–	5	5	0.3	20	
2N1125	PH	pnp,AJ,ge	2	300	85	5.0	40	250	–	10	–	–	–	0.15	50	
2N1220	SSD	pnp,AJ,si	2	150	150	1.2	25	–	9	0.1	–	–	–	–	10	
2N1223	SSD	pnp,AJ,si	2	150	150	1.2	40	–	6	0.1	–	–	–	–	–	
2N1446	IND	pnp,AJ,ge	2	200	85	3.33	45	400	30	5	–	–	–	–	–	
OC80	AMP	pnp,PADT,ge	2	550	75	–	32	600	85	10						
2N438	SY	npn,AJ,ge	2.5	100	85	1.6	30	–	20	10	–	0.7	–	–	0.5	
2N817	RA	npn,AJ,ge	2.5	75	85	1.25	30	400	20	10	20	–	–	–	–	Submin
2N818	RA	npn,AJ,ge	2.5	75	85	1.25	30	400	20	10	20	–	–	–	–	Submin
2N356	SY	npn,AJ,ge	3	100	85	1.6	20	500	–	25	–	1.0	0.3	0.6	–	GI
2N356A	GI	npn,AJ,ge	3	150	100	2	30	500	60	3	14	1.5	0.3	0.18	35	SY
2N520	KF	pnp,AJ,ge	3	150	100	2	20	–	20(min)	25	–	–	–	–	–	
2N801	RA	pnp,AJ,ge	3	75	85	1.25	30	400	30	4	20	–	–	–	–	Submin
2N802	RA	pnp,AJ,ge	3	75	85	1.25	30	400	30	4	20	–	–	–	–	Submin
2N1447	IND	pnp,AJ,ge	3	200	85	3.33	45	400	45	5	-	–	–	–	–	
2N1353	IND	pnp,AJ,ge	3.5	200	85	3.33	15	200	70	2.5	12	.6	.4	0.1	–	
2N385A	SY	npn,AJ,ge	4	150	100	2	40	200	30-110	40	–	–	–	–	–	GI
2N404A	RCA	pnp,AJ,ge	4	150	100	–	40	150	30	5	20	–	–	–	–	GI IND, TS
2N425	SY	pnp,AJ,GE	4	150	85	2.5	20	400	–	2.0	14	1.0	0.3	0.2	30	RA, INOTS, US, KF, GI
2N799	RA	pnp,AJ,ge	4	75	85	1.25	25	150	30	5	20	–	–	–	–	Submin
2N800	RA	pnp,AJ,ge	4	75	85	1.25	25	150	20	5	20	–	–	–	–	Submin
2N824	RA	npn,AJ,ge	4	75	85	1.25	25	100	40	5	20	–	–	–	–	Submin
2N1027	SSD	pnp,AJ,si	4	150	150	1.2	15	100	18	25	–	–	–	–	–	NA, SSD
2N1028	SSD	pnp,AJ,si	4	150	150	1.1	10	100	9	25	7	–	–	0.15	–	NA

Low Level (continued)

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics h_{fe} h_{FE}	I_{co} μa	C_{coe} μμf	Switching Rise Time	Stor Time	Sat Volt	Leak Cur	Remarks
2N1448	IND	pnp,AJ,ge	4	200	85	3.33	45	400	65	5		–	–	–	–	
2N1605A	SY	npn,AJ,ge	4	200	100	2.6	40	200	40	10	20	–	–	–	–	
2N1780	SY	npn,AJ,ge	4	100	100	1.3	25	100	30-110	10	20	–	–	–	–	
2N1781	SY	npn,AJ,ge	4	100	100	1.3	25	100	40	5	20	–	–	–	–	
2N2000	TI	pnp,AJ,ge	4	300	100	4	50	750		8	30	–	–	–	–	
CK25	RA	pnp,FA,ge	4	80	85	–	20	400	–	2	14	0.5	0.3	0.25	30	
2N395	GE	pnp,AJ,ge	4.5	200	100	3.3	15	200	–	6	12	0.55	0.5	0.1	20	TI, KF
2N520	IND	pnp,AJ,ge	4.5	150	85	2.5	15	200	40	1	14	–	–	–	–	US
2N520A	IND	pnp,AJ,ge	4.5	150	85	2.5	25	200	100	1	14	0.9	0.7	–	75	US
2N1302	TI	npn,AJ,ge	4.5	150	85	2.5	25	300	–	5	11	.70	.50	.1v	–	TO-5, SY, GI
2N1303	TI	pnp,AJ,ge	4.5	150	85	2.5	30	300	–	3	16	.40	.90	.1v	–	GI, KF
2N1354	IND	pnp,AJ,ge	4.5	200	85	3.33	30	200	70	2.5	12	.55	.5	0.1	–	
2N1169	SY	npn,AJ,ge	4.5	120	85	2	25	400	20	50	20	–	–	–	–	RCA
2N1170	SY	npn,AJ,ge	4.5	120	85	2	25	400	20	50	20	–	–	–	–	RCA
2N123	SY	pnp,AJ,ge	5	100	85	1.66	15	125	30-150	0.6		–	–	0.2 (max)	–	
2N315	GI	pnp,AJ,ge	5	100	85	2	20	500	–	1	14	1.0	0.2	0.12	20	KF, IND, US
2N315A	GI	pnp,AJ,ge	5	150	100	2	30	500	70	1	14	0.9	0.4	0.12	35	IND, US, KF
2N396A	SY	pnp,AJ,ge	5	150	100	2	30	200	30-150	6	–	–	–	–	–	TS,KF,GE,GI
2N414	SY	pnp,AJ,ge	5	150	85	2.5	30	200	30-90	5	–	–	–	–	–	KF, GI
2N439	SY	npn,AJ,ge	5	100	85	1.66	20	–	–	10	–	0.5	0.7	0.25	30	
2N450	GE	pnp,AJ,ge	5	150	85	2.5	12	125	–	6	20	–	–	0.2	30	
2N576	SY	npn,AJ,ge	5	200	100	2.6	20	400	–	20	–	2	1	0.4	40	
2N578	RCA	pnp,AJ,ge	5	120	71	–	20	400	15	3	–	0.85	0.33	0.2	15	TS,IND,US,KF,GI
2N585	RCA	npn,AJ,ge	5	120	71	–	25	200	40	3	–	0.35	0.25	0.1	40	SY, GI
2N658	RA	pnp,FA,ge	5	150	85	–	16	1a	–	2.5	12	–	–	0.25	50	KF
2N803	RA	pnp,AJ,ge	5	75	85	1.25	30	400	40	4	20	–	–	–	–	Submin
2N804	RA	pnp,AJ,ge	5	75	85	1.25	30	400	40	4	20	–	–	–	–	Submin
2N815	RA	npn,AJ,ge	5	75	85	1.25	25	200	60	10	20	–	–	–	–	Submin
2N816	RA	npn,AJ,ge	5	75	85	1.25	25	200	60	10	20	–	–	–	–	Submin
2N819	RA	npn,AJ,ge	5	75	85	1.25	30	400	30	10	20	–	–	–	–	Submin
2N820	RA	npn,AJ,ge	5	75	85	1.25	30	400	30	10	20	–	–	–	–	Submin
2N825	RA	pnp,AJ,ge	5	75	85	1.25	30	200	30	6	20	–	–	–	–	Submin
2N826	RA	pnp,AJ,ge	5	75	85	1.25	30	200	30	6	20	–	–	–	–	
2N1012	GI	npn,AJ,ge	5	150	100	2	40	–	–	5	10	0.1	0.1	0.1	50	
2N1123	PH	pnp,AJ,ge	5	150	100	10	45	500	3.5	10	15	–	–	0.085	70	
2N1219	SSD	pnp,AJ,si	5	250	175	1.7	25	100	–	.001	15	–	–	–	–	
2N1348	IND	pnp,AJ,ge	5	200	85	3.33	40	400	95	5	12	–	–	–	–	
2N1449	IND	pnp,AJ,ge	5	200	85	3.33	45	400	80	5	–	–	–	–	–	
2N1994	TI	npn,AJ,ge	5	150	85	2.5	30	300	–	5	11	1.1	1.5	–	–	
GT1658	GI	npn,AJ,ge	5	150	100	2	30	–	50	3	10	–	–	–	–	
KGS1005	KF	pnp,AJ,ge	5	200	85	5.2	30	400	40	12	–	–	–	–	–	
2N377	SY	npn,AJ,ge	6	150	100	2	20	200	–	10	–	2.5	0.7	–	40	GE, GI
2N357	SY	npn,AJ,ge	6	100	85	1.6	15	500	–	25	–	1.2	.7	.20	–	GI
2N357A	GI	npn,AJ,ge	6	150	100	2	30	500	90	3	14	0.5	0.5	0.18	40	SY
2N426	SY	pnp,AJ,ge	6	150	85	2.5	20	400	–	2	14	1.0	0.3	0.22	40	RA,TR,TS,GI,US, TI, KF
2N789	RA	npn,DB,si	6	–	–	1.4	45	25	15	.002	5	–	–	–	–	
2N902	RA	npn,DB,si	6	–	–	–	45	25	15	.002	5	–	–	–	–	
2N1319	RCA	pnp,AJ,ge	6	120	71	–	20	400	30	2.5		20	–	–	–	
2N1343	IND	pnp,AJ,ge	6	150	85	2.5	20	400	40	3	12	1.0	–	–	–	
2N1997	TI	npn,AJ,ge	6	250	100	3.3	45	–	4	15	–	–	–	–	–	
CK26	RA	pnp,FA,ge	6	80	85	–	18	400	–	2	14	0.5	0.3	0.25	40	
2N100	SY	npn,AJ,ge	7	150	100	2	40	–	25(min)	15	–	–	–	–	–	
2N1090	RCA	npn,AJ,ge	7	120	85	–	25	400	50	4	–	0.25	0.20	–	50	GI
2N1114	SY	npn,AJ,ge	7	150	100	2	15	200	–	30	–	–	–	–	60	
2N1995	TI	npn,AJ,ge	7	150	85	2.5	25	300	–	5	11	–	–	–	–	
GT123	GI	pnp,AJ,ge	7	150	150	2	25	–	40	3	15	0.9	0.5	0.1	90	
2N123	GE	pnp,AJ,ge	8	150	85	2.5	15	125	0.987	6	15	0.45	0.90	0.15	65	SY
2N388	GI	npn,AJ,ge	8	150	100	2	25	500	–	5	10	0.6	0.4	–	120	SY, GE, RA
2N396	GE	pnp,AJ,ge	8	200	100	3.3	20	200	–	6	12	0.4	0.6	0.08	30	TI,GI,SY,TS
2N576A	SY	npn,AJ,ge	8	200	100	2.6	40	400	–	40	–	2	1	0.4	40	
2N579	RCA	pnp,AJ,ge	8	120	71	–	20	400	30	3	–	0.36	0.33	0.2	30	IND,US,TS,KF,GI
2N581	RCA	pnp,AJ,ge	8	150	85	–	18	100	30	3	12	0.20	0.20	0.35	30	US,IND,GI,KF
2N583	RCA	pnp,AJ,ge	8	120	85	–	18	100	30	3	12	0.20	0.20	0.35	30	
2N598	PH	pnp,AJ,ge	8	250	100	3.3	35	500	–	3	15	–	–	0.085	85	
2N662	RA	pnp,FA,ge	8	150	85	–	11	1a	–	2.5	12	–	–	0.25	60	KF
2N714	RCA	pnp,AJ,ge	8	150	85	–	30	200	80	2	11	–	–	–	–	
2N790	RA	npn,DB,si	8	–	–	1.4	45	25	30	.002	8	–	–	–	–	
2N792	RA	npn,DB,si	8	–	–	1.4	45	25	60	.002	5	–	–	–	–	
2N903	RA	npn,DB,si	8	–	–		45	25	30	.002	20	–	–	–	–	
2N905	RA	npn,DB,si	8	–	–		45	25	80	.002	20	–	–	–	–	
2N1280	IND	pnp,AJ,ge	8	200	85	3.33	16	400	60	5	10	.10	–	–	–	
2N1284	IND	pnp,AJ,ge	8	150	85	2.5	20	400	90	2	15	.45	.9	15	–	
2N1304	TI	npn,AJ,ge	8	150	85	2.5	25	300	110	5	16	.45	.50	.1v	–	TO-5,GI,SY,GE

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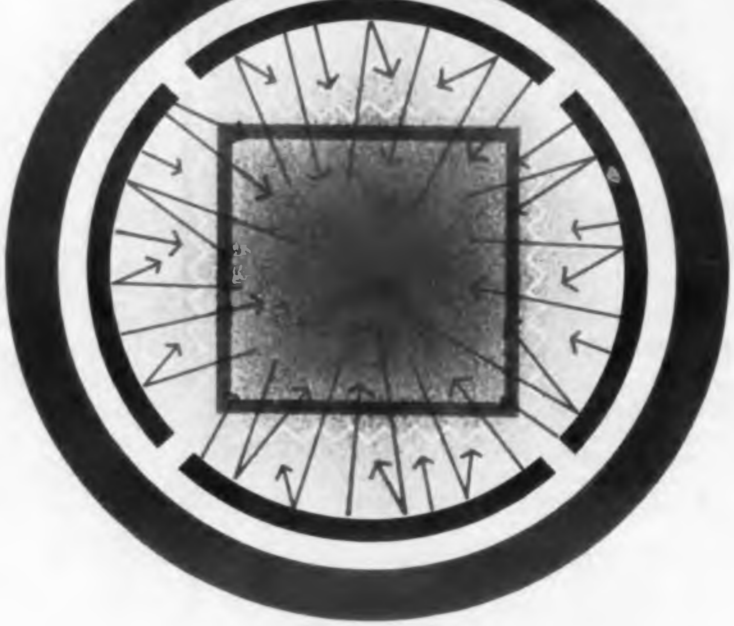
Low Level

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings W_c (mw)	T_j (c)	mw/c	V_c v	I_c
2N1305	TI	pnp,AJ,ge	8	150	85	2.5	30	300
2N1347	IND	pnp,AJ,ge	8	150	85	2.5	20	200
2N1350	IND	pnp,AJ,ge	8	200	85	3.33	50	100
2N1351	IND	pnp,AJ,ge	8	200	85	3.33	40	100
2N1355	IND	pnp,AJ,ge	8	200	85	3.33	30	200
2N1356	IND	pnp,AJ,ge	8	200	100	2.66	30	200
2N1685	SY	npn,AJ,ge	8	100	100	1.3	25	200
2N2001	TI	pnp,AJ,ge	8	300	100	4	30	750
2N167	GE	npn,GJ,ge	9	65	85	1.1	30	75
2N358	GI	npn,AJ,ge	9	100	85	2	20	500
2N358A	SY	npn,AJ,ge	9	150	100	2	30	500
2N394	GE	pnp,AJ,ge	9	150	85	2.5	10	200
2N823	RA	npn,AJ,ge	9	75	85	1.25	25	100
2N1198	GE	npn,RG,ge	9	65	85	1.1	25	75
OC141	AMP	npn,PADT,ge	9	100	75	–	20	250
2N440	SY	npn,AJ,ge	10	100	85	1.66	15	–
2N518	GE	pnp,AJ,ge	10	150	85	2.5	12	125
2N521	IND	pnp,AJ,ge	10	150	85	2.5	15	200
2N521A	IND	pnp,AJ,ge	10	150	85	2.5	25	200
2N600	PH	pnp,AJ,ge	10	750	100	10	35	500
2N659	RA	pnp,FA,ge	10	150	85	–	14	la
2N745	RA	npn,MS,si	10	150	175	0.75	45	50
2N805	RA	pnp,AJ,ge	10	75	85	1.25	30	400
2N806	RA	pnp,AJ,ge	10	75	85	1.25	30	400
2N821	RA	npn,AJ,ge	10	75	85	1.25	30	400
2N822	RA	npn,AJ,ge	10	75	85	1.25	30	400
2N1281	IND	pnp,AJ,ge	10	200	85	3.33	16	400
2N1349	IND	pnp,AJ,ge	10	200	85	3.33	40	400
2N1996	TI	npn,AJ,ge	10	150	85	2.5	20	300
2N1998	TI	pnp,AJ,ge	10	250	100	3.3	35	400
2N427	GI	pnp,AJ,ge	11	150	100	2	30	–
2N791	RA	npn,DB,si	11	–	–	1.4	45	25
2N904	RA	npn,DB,si	11	–	–	–	45	25
CK27	RA	pnp,FA,ge	11	80	85	–	15	400
2N316	GI	pnp,AJ,ge	12	100	85	2	20	500
2N316A	GI	pnp,AJ,ge	12	150	100	2	30	500
2N397	GE	pnp,AJ,ge	12	200	100	3.3	15	200
2N404	RCA	pnp,AJ,ge	12	120	85	–	25	100
2N635	GE	npn,AJ,ge	12	150	85	2.5	20	300
2N1306	TI	npn,AJ,ge	12	150	85	2.5	25	300
2N1307	TI	pnp,AJ,ge	12	150	85	2.5	30	300
2N1313	IND	pnp,AJ,ge	12	175	85	–	30	400
2N1344	IND	pnp,AJ,ge	12	150	85	2.5	15	400
2N1345	IND	pnp,AJ,ge	12	150	85	2.5	10	400
2N1346	IND	pnp,AJ,ge	12	150	85	2.5	12	400
2N1357	IND	pnp,AJ,ge	12	200	85	3.33	30	200
2N269	RCA	pnp,AJ,ge	13	120	85	–	25	100
2N793	RA	npn,DB,si	13	–	–	1.4	45	25
2N906	RA	npn,DB,si	13	–	–	–	45	25
2N1091	RCA	npn,AJ,ge	13	120	85	–	25	400
2N582	SY	pnp,AJ,ge	14	120	71	2.6	25	100
2N807	RA	pnp,AJ,ge	14	75	85	1.25	25	100
2N808	RA	pnp,AJ,ge	14	75	85	1.25	25	100
2N858	PH	pnp,SP,si	14	150	140	1.3	40	50
2N859	PH	pnp,SP,si	14	150	140	1.3	40	50
2N860	PH	pnp,SA,si	14	150	140	1.3	25	50
2N862	PH	pnp,SP,si	14	150	140	1.3	15	50
2N580	RCA	pnp,AJ,ge	15	120	71	–	20	40
2N636A	SY	npn,AJ,ge	15	150	100	2	25	30
2N660	RA	pnp,FA,ge	15	150	85	–	11	la
2N1282	IND	pnp,AJ,ge	15	200	85	3.33	16	40
2N1316	IND	pnp,AJ,ge	15	200	85	3.33	30	40
2N1317	IND	pnp,AJ,ge	15	200	85	3.33	20	40
2N1318	IND	pnp,AJ,ge	15	200	85	3.33	10	40
2N1999	TI	pnp,AJ,ge	15	250	100	3.33	30	40
2N599	PH	pnp,AJ,ge	16	250	100	3.3	30	50
2N601	PH	pnp,AJ,ge	16	750	100	10.0	30	50
2N428	GI	pnp,AJ,ge	17	150	100	2	30	–
2N636	GE	npn,AJ,ge	17	150	85	2.5	20	30
CK28	RA	pnp,FA,ge	17	80	85	–	12	40
2N522	IND	pnp,AJ,ge	18	150	85	2.5	15	20
2N522A	IND	pnp,AJ,ge	18	150	85	2.5	25	20
2N582	RCA	pnp,AJ,ge	18	120	85	–	25	10
2N584	RCA	pnp,AJ,ge	18	120	85	–	25	10

DATA CHART

(continued)

Characteristics h_{fe} h_{FE}	I_{co} μa	C_{con} μμf	Switching Rise Time	Stor Time	Sat Volt	Leak Cur	Remarks	Type No.
100	3	11	.28	.80	.1v	–	TO-5, KF, GI	2N1305
80	2.5	12	–	–	–	–		2N1347
95	10	12	–	–	–	–		2N1350
65	5	12	–	–	–	–		2N1351
80	2.5	12	.4	.6	0.08	–		2N1355
80	2.5	12	.4	.6	0.08	–		2N1356
40	10	20	–	–	–	–		2N1685
–	5	30	–	–	–	–		2N2001
0.985	1.5	2.5	0.4	0.7	0.35	30	USAF2N167-MIL	2N167
60	3	14	0.4	0.5	0.18	30	SY	2N358
25-75	5	14	–	–	–	–	GI	2N358A
–	6	12	–	–	0.04	70	KF,	2N394
40	5	20	–	–	–	–		2N823
--	1.5	2.5	0.4	0.7	0.35	30		2N1198
150	0.8	–	–	–	–	–		OC141
–	10	–	0.3	0.7	0.25	40	GI	2N440
–	6	12	0.8	0.9	0.15	60		2N518
70	1	14	–	–	–	–	US, KF	2N521
150	1	14	0.2	0.5	–	135	US, KF	2N521A
–	10	15	–	–	0.085	90	EM	2N600
–	2.5	12	–	–	0.25	70	KF, GI	2N659
22	10	3	–	–	–	–		2N745
60	4	20	–	–	–	–	Submin	2N805
60	4	20	–	–	–	–	Submin	2N806
40	10	20	–	–	–	–	Submin	2N821
40	10	20	–	–	–	–	Submin	2N822
90	5	10	.9	–	–	–		2N1281
110	5	12	–	–	–	–		2N1349
–	5	11	–	–	–	–		2N1996
–	4	15	–	–	–	–		2N1998
–	2	14	0.43	0.3	0.105	55	KF,TS,TI,MO IND,RA,US	2N427
60	.002	5	–	–	–	–		2N791
60	.002	20	–	–	–	–		2N904
–	2	14	0.4	0.3	0.25	55		CK27
–	1	14	0.4	0.4	0.14	30		2N316
130	1	14	0.4	0.4	0.14	35	IND, US, KF	2N316A
–	6	12	0.3	0.7	0.07	40	TI, KF	2N397
–	5	–	0.17	0.20	0.12		US,GE,RA,GI,SY,KF	2N404
–	5	–	–	–	–	25		2N635
110	5	16	.22	.50	.1v	–	TO-5,GI,SY,GE	2N1306
110	3	11	.20	.80	.1v	–	TO-5, GI, KF	2N1307
80	–	14	–	–	–	–		2N1313
90	5	12	0.7	0.3	–	–		2N1344
60	3	14	.3	.4	–	–		2N1345
125	2.5	14	.3	.4	.10	–		2N1346
85	2.5	12	.3	.7	0.07	–		2N1357
40	2	–	0.17	0.20	0.12	–		2N269
50	.002	5	–	–	–	–		2N793
50	.002	20	–	–	–	–		2N906
70	4	–	.20	0.17	–	70	GI	2N1091
(min)	5	–	–	–	–	–	KF, RCA	2N582
40	5	20	–	–	–	–	Submin	2N807
40	5	20	–	–	–	–	Submin	2N808
33	.1	5	–	–	–	–		2N858
65	.1	5	–	–	–	–		2N859
33	.1	5	–	–	–	–		2N860
33	.1	5						2N862
45	3	–	0.16	0.29	0.2	45	GI,IND,US,TS,KF	2N580
0-300	6	20	–	–	–	–		2N636A
–	2.5	12	–	–	0.25	90	KF	2N660
00	5	10	.8	–	–	–		2N1282
00	2	14	–	–	–	–	KF	2N1316
95	3	14	–	–	–	–	KF	2N1317
85	4	14	–	–	–	–		2N1318
--	4	15	–	–	–	–		2N1999
–	3.5	15	–	–	0.085	125		2N599
–	3.5	15	–	–	–	125		2N601
–	2	14	0.43	0.3	0.22	80	SY,MO,RA,IND,US, TS,TI,KF, GE	2N426
–	5	–	–	–	–	35		2N636
–	2.0	14	0.4	0.3	0.25	80		CK28
20	1	14	–	–	–	–	US,KF	2N522
00	1	14	0.2	0.5	–	175	US,KF	2N522A
50	5	–	0.15	0.17	0.2	60	TS,GI,IND,SY,KF	2N582
50	2	12	0.15	0.17	0.2	60	US	2N584



TRANSISTORS—1961

Abbreviation of Terms

AJ Alloy Junction
DD Double Diffused
DG Grown Diffused
DJ Diffused Junction
DM Diffused Mesa
DP Diffused Planar
Dr Drift
Ep Epitaxial
FA Fused Alloy
FJ Fused Junction
GD Grown Diffused
Ge Germanium
GJ Grown Junction
GR Grown Rate
MB Meltback
MD MADT
Ms Mesa
RG Rate Grown
Si Silicon
SBT Surface Barrier

C_{oe} = Collector-to-emitter capacitance measured across the output terminals with the input ac open-circuited.

f_{ae} = Frequency at which the magnitude of the forward-current transfer ratio (small-signal) is 0.707 of its low-frequency value.

f_t = Frequency at which common emitter gain is unity.

h_{fe} = Common emitter-small signal forward current transfer ratio.

h_{FE} = Common emitter-static value of short-circuited forward current ratio.

I_{co} = Collector current when collector junction is reverse-biased and emitter is dc open-circuited.

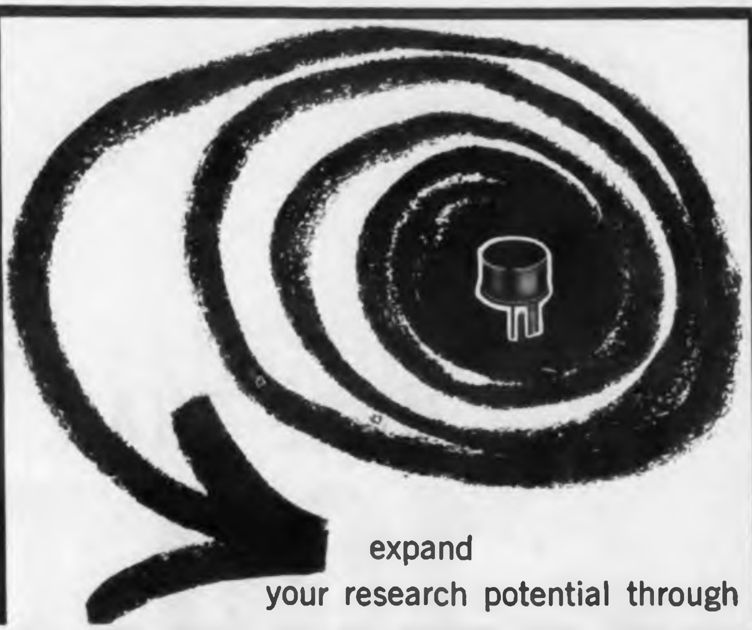
For an additional copy of the Transistor Data Chart turn the Reader-Service Card and circle 251.

Low Level (continued)

Type No.	Mfg.	Type	Maximum Ratings f_{ae}	W_C (mw)	T_j (c)	mw/c	V_C v	I_C ma	Characteristics h_{fe} h_{FE}	I_{co} μa	C_{coe} μμf	Switching Rise Time	Stor Time	Sat Volt	Leak Cur	Remarks
2N1308	TI	npn,AJ,ge	18	150	85	2.5	25	300	200	5	15	–	–	–	–	TO-5,SY,GE
2N1309	TI	pnp,AJ,ge	18	150	85	2.5	30	300	210	3	11	–	–	–	–	TO-5, KF, GI
2N317	GI	pnp,AJ,ge	20	100	85	2	30	500	–	1	14	0.3	0.4	0.18	30	US, IND, KF
2N317A	GI	pnp,AJ,ge	20	150	100	2	30	500	180	1	14	0.3	0.4	0.18	40	IND, US, KF
2N337	TI	npn,GD,si	20	125	150	.001	45	20	19	1	–	0.05	0.02	1.5	35	TR, RA, GE
2N417	IND	pnp,AJ,ge	20	200	85	3	30	200	140	2	12	–	–	–	–	KF
2N661	RA	pnp,FA,ge	20	150	85	–	9	1a	–	2.5	12	–	–	0.25	120	KF
2N746	RA	npn,MS,si	20	150	175	0.75	45	50	45	10	3	–	–	–	–	
2N1008	BE	pnp,AJ,ge	20	400	85	6.6	20	300	100	10	–	–	–	0.25	–	
2N1008A	BE	pnp,AJ,ge	20	400	85	6.6	40	300	100	10	–	–	–	0.25	–	
2N1008B	BE	pnp,AJ,ge	20	400	85	6.6	60	300	100	10	–	–	–	0.25	–	
2N1017	RA	pnp,FA,ge	20	150	85	–	10	400	–	2	12	0.25	–	0.25	100	US, KF
CK419	RA	npn,FA,si	20	385	160	–	40	50	15	.005	35	–	–	–	–	
CK420	RA	npn,FA,si	20	385	160	–	35	50	30	.005	–	–	–	–	–	
CK421	RA	npn,FA,si	20	385	160	–	30	50	60	.005	20	–	–	–	–	
CK474	RA	npn,DB,si	20	250	180	1.9	40	50	15	.005	20	–	–	–	–	
CK475	RA	npn,DB,si	20	250	180	1.9	35	50	30	.005	20	–	–	–	–	
CK476	RA	npn,DB,si	20	250	180	1.9	30	50	60	.005	20	–	–	–	–	
CK477	RA	npn,DB,si	20	250	180	1.9	30	50	65	.005	20	–	–	–	–	
2N861	PH	pnp,SP,si	22	150	140	1.3	25	50	65	0.1	5					
2N863	PH	pnp,SP,si	22	150	140	1.3	15	50	65	.1	5	–	–	–	–	
2N864	PH	pnp,SP,si	22	150	140	1.3	6	50	65	.1	–	–	–	–	–	
2N523	IND	pnp,AJ,ge	24	150	85	2.5	15	200	200	1	14	–	–	–	–	US, KF
2N523A	IND	pnp,AJ,ge	24	150	85	2.5	20	200	300	1	14	0.1	0.4	–	200	US, KF
2N747	RA	npn,MS,si	25	150	175	0.75	25	50	30	10	6	–	–	–	–	
2N748	RA	npn,MS,si	25	150	175	0.75	30	50	10	6	–	–	–	–	–	
2N1386	RA	npn,MS,si	25	300	175	0.5	25	50	30	10	6	–	–	–	–	
2N1387	RA	npn,MS,si	25	300	175	0.5	30	50	20	10	6	–	–	–	–	
2N1205	TR	npn,GR,si	27	150	150	–	20	–	6	50	3.0	–	–	–	30	
2N338	TI	npn,GD,si	30	125	150	.001	45	20	39	1	–	.06	.02	1.5	75	TR, RA, NA, GE
2N643	RCA	pnp,DR,ge	30*	120	71	–	30	100	45	3	2	0.03	0.006	–	45	*gain-bandwidth product
2N907	RA	npn,DB,si	30	–	–	–	45	25	35	.002	20	–	–	–	–	
KGS1004	KF	pnp,AJ,ge	32	200	85	3	10	400	120	12	–	–	–	–	–	
2N842	TR	npn,GJ,si	44	300	175	–	45	25	20	0.1	6	–	–	–	–	
TMT842	TR	npn,DJ,si	44	150	175	–	45	25	20	1	6	–	–	–	–	
2N908	RA	npn,DB,si	45	–	–	–	45	25	75	.002	20	–	–	–	–	
2N644	RCA	pnp,DR,ge	50*	120	71	–	30	100	45	3	–	0.015	0.004	–	45	*gain bandwidth product
ST3030	TR	npn,DJ,si	50	100	150	0.8	15	–	–	50	4	.04	.07	40	–	
2N865	PH	pnp,SP,si	52	150	140	1.3	10	50	150	.1	5	–	–	–	–	
2N1254	HU	pnp,MS,si	55	250	160	1.8	15	–	25	30	8	–	.015	.015	0.28	TO-5 package
2N1256	HU	pnp,MS,si	55	250	160	1.8	30	–	25	30	8	–	–	–	–	TO-5 package
2N1258	HU	pnp,MS,si	55	250	160	1.8	50	–	25	30	8	–	–	–	–	TO-5 package
2N1779	SY	npn,AJ,ge	60	100	100	1.3	25	100	25	10	10	–	–	–	–	
2N843	TR	npn,DJ,si	64	300	175	–	45	25	40	.1	6	–	–	–	–	
TMT843	TR	npn,DJ,si	64	150	175	–	45	25	40	.1	6	–	–	–	–	
2N560	WE	npn,DD,si	70	600	150	.25	60	100	20	.1	8	.06	.05	–	–	US,MIL only,NA
2N645	RCA	pnp,Dr,ge	70	120	85	–	30	100	45	3	2	0.01	0.002	–	45	*gain bandwidth product
OC46	AMP	pnp,PADT,ge	73	83	75	–	20	125	< 80	<3	–	–	–	–	–	
OC139	AMP	npn,PADT,ge	73.5	100	75	–	20	250	45	0.8	–	–	–	–	–	
OC140	AMP	npn,PADT,ge	74.5	100	75	–	20	250	75	0.8	–	–	–	–	–	
2N1255	HU	pnp,MS,si	75	250	160	1.8	15	–	55	30	8	–	–	–	–	TO-5 Package
2N1257	HU	pnp,MS,si	75	250	160	1.8	30	–	55	30	8	–	–	–	–	TO-5 Package
2N1259	HU	pnp,MS,si	75	250	160	1.8	50	–	55	30	8	–	–	%	–	TO-5 Package
OC47	AMP	pnp,PADT,ge	75.5	83	75	–	20	125	<200	<3	–	–	–	–	–	
2N706	FA	npn,DP,si	80(f_T)	1w	175	6.7	20	–	45	.005	5	.02	–	–	–	GI,TR,SSD,SY,NA, RH,IND,TI,RCA
2N702	TI	npn,DJ,si	100	150	175	.002	20	50	15-45	.5	–	–	–	.6	–	FA, NA
2N1507	RH	npn,DD,si	120	1w	175	13.2	60	500	200	.003	20	80	600	.07	–	TI
2N1139	TR	npn,GR,si	150	500	175	–	15	25	20	.25	8	12	10	0.7	5	
2N501	PH	pnp,MD,ge	175	60	100	0.8	15	50	–	1.0	1.75	0.013	0.007	0.08	35	SPR, GI
2N501A	PH	pnp,MD,ge	175	175	60	0.8	15	50	–	-1.0	1.1	0.013	0.007	1.0	35	SPR, GI
2N705	TI	pnp,AJ,ge	300	300	100	4	15	50	6	.3	5	0.03	0.075	0.2	40	MO,SY,GE,RA
2N710	TI	pnp,MS,ge	300	100	300	4	15	50	6	.3	5	.06	.075	80	–	SY,MO,RCA,GE,RA
2N711	TI	pnp,MS,ge	300	300	100	4	12	50	6	0.3	5	.07	0.1	90 μsec	–	MO,SY,RCA,GE,RA
2N707A	MO	npn,DM,si	350	1w	175	6.7	70	–	30	.01	4	–	–	–	–	Epitaxial
2N706A	MO	npn,DM,si	400	1w	175	6.7	25	–	4	.005	4.5	.018	.016	–	–	(Epitaxial,MO) SY, TI PSI,HU,NA,GI
2N706B	MO	npn,DM,si	400	1w	175	6.7	25	–	4	.005	4.5	.018	.016	–	4	(MO, Epitaxial) SY, PSI NA,HU,GI
2N753	MO	npn,DM,si	400	1w	175	6.7	25	–	4	.005	4.5	.018	.019	–	–	(MO, Epitaxial) HU, SY NA

Low Level (concluded)

Type No.	Mfg.	Type	f_{ae}	Maximum Ratings: W_c (mw)	T_j (c)	mw/c	V_c v	I_c ma	Characteristics: h_{fe} hFE	I_{co} μa	C_{coe} μμf	Switching: Rise Time	Stor Time	Sat Volt	Leak Cur	Remarks
2N828	MO	pnp,DM,si	400	500	175	4	15	200	4	.4	3.5	–	–	–	–	Epitaxial, SY
NS345	NA	npn,DM,si	400	500	175	2.8	30		80-200		5	–	–	–	–	
2N779A	PH	pnp,MD,ge	450	60	100	.8	15	50	–	1	1.9	–	–	–	–	
2N846A	PH	pnp,MD,ge	450	60	100	.8	15	50	–	1	1.9	–	–	–	–	
2N834	MO	npn,DM,si	500	1w	175	6.7	40	200	5	.01	2.8	.015	.016	–	–	Epitaxial, SY
2N559	WE	pnp,DG,ge	750	150	100	.5	15	50	25	5	–	.002	.003	–	–	US, MIL only
2N1385	TI	pnp,MS,ge	750	750	100	8	25	100	30	5	1.3	.001	.002	4 mμsec	–	TO-5, non saturated
2N917	FA	npn,DP,si	800*	300	200	1.71	20	–	50	.05	–	–	–	–	–	*TT
2N167A	GE	npn,AJ,ge	–	65	85	–	30	75	30	0.6	–	–	–	–	–	
2N240	PH	pnp,SB,ge	–	25	85	0.5	6	15	30	0.5	4	–	–	0.04	20	SPR
2N335B	GE	npn,GJ,si	–	500	175	–	60	25	52	1	–	–	–	–	–	
2N336A	GE	npn,GJ,si	–	500	175	–	45	25	75	1	11	–	–	–	–	
2N377A	SY	npn,AJ,ge	–	150	100	2	40	200	20-60	40		Tr + td =2.5 μsGC (max)				GI
2N388A	SY	npn,AJ,ge	–	150	100	2	25	200	60-180	40	–	Tr + td = μsGC (max)				
2N398	RCA	pnp,AJ,ge	–	50	55	–	105	100	60	6	–	–	–	0.3	60	GI
2N399A	GE	pnp,AJ,ge	–	150	100	–	15	200	70	2	–	–	–	–	–	
2N438A	SY	npn,AJ,ge	–	150	85	2.5	25	200	15(min)	10	–	0.7	–	–	–	
2N439A	SY	npn,AJ,ge	–	150	85	2.5	25	200	30(min)	10	–	0.5	–	–	–	
2N440A	SY	npn,AJ,ge	–	200	85	3.3	25	200	40	10	–	0.3	–	–	–	
2N496	PH	pnp,SB,si	–	150	140	1.3	10	50	5.0	1	6	–	–	0.08	16	
2N556	SY	npn,AJ,ge	–	100	85	1.66	20	200	–	25	–	3.5	2	0.5	55	t_2=3.5 ns max t_0=2.0 ns max
2N557	SY	npn,AJ,ge	–	100	85	1.66	20	200	–	25	–	6.5	2.5	0.5	20	
2N558	SY	npn,AJ,ge	–	100	85	1.66	15	200	–	15	–	3.5	2	0.75	20	
2N586	RCA	pnp,AJ,ge	–	250	85	–	45	250	55	8	–	–	–	0.25	55	
2N587	SY	npn,AJ,ge	–	150	85	2.5	40	200	20	10	30	–	–	–	20	
2N597	PH	pnp,AJ,ge	–	250	100	3.3	45	400	–	5	15	–	–	0.085	70	
2N634A	GE	npn,AJ,ge	–	150	85	–	20	300	55	6	–	–	–	–	–	
2N635A	GE	npn,AJ,ge	–	150	–	85	20	300	100	6	–	–	–	–	–	
2N636A	GE	npn,AJ,ge	–	150	85	–	15	300	190	6	–	–	–	–	–	
2N707	FA	npn,DP,si	–	1w	175	6.7	28	–	12	.005	5	.02	–	–	–	(Epitaxial, MO), GI
2N725	SY	pnp,DM,ge	–	150	100	2	15	50	20	3	–	0.1	–	–	–	GE
2N770	PH	npn,SA,si	–	150	150	1.2	20	100	5.5	.02	1.3	–	–	–	–	
2N771	PH	npn,SA,si	–	150	150	1.2	20	100	7.5	.7	1.3	–	–	–	–	
2N772	PH	npn,SA,si	–	150	150	1.2	25	100	5.5	.5	1.3	–	–	–	–	
2N794	RCA	pnp,DM,ge	–	150	85	2.5	13	100	50	1	8	–	–	–	–	
2N795	RCA	pnp,DM,ge	–	150	85	2.5	13	100	50	1	8	–	–	–	–	
2N1119	PH	pnp,SAT,si	–	150	140	1.3	10	50	5.0	.001	6.0	–	–	–	–	
2N1122	PH	pnp,MA,ge	–	25	85	0.63	12	50	8	5.0	6.0	–	–	0.1	25	SPR, GI
2N1122A	PH	pnp,MA,ge	–	25	85	0.63	15	50	8	5.0	6.0	–	–	0.1	25	SPR, GI
2N1175	GE	pnp,AJ,ge	–	200	85	–	25	200	80	6	–	–	–	–	–	
2N1175A	GE	pnp,AJ,ge	–	200	85	–	25	200	80	6	–	–	–	–	–	
2N1213	RCA	pnp,MESA,ge	–	75	85	–	25	100	–	3	–	.015	.05	–	–	
2N1214	RCA	pnp,MESA,ge	–	75	85	–	25	100	–	3	–	.015	.05	–	–	
2N1215	RCA	pnp,MESA,ge	–	75	85	–	25	100	–	3	–	.015	.05	–	–	
2N1216	RCA	pnp,MESA,ge	–	75	85	–	25	100	–	3	–	.015	.05	–	–	
2N1217	GE	npn,AJ,ge	–	75	85	–	20	25	40	.6	–	–	–	–	–	
2N1277	GE	npn,GJ,si	–	150	150	–	30	25	20	.001	–	–	–	–	–	
2N1278	GE	npn,GJ,si	–	150	150	–	30	25	33	.001	–	–	–	–	–	
2N1279	GE	npn,GJ,si	–	150	150	–	30	25	80	.001	–	–	–	–	–	
2N1288	GE	npn,BG,ge	–	75	85	–	10	50	50	2	–	–	–	–	–	
2N1289	GE	npn,MB,ge	–	75	85	–	15	100	50	2	–	–	–	–	–	
2N1299	SY	npn,AJ,ge	–	150	100	2	40	200	35-110	0.1	–	Rise + Fall time = 1.5 μsGC				
2N1300	RCA	pnp,DM,ge	–	150	85	2.5	13	100	50	1	8	–	–	–	–	
2N1301	RCA	pnp,DM,ge	–	150	85	2.5	13	100	50	1	8	–	–	–	–	
2N1384	RCA	pnp,DR,ge	–	240	85	4	30	500	50	4	–	–	–	–	–	
2N1404	TI	pnp,AJ,ge	–	150	85	2.5	25	300	–	3	16	–	–	–	–	
2N1413	GE	pnp,AJ,ge	–	200	85	–	25	200	36	8	–	–	–	–	–	
2N1414	GE	pnp,AJ,ge	–	200	85	–	25	200	52	8	–	–	–	–	–	
2N1450	RCA	pnp,DR,ge	–	120	85	–	30	100	20	10	–	–	–	–	–	
2N1473	SY	npn,AJ,ge	–	200	75	4	40	400	25-80	100	–	–	–	–	–	
2N1499	PH	pnp,MD,ge	–	25	85	0.63	20	50	35	1	25	–	0.12	–	–	
2N1614	GE	pnp,AJ,ge	–	240	85	–	40	300	32	25	–	–	–	–	–	
2N1663	PH	npn,SA,si	–	150	150	1.2	20	100	7.5	1.5	–	–	–	–	–	
2N1683	RCA	pnp,DM,ge	–	150	85	2.5	13	100	75	1	8	–	–	–	–	
2N1694	GE	npn,AJ,ge	–	75	85	–	20	25	30	0.6	–	–	–	–	–	
2N1754	PH	pnp,MD,ge	–	50	85	.83	13	100	–	1	1.5	–	–	–	–	
2N1808	TI	npn,AJ,ge	–	150	85	2.5	25	300	–	5	11	–	–	–	–	
2N1954	RA	pnp,AJ,ge	–	375	100	0.2	60	1a	90	10	–	–	–	–	–	
2N1955	RA	pnp,AJ,ge	–	375	100	0.2	60	1a	100	10	–	–	–	–	–	
2N1956	RA	pnp,AJ,ge	–	375	100	0.2	60	1a	90	–	–	–	–	–	–	
2N1957	RA	pnp,AJ,ge	–	375	100	0.2	60	1a	90	10	–	–	–	–	–	
2N2002	NA	pnp,AJ,si	–	250	175	1.67	30	100		.001	8	–	–	–	–	
2N2003	NA	pnp,AJ,si	–	250	175	1.67	30	100	–	.001	8	–	–	–	–	
2N2004	NA	pnp,AJ,si	–	250	175	1.67	50	100	–	.003	8	–	–	–	–	
2N2005	NA	pnp,AJ,si	–	250	175	1.67	50	100	–	.0015	8	–	–	–	–	
2N2006	NA	pnp,AJ,si	–	250	175	1.67	60	100	–	.002	8	–	–	–	–	
2N2007	NA	pnp,AJ,si	–	250	175	1.67	60	100	–	.005	8	–	–	–	–	



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CIRCLE 62 ON READER-SERVICE CARD

MORE THAN

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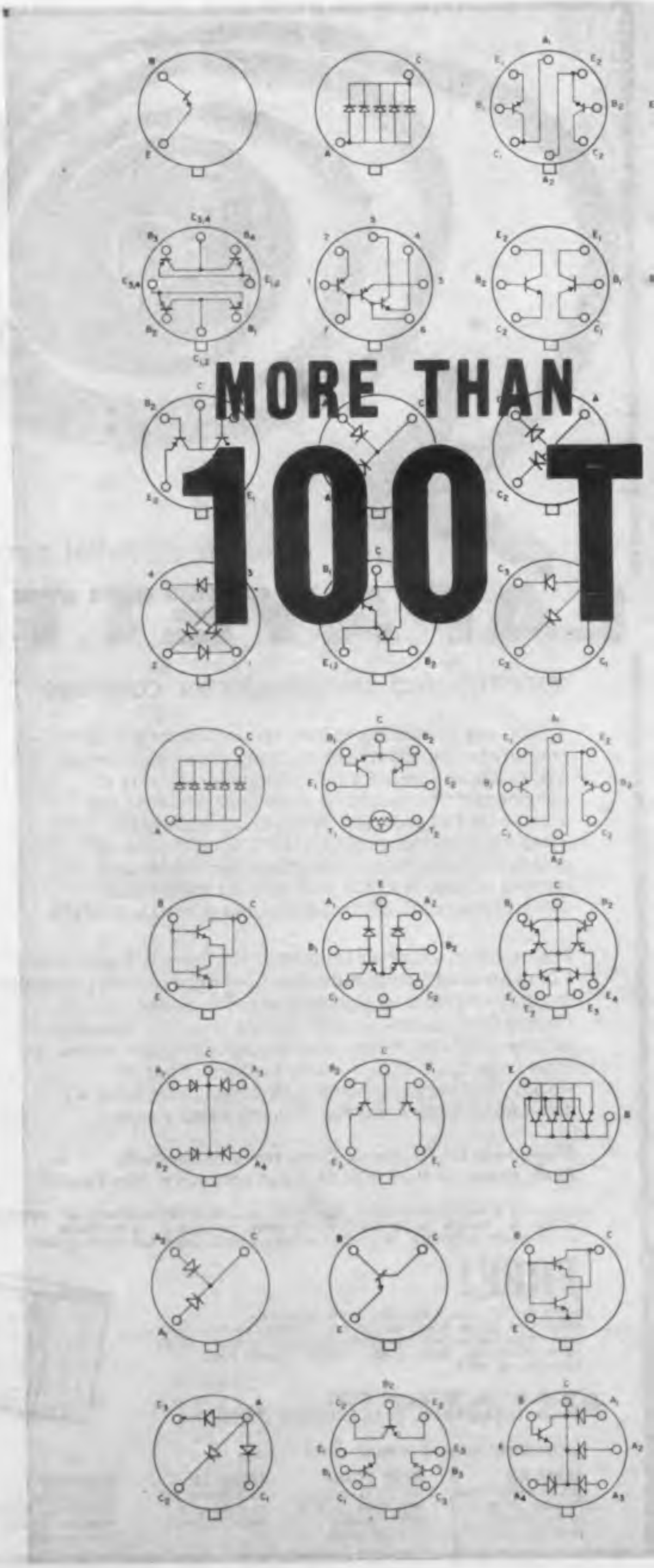

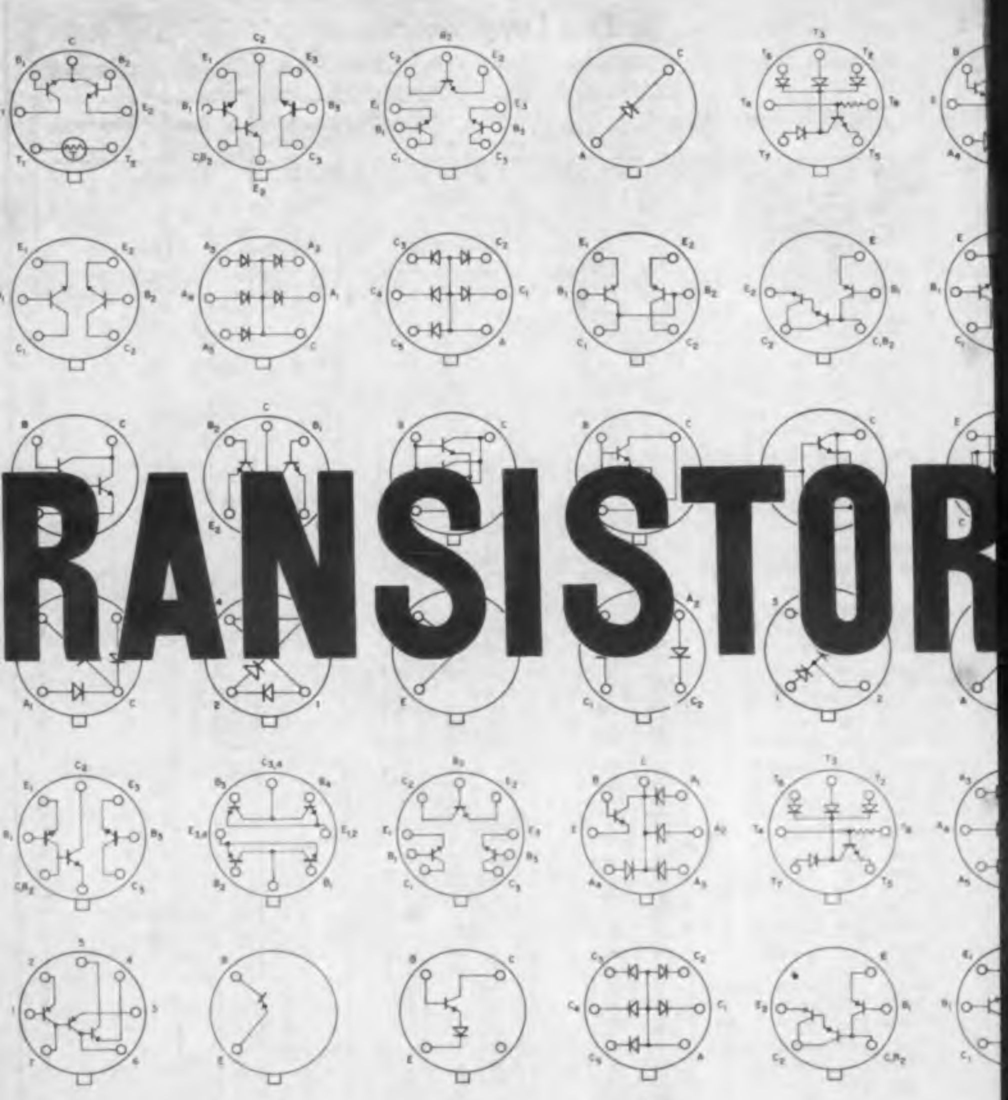
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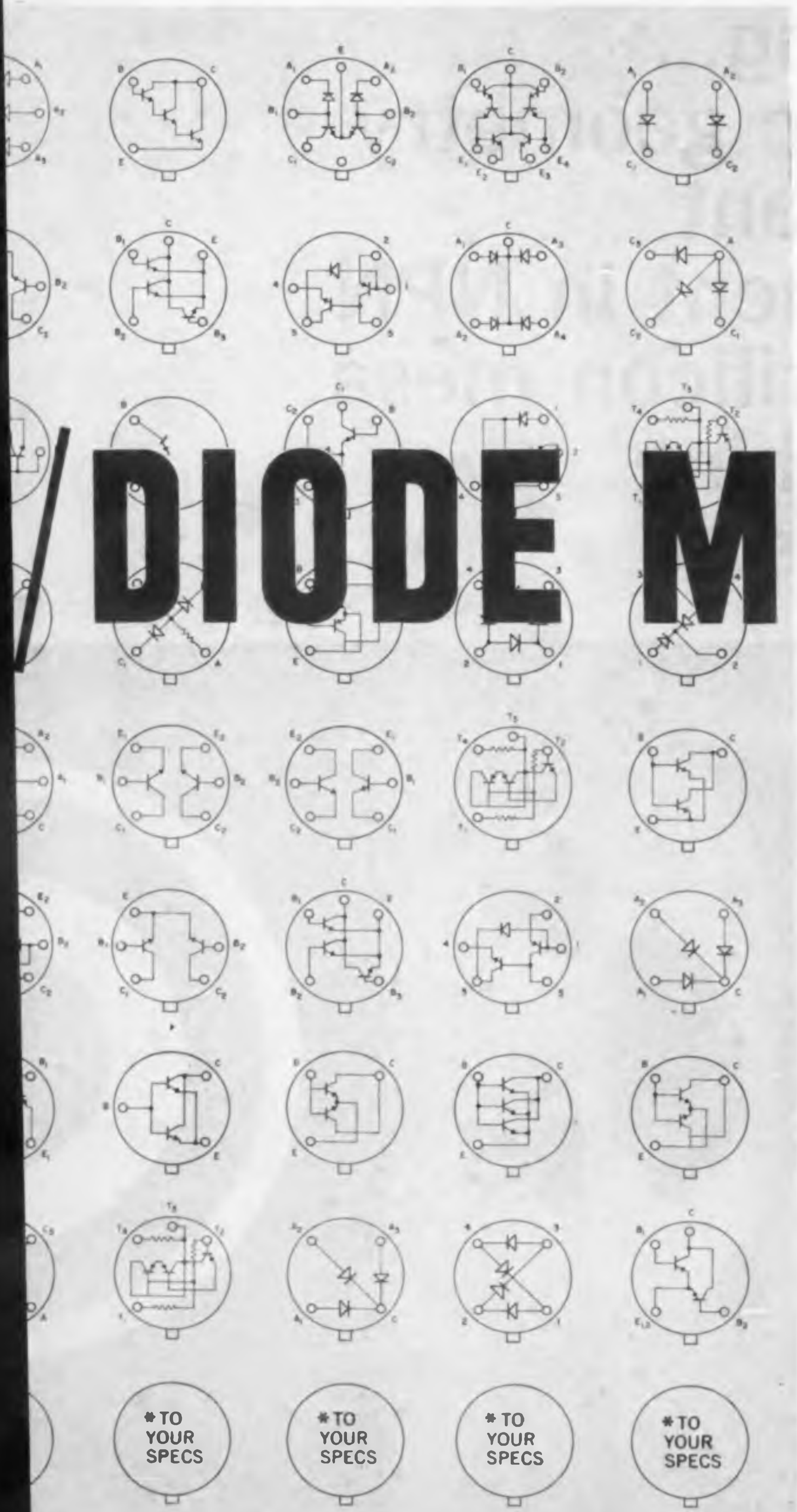

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2N212	HF	2N330	A	2N404	LL
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2N213A	A	2N331	A	2N405	A
2N214	A	2N332	A	2N406	A
2N215	A	2N332A	A	2N407	A
2N217	A	2N333	A	2N408	A
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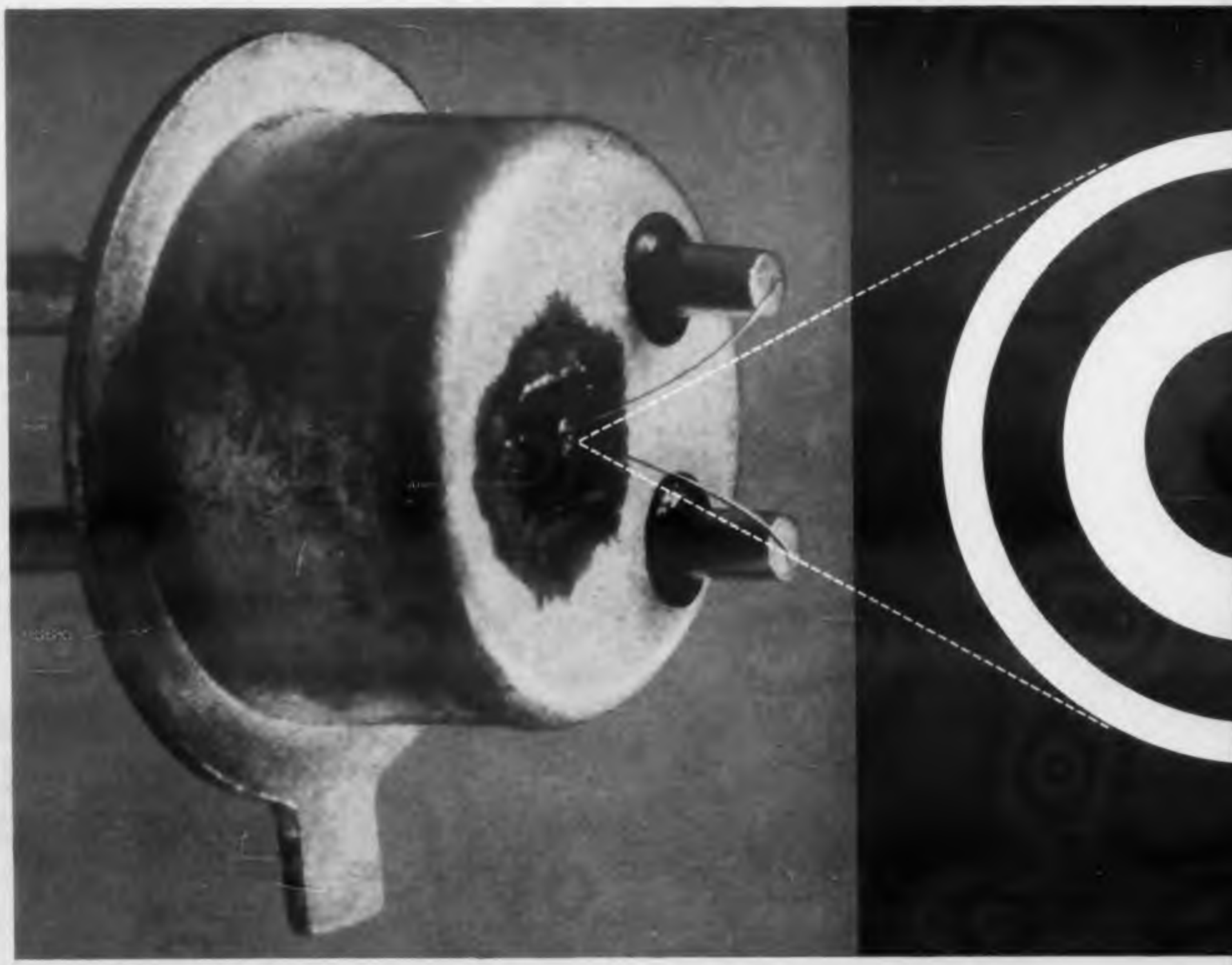
2N234A	P	2N339A	LL	2N418	HL
2N235A	P	2N340	P	2N419	P
2N235B	P	2N340A	A	2N420	HL
2N236A	P	2N341	P, A	2N420A	HL
2N236B	P	2N341A	P	2N422	A
2N238	A	2N342	P	2N424	P
2N240	LL	2N342A	P	2N424A	HL
2N241	A	2N343	P	2N425	LL

Introducing... concentric geometry A significant improvement in NPN diffused silicon mesa fast-switching transistors



Hughes Semiconductor Division offers immediate delivery of a *whole family* of exceptionally fast-switching *NPN* silicon mesa transistors.

These devices incorporate a new design feature that increases both performance and reliability.

We call it concentric geometry—with a continuous surrounding base contact. It provides extremely low base spreading resistance r_b'. This results in a faster switch and a much improved amplifier.

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Hughes NPN silicon mesa transistors also provide other important advantages—controlled gain bands, low storage time, high f_t, low collector saturation voltage.

Here are some typical values for these high-performance transistors: 2N706... I_{CBO} = 20 mμA; 2N706A... V_{CE} = 0.3V, t_s = 15 nsec.; 2N706B... r_b' = 15 ohm, t_s = 15 nsec.; 2N707... $r_b'C_c$ = 60 psec, f_{max} = 400mc; 2N753... V_{CE} = 0.3V, t_s = 20 nsec.

To get complete information on these high performance NPN transistors—or Hughes extensive PNP line—contact your nearest Hughes Semiconductor Sales Office or Hughes Authorized Distributor. Or write Hughes Semiconductor Division, Marketing Department, Newport Beach, California. For export, write Hughes International, Culver City, California.

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Type	Breakdown Voltages @ -100μA BV_{CBO} (V)	BV_{EBO} (V)	BV_{CEO} (V)	BV_{CER} I_C = 2mA R_{BE} = 10Ω (V)	h_{FE} I_C = 10mA V_{CE} = 1V Min.	Max.	Min. f_t I_C = 10mA V_{CE} = 15V (mc)	Max. Switching Time (nsec) t_{on}	t_{off}	t_s	Max. I_{CBO} @ 15V (μA)	Max. C_{ob} @ 5V (pf)	V_{CE} I_C = 10mA I_B = 1mA (V)	V_{BE} (sat) I_C = 10mA I_B = 1mA (V)		r_b'
2N706	25	3	—	20	20	—	200	—	—	60	0.5	6	0.6	—	0.9	—
2N706A	25	5	15	20	20	60	200	40	75	25	0.5	5	0.6	0.7	0.9	—
2N706B	25	5	15	20	20	60	200	40	75	25	0.5	5	0.4	0.7	0.9	50
2N753	25	5	15	20	40	120	200	40	75	35	0.5	5	0.6	0.7	0.9	—
2N707	56	4	—	25	9	—	—	—	—	—	5.0	10	0.6	—	0.9	—

Standard TO-18 Case; 1 Watt dissipation @ 25 C case temperature

CIRCLE 64 ON READER-SERVICE CARD

2N426	LL
2N427	LL
2N428	LL
2N438	LL,HF
2N438A	HF
2N439	LL,HF
2N439A	HF
2N440	LL,HF
2N440A	HF
2N441	P
2N442	P
2N443	P
2N444	HF
2N444A	HF
2N445	HF
2N445A	HF
2N446	HF
2N446A	HF
2N447	HF
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2N450	LL
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2N457	HL
2N457A	HL
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2N461	A
2N463	P
2N464	A
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2N470	A
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2N477	HF
2N478	HF
2N479	HF
2N479A	HF
2N480	HF
2N480A	A
2N481	HF
2N482	HF
2N484	HF
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2N496	HF
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2N497A	HL
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2N822	LL	2N1015B	HL
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2N825	LL	2N1016	HL
2N826	LL	2N1016A	HL
2N828	LL	2N1016B	HL
2N834	LL	2N1016C	HL
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2N841	HF	2N1018	A
2N842	LL	2N1021	P
2N843	LL	2N1022	P
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2N845	HF	2N1024	HF
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2N862	LL	2N1031A	P
2N863	LL	2N1031B	P
2N864	LL	2N1031C	P
2N865	LL	2N1032	P
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2N871	HL	2N1032B	P
2N902	LL	2N1032C	P
2N903	A,LL	2N1034	LL
2N904	A,LL	2N1035	LL
2N904A	A	2N1036	LL
2N905	A,LL	2N1037	LL
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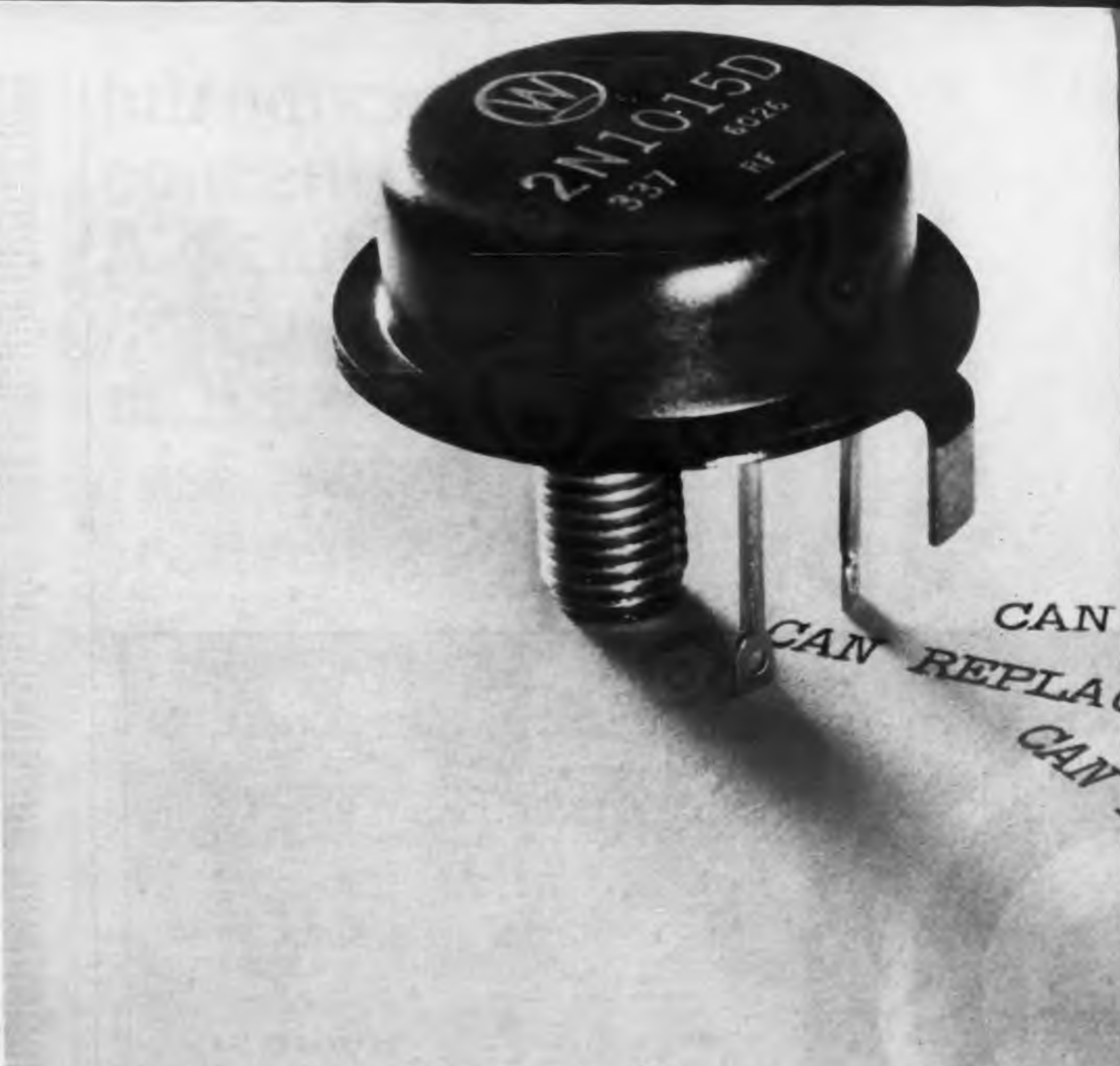
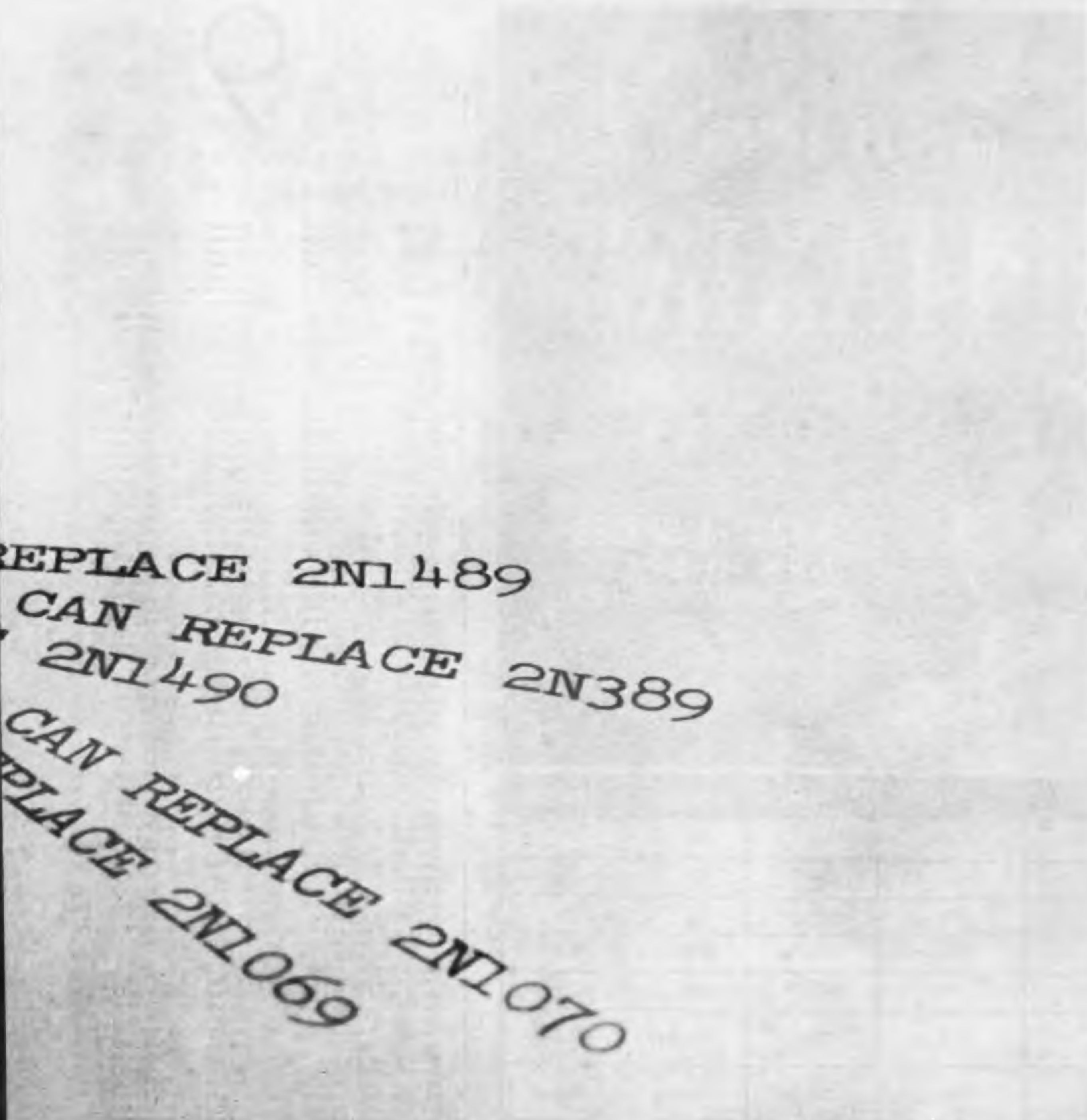
2N907	LL	2N1039	HL
2N908	LL	2N1040	HL
2N909	HL	2N1041	HL



greater derating margin for higher reliability...at lower cost than lower rated types

Westinghouse 2N1015 and 2N1016 transistors—Circuits which use power transistors can be upgraded in reliability by changing to the Westinghouse 2N1015-2N1016 series. The low saturation resistance and high dissipation rating (150 watts) of these transistors mean cooler operation—more safety factor in service. In fact, the 2N1015-2N1016 series offers twice the derating margin you can get in competitive types. Their high voltage ratings—up to 200 volts V_{CE}—also mean an end to series connections of lower rated types. Yet all this is yours at less cost than you are now paying.

In addition to these many circuit advantages, the 2N1015-2N1016 transistors give you the reliability assurance of



rue Voltage Ratings verified by 100% Power Testing nder full operating conditions. You also get the advanges of reduced inventory, and the convenience of ngle-source purchasing. Next time you buy transistors the 2N1015-2N1016 family make sure they're 100% ower tested. You can be sure . . . if it's Westinghouse. r complete information, write or call: Westinghouse ectric Corp., Semiconductor Dept., Youngwood, Penna.

SC-1042

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HAMILTON ELECTRO SALES — Los Angeles, Calif./BR 2-9154
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2N1042	P	2N1147C	P
2N1043	P	2N1149	A
2N1044	P	2N1150	A
2N1045	P	2N1151	A
2N1046	HL	2N1152	A
2N1046A	HL	2N1153	A
2N1046B	P	2N1154	A
2N1047	P	2N1155	A
2N1047A	P	2N1156	A
2N1048	P	2N1157	P
2N1048A	P	2N1157A	P
2N1049	P	2N1158	HF
2N1049A	P	2N1158A	HF
2N1050	P	2N1159	P
2N1050A	P	2N1160	P
2N1051	A	2N1162	P
2N1052	HL	2N1162A	P
2N1054	HL	2N1163	P
2N1055	HL	2N1163A	P
2N1056	LL	2N1164	P
2N1057	LL	2N1164A	P
2N1058	HF	2N1165	P
2N1059	A	2N1165A	P
2N1060	HL	2N1166	P
2N1065	HF	2N1166A	P
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2N1068	P	2N1168	P
2N1069	P	2N1169	LL
2N1070	P	2N1170	LL
2N1072	HL	2N1172	P
2N1073	HL	2N1173	HL
2N1073A	HL	2N1174	HL
2N1073B	P	2N1175	LL
2N1078	P	2N1175A	LL
2N1086	HF	2N1176	A
2N1086A	HF	2N1176A	A
2N1087	HF	2N1176B	A
2N1090	LL.HF	2N1177	HF
2N1091	LL.HF	2N1178	HF
2N1094	HF	2N1179	HF
2N1095	A	2N1180	HF
2N1096	A	2N1183	P
2N1097	A	2N1183A	P
2N1098	A	2N1183B	P
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2N1100	P	2N1184A	P
2N1101	A	2N1184B	P
2N1102	A	2N1185	A
2N1107	HF	2N1186	A
2N1108	HF	2N1187	A
2N1109	HF	2N1188	A
2N1110	HF	2N1191	A
2N1111	HF	2N1192	A
2N1111A	HF	2N1193	A
2N1111B	HF	2N1194	HF
2N1114	LL	2N1194A	HF
2N1116	HL	2N1195	HF
2N1117	HL	2N1196	HF
2N1118	HF	2N1197	HF
2N1118A	HF	2N1198	LL
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2N1120	P	2N1203	P
2N1121	HF	2N1204	HF
2N1122	LL	2N1205	LL
2N1122A	LL	2N1208	HL
2N1123	LL	2N1209	HL
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2N1125	LL	2N1211	P
2N1128	A	2N1212	HL
2N1129	A	2N1213	LL
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2N1132	HL	2N1216	LL
2N1136	P	2N1217	LL
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2N1136B	P	2N1220	LL
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2N1137A	P	2N1222	LL
2N1137B	P	2N1223	LL
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2N1138B	P	2N1226	HF
2N1139	LL	2N1228	LL
2N1141	HF	2N1229	LL
2N1142	HF	2N1230	LL
2N1143	HF	2N1231	LL
2N1144	A	2N1232	LL
2N1145	A	2N1233	LL
2N1146	P	2N1234	LL
2N1146A	P	2N1238	HL,LL
2N1146B	P	2N1239	LL
2N1146C	P	2N1240	LL
2N1147	P	2N1241	LL
2N1147A	P	2N1242	LL
2N1147B	P	2N1243	LL

◄ CIRCLE 65 ON READER-SERVICE CARD

PARAMETER	CONDITIONS	NS381	NS382	NS383	NS384
Min. BV_{CEO}	(I_{CE} = 10mA)	20v	20v	12v	12v
Min. BV_{CER}	(I_{CE} = 10mA, R_{BE} = 10Ω)	25v	25v	15v	15v
Min. BV_{EBO}	(I_{EB} = 10μA, I_C = 0)	5v	5v	5v	5v
h_{FE}	(I_C = 3mA, V_{CE} = .4v)	20-60	40-120	20-60	40-120
Max. V_{CE}	(I_C = 3mA, I_B = .3mA)	.25v	.25v	.15v	.15v
Max. t_{ON}	(I_{B_1} = 3mA, I_{B_2} = 1mA, V_{CC} = 3v, R_L = 270Ω)	15nsec	15nsec	15nsec	15nsec
Max. t_{OFF}	(I_{B_1} = 3mA, I_{B_2} = 1mA, V_{CC} = 3v, R_L = 270Ω)	25nsec	25nsec	25nsec	25nsec
Max. t_S	(I_{B_1} = I_{B_2} = I_C = 10mA, V_{CC} = 10v, R_L = 1k)	15nsec	15nsec	12nsec	12nsec

Full technical specifications available on request. Write, wire or call:

National Semiconductor CORPORATION

Danbury, Conn. • Pioneer 3-7624 • TWX DANB 452-U

CIRCLE 66 ON READER-SERVICE CARD

61-5

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TRANSISTORS–1961

Cross Index (continued)

2N1244	LL
2N1247	A
2N1248	A
2N1250	HL
2N1251	A
2N1252	HF,HL
2N1253	HF,HL
2N1254	LL
2N1255	LL
2N1256	LL
2N1257	LL
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2N1645	HF
2N1646	HF
2N1647	P
2N1648	P
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2N1650	P
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2N1652	P
2N1653	P

2N1654	A	2N1899	P,HF	C652	SP	OC53	A
2N1655	A	2N1900	P,HF	C653	SP	OC54	A
2N1656	A	2N1901	P,HF	CF45017	HL	OC55	A
2N1657	P	2N1905	P	CK4	A	OC56	A
2N1658	P	2N1906	P	CK4A	A	OC57	A
2N1659	P	2N1917	A	CK13	HF	OC58	A
2N1660	P	2N1918	A	CK14	HF	OC59	A
2N1661	P	2N1919	A	CK16	HF	OC60	A
2N1662	P	2N1920	A	CK17	HF	OC74	A
2N1663	LL	2N1921	A	CK17A	A	OC79	A
2N1665	HF	2N1922	A	CK22	A	OC80	LL
2N1667	HL	2N1924	A	CK22A	A	OC139	LL
2N1668	HL	2N1925	A	CK22B	A	OC140	LL
2N1669	HL	2N1926	A	CK22C	A	OC141	LL
2N1670	A	2N1936	P	CK25	LL	OC170	HF
2N1672	A	2N1937	P	CK25A	A	OC171	HF
2N1676	HF	2N1944	A	CK26	LL	OC200	A
2N1677	HF	2N1945	A	CK26A	A	OC201	A
2N1678	A	2N1946	A	CK27	LL	OCP70	A
2N1681	HF	2N1947	A	CK27A	A	PADT20	HF
2N1683	LL	2N1948	A	CK28	LL	PADT21	HF
2N1684	HF	2N1949	A	CK28A	A	PADT22	HF
2N1692	P	2N1950	A	CK64	A	PADT23	HF
2N1693	P	2N1951	A	CK64A	A	PADT24	HF
2N1701	HL	2N1952	A	CK64B	A	PADT25	HF
2N1702	HL	2N1954	LL	CK64C	A	PADT26	HF
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2N1706	A	2N1956	LL	CK65B	A	PADT28	HF
2N1707	A	2N1957	LL	CK65C	A	PADT29	HF
2N1709	P,HF	2N1958	HF	CK66	A	PADT30	HF
2N1710	P,HF	2N1959	HF	CK66B	A	PADT31	HF
2N1711	HL	2N1960	HF	CK66C	A	PADT40	LL
2N1714	P	2N1961	HF	CK67	A	PADT50	HL
2N1715	P	2N1962	HF	CK67A	A	PADT51	LL
2N1716	P	2N1963	HF	CK67B	A	PADT60	SP
2N1717	P	2N1964	HF	CK67C	A	PT600	HF
2N1718	P	2N1965	HF	CK261	A	PT601	HF
2N1719	P	2N1969	HF	CK262	A	PT850	HF
2N1720	P	2N1970	HL	CK419	LL	PT850A	HF
2N1721	P	2N1971	HL	CK420	LL	PT900	P
2N1722	P	2N1972	HL	CK421	LL	RT409	HL
2N1723	P	2N1973	HL	CK474	LL	RT482	HL
2N1724	P	2N1974	HL	CK475	LL	RT483	HL
2N1726	HF	2N1975	HL	CK476	LL	RT484	HL
2N1727	HF	2N1978	HL	CK477	LL	RT497M	HL
2N1728	HF	2N1983	HL	CDT1310	P	RT498M	HL
2N1730	A	2N1984	HL	CDT1311	P	RT656M	HL
2N1731	A	2N1985	HL	CDT1312	P	RT657M	HL
2N1742	HF	2N1986	HL	CDT1313	P	RT696M	HL
2N1743	HF	2N1987	HL	CDT1319	P	RT696AM	HL
2N1744	HF	2N1988	HL	CDT1320	P	RT697M	HL
2N1745	HF	2N1989	HL	CDT1321	P	RT697AM	HL
2N1746	HF	2N1990	HL	CDT1322	P	RT698M	HL
2N1747	HF	2N1991	HL	CST1739	P	RT699M	HL
2N1748	HF	2N1994	LL	CST1740	P	RT1420M	HL
2N1749	HF	2N1995	LL	CST1741	P	RT1613M	HL
2N1750	HF	2N1996	LL	CST1742	P	RT5151	HL
2N1752	HF	2N1997	LL	CST1743	P	RT5152	HL
2N1754	LL	2N1998	LL	CST1744	P	RT5202	HL
2N1755	P	2N1999	LL	CST1745	P	RT5203	HL
2N1756	P	2N2000	LL	CST1746	P	RT5204	HL
2N1757	P	2N2001	LL	CTP1104	P	RT5212	HL
2N1758	P	2N2002	LL	CTP1105	P	RT5230	HL
2N1759	P	2N2003	LL	CTP1108	P	SO-1	HF
2N1760	P	2N2004	LL	CTP1109	P	SO-2	HF
2N1768	HL	2N2005	LL	CTP1500	P	SO-3	HF
2N1769	HL	2N2006	LL	CTP1503	P	ST15	HF
2N1779	LL	2N2007	LL	CTP1504	P	ST35	HF
2N1780	LL	2N2018	P	CTP1508	P	ST45	HF
2N1781	LL	2N2019	P	CTP1544	P	ST401	HL
2N1782	HF	2N2020	P	CTP1552	P	ST440	P
2N1783	HF	2N2021	P	CTP1553	P	ST450	P
2N1784	HF	3N34	HF	CTP1728	P	ST4201	P
2N1785	HF	3N35	HF	GK13A	HF	ST4203	P
2N1786	HF	3N36	HF	GK16A	HF	ST4204	P
2N1787	HF	3N37	HF	GT74	A		
2N1788	HF	3N45	P	GT81	A	STC1103	HL
2N1789	HF	3N46	P	GT109	A	STC1104	HL
2N1790	HF	3N47	P	GT123	LL	TMT839	HF
2N1837	HF	3N48	P	GT1200	SP	TMT840	HF
2N1837A	HF	3N49	P	GT1624	SP	TMT841	HF
2N1838	HF	3N50	P	KGS1004	LL	TMT842	
2N1838A	HF	3N51	P	KGS1005	LL		HF,LL
2N1839	HF	3N52	P	LT11	P	TMT843	
2N1839A	HF	3N54	P	LT12	P		HF,LL
2N1840	HF	B177	P	LT13	P	WX115UA	P
2N1840A	HF	B178	P	LT14	P	WX115UB	P
2N1841	P	B179	P	LT15	P	WX115UC	P
2N1864	HF	B1085	HL	MA-1	HF	WX115UD	P
2N1865	HF	B1154	LL	MA-2	HF	WX115WA	P
2N1866	HF	B1154A	LL	NS345	LL	WX115WB	P
2N1867	HF	C101	LL	OC22	HL	WX115WC	P
2N1868	HF	C102	LL	OC23	HL	WX115WD	P
2N1886	P	C103	LL	OC24	HL	WX115XA	P
2N1889	HL	C106	LL	OC28	HL	WX115XB	P
2N1890	HL	C301	LL	OC29	HL	WX115XC	P
2N1893	HL	C302	LL	OC30	P	WX115XD	P
2N1894	P	C611	SP	OC35	HL	WX118UA	P
2N1895	P	C612	SP	OC36	HL	WX118UB	P
2N1896	P	C613	SP	OC44	HF	WX118UC	P
2N1897	P	C614	SP	OC45	HF	WX118XA	P
2N1898	P	C650	SP	OC46	LL	WX118XB	P
2N1899	P	C651	SP	OC47	LL	WX118XC	P

Transistor Data Sheets— What They Mean and How to Use Them Properly

ELECTRONIC DESIGN'S *Ninth Annual Transistor Data Chart (p 33) contains 1714 transistor types with abbreviated specifications. For complete details on the various transistor parameters and explanation of the test conditions used, reference to manufacturers' data sheets is necessary. Thus, the Transistor Data Chart is intended to guide the design engineer to several types; the specific selections is then based on complete device characteristics and price as obtained from the manufacturer. The relationship which exists between published characteristics and design requirements is discussed and a useful circuit design check list is included.*

Mitchell Baker, Jordan V. Sukert
Motorola Semiconductor Div., Inc.
Phoenix, Ariz.

A WELL-PREPARED transistor data sheet, properly interpreted by a circuit design engineer, is an extremely useful design aid. To meet the present demands for circuit and systems reliability, an understanding of transistor specifications and their relationship to design requirements is a valuable design asset.

Basic Structure of a Transistor Data Sheet

A modern, well-prepared data sheet should provide the design engineer with all the necessary information for selecting a transistor capable of performing a particular job. To accomplish this, the data sheet is normally divided into six general sections. A description of the device is given first, followed by sections on absolute ratings, electrical and thermal characteristics, mechanical data and applications information.

The description of the device usually gives the broad general application which permits the designer to classify transistors according to his specific requirements. Thus, a typical power transistor description might indicate whether the unit was designed for audio work or switching applications. In addition, the power and/or current rating is specified, the polarity (pnp or npn) is given, and the type of material is indicated. At a glance, therefore, the engineer can determine if a particular transistor or group of transistors is suitable for using in a particular purpose.

From this point, however, the selection of a specific transistor for a particular project becomes more involved. The unit must be considered in terms of its various electrical ratings and characteristics to make sure that it fits the application from every conceivable standpoint. In addition, the engineer is responsible for selecting the least expensive transistor.

Distinction Between Ratings and Characteristics

A rating is defined as a limiting value assigned by the manufacturer which, if exceeded, may result in permanent damage to the device. On the other hand, a characteristic is a measurable property of the device under specific operating conditions for which the transistor will provide satisfactory and reliable performance.

Absolute Maximum Ratings are those ratings beyond which degradation regarding the life and reliability of a transistor may be expected. These ratings are based on internal physical construction, semiconductor material and manufacturing processes. Because these are "ratings", most data sheets will not indicate test conditions under which these "ratings" are specified. Therefore, "ratings" are the extreme capabilities of a transistor and are not intended to be used as design conditions.

For example, under absolute maximum ratings, the letter B placed before a characteristic symbol usually means breakdown. Therefore, BV_{CBO}, BV_{CEO}, BV_{CES}, BV_{CEX}, and BV_{EBO} represent the breakdown ratings of the device; when these ratings are exceeded, an avalanche or breakdown condition may take place and destroy a transistor. Breakdown is dependent upon temperature and an

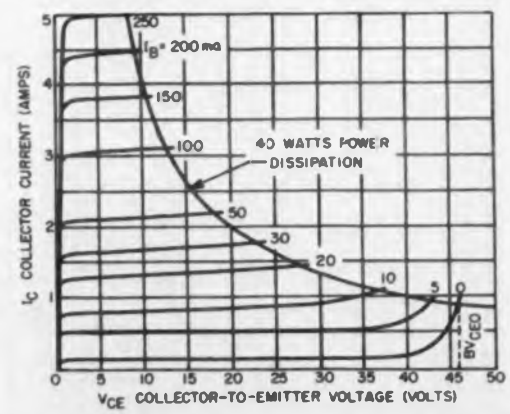


Fig. 1. Typical output characteristics of a Motorola 2N1530 power transistor.

If you would like an additional copy of the Transistor Data Chart Section circle 251 on the Reader-Service Card.

arbitrary voltage and current condition, the combination of which can trigger the avalanche effect.

As a practical example, the graph in Fig. 1 illustrates the typical output characteristics of a 2N1530 power transistor. The absolute maximum voltage BV_{CEO} is shown as being 45 v, the absolute maximum current is shown as 5 amp.

With an absolute maximum power rating of 90 w (as shown on the data sheet for this particular transistor), it is now possible for the design engineer to calculate and plot a maximum voltage-current relationship which must not be exceeded.

Thermal characteristics, listed with the absolute maximum ratings, are expressed in degrees C per watt and define the dissipation capability of the transistor regarding the junction temperature in relation to the transistor case temperature.

Electrical Characteristics Indicate Design Centers

Whereas the absolute maximum specifications provide the limits beyond which reliable operation cannot be obtained, this section of the data sheet contains the device design centers. When discussing any specific characteristics, the test conditions must be defined in order to achieve a common understanding between the user and the manufacturer of the transistor. Almost every parameter listed on a data sheet is subject to variation among manufacturers due to these test conditions. Motorola data sheets covering the power transistor series from 2N1539 through 2N1548 will be used to discuss each parameter in order. (See Fig. 2).

Collector-Base Leakage Currents: I_{CBO} is a term initially used to signify the quality of a transistor. Actually, three very definite I_{CBO}'s are of importance to the designer. The first is the reading taken at some low collector-base voltage, in this case, 2 v, with a maximum value of I_{CBO} indicated at this voltage. This value, for all practical purposes, represents the thermal component of the collector current which cannot be reduced by further decrease of V_{CB}. As the ambient temperature increases, the leakage current increases. Using the arbitrary rule that the thermal component of current will double for every 10 C, the design engineer can pinpoint the temperature component of the leakage current.

Collector-Base Voltage Characteristics: The second component of I_{CBO} which is important in high-temperature usage is the current due to the collector-base voltage with the emitter open. The data sheet indicates that V_{CB} at 25 v on the 2N1539 power transistor produces a maximum leakage of 2 ma. This voltage component is not temperature sensitive. Therefore, the design engineer wishing to determine his leakage value at some higher temperature (e.g. T_j = 75 C), can safely assume that the maximum increase in the thermal component of leakage current will be 32 times 200 μa (using the "doubling-every-10 C" rule). Adding to this the 2-ma voltage component results in a value of 8.4 ma maximum leakage at 75 C with 25 v across the transistor. All future references to temperature will refer to the transistor case temperature and not the ambient temperature.

High-Temperature Collector-Base Leakage Currents: Since there are many voltages and many applications to be considered, it is difficult for any manufacturer to specify leakage under all voltages at all tempera-

ELECTRICAL CHARACTERISTICS, GENERAL (At 25°C Case Temperature unless otherwise specified)

Parameter	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current	I_{CBO}				mA
$V_{CB} = -25V$ 2N1539, 2N1544		—	—	2.0	
$V_{CB} = -40V$ 2N1540, 2N1545		—	—	2.0	
$V_{CB} = -55V$ 2N1541, 2N1546		—	—	2.0	
$V_{CB} = -65V$ 2N1542, 2N1547		—	—	2.0	
$V_{CB} = -80V$ 2N1543, 2N1548		—	—	2.0	
Collector-Base Cutoff Current $V_{CB} = -2V$ (all types)	I_{CBO}	—	—	200	μA
Collector-Base Cutoff Current at $T_C = +90°C$ at V_{CB} = ½ BV_{CBO} rating	I_{CBO}	—	—	20	mA
Emitter-Base Cutoff Current V_{EB} = 12V (all types)	I_{EBO}	—	—	0.5	mA
Collector-Emitter Breakdown Voltage I_C = 500mA, V_{EB} = 0	BV_{CES}				volts
2N1539, 2N1544		30	—	—	
2N1540, 2N1545		45	—	—	
2N1541, 2N1546		60	—	—	
2N1542, 2N1547		75	—	—	
2N1543, 2N1548		90	—	—	
Collector-Emitter Leakage Current V_{BE} = 1.0V	I_{CEX}				mA
V_{CE} = 40 2N1539, 2N1544		—	—	20	
V_{CE} = 60 2N1540, 2N1545		—	—	20	
V_{CE} = 80 2N1541, 2N1546		—	—	20	
V_{CE} = 100 2N1542, 2N1547		—	—	20	
V_{CE} = 120 2N1543, 2N1548		—	—	20	
Collector-Emitter Breakdown Voltage I_C = 500mA, I_B = 0	BV_{CEO}				volts
2N1539, 2N1544		20	—	—	
2N1540, 2N1545		30	—	—	
2N1541, 2N1546		40	—	—	
2N1542, 2N1547		50	—	—	
2N1543, 2N1548		60	—	—	
Collector-Base Breakdown Voltage I_C = 20mA	BV_{CBO}				volts
2N1539, 2N1544		40	—	—	
2N1540, 2N1545		60	—	—	
2N1541, 2N1546		80	—	—	
2N1542, 2N1547		100	—	—	
2N1543, 2N1548		120	—	—	

ELECTRICAL CHARACTERISTICS, COMMON EMITTER (At 25°C Case Temperature unless otherwise specified)

Parameter	Symbol	Min	Typ	Max	Unit
Current Gain $V_{CE} = -2V$, I_C = 3A	h_{FE}				—
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		50	—	100	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		75	—	150	
Base-Emitter Drive Voltage I_C = 3A, I_B = 300mA	V_{BE}				volts
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		—	—	0.7	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		—	—	0.5	
Collector Saturation Voltage I_C = 3A, I_B = 300mA	$V_{CE(SAT)}$				volts
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		—	0.2	0.6	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		—	0.1	0.3	
Frequency Cutoff $V_{CE} = -2V$, I_C = 3A	f_{ae}				kc
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		—	4	—	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		—	4	—	
Switching Characteristics I_C = 3A					
Delay + Rise Time	$t_d + t_r$				μsec
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		—	5	—	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		—	5	—	
Storage Time	t_s				μsec
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		—	3	—	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		—	5	—	
Fall Time	t_f				μsec
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		—	5	—	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		—	8	—	
Transconductance $V_{CE} = -2V$, I_C = 3A	g_{FE}				mhos
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		3.0	6.0	—	
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		5.0	7.5	—	

Fig. 2. Electrical characteristics contained in a transistor data sheet.

TRANSISTORS—1961

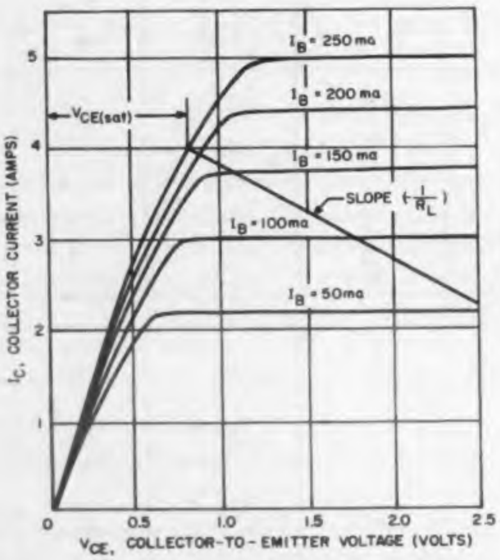


Fig. 5. Output characteristics of the 2N351A with the saturation region indicated.

tures hence, the third I_{CBO}. Motorola specifies a guaranteed maximum leakage at 90 C at a voltage level well within reliable usage of any given transistor. The selection of the one-half collector-emitter breakdown voltage (BV_{CES}) rating for the high temperature test is an arbitrary one but is established at a point where the manufacturer knows the device will be in a reliable operating area.

Emitter-Base Cut-Off Current (I_{EBO}): One of the least used parameters on a data sheet is I_{EBO}. It is well to know the I_{EBO} limit of any given junction within a transistor; therefore this limit is shown at a region where most design will be taking place. The emitter-base diode breakdown voltage rating is indicated by the BV_{EBO} listed under the absolute maximum ratings.

Collector-Emitter Leakage Current (I_{CEX}): The X in this symbol means that there is some known back-bias voltage applied to the base-emitter diode. For each transistor, this back-bias must be specified as a test condition for any given I_{CEX} or BV_{CEX} rating. This rating is very useful in designing power converters where one transistor is conducting while the other transistor is back-biased in the off condition waiting for transformer action to turn it back on. It is more convenient to apply a given voltage and guarantee that the current will not be above a certain maximum value than to apply a test current and see if the voltage will be above a certain minimum value. The latter test could be related to a second breakdown[1] type of relationship. On many diodes, applying a given test current could show a voltage rating of many volts above the manufacturer's listed rating. The collector-emitter could, for example, possibly withstand 150 to 200 v; however, power dissipation could be exceeded.

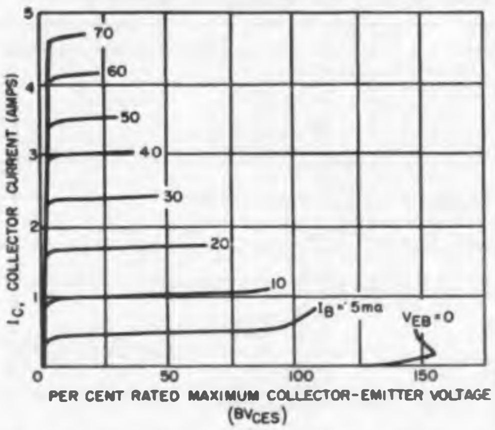


Fig. 3. Collector characteristics of a power transistor in a common emitter connection.

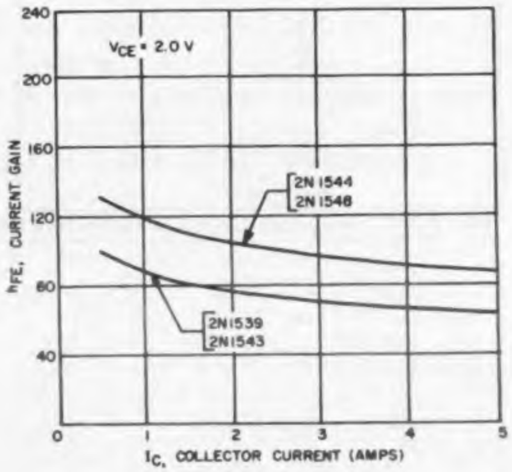


Fig. 4. The current gain, h_{FE} of alloy transistors decreases with increased collector current.

Collector-Emitter Breakdown (BV_{CES}): The most important rating that the engineer can consider when selecting the transistor for his circuit is BV_{CES}, see Fig. 3.

Almost all power transistor applications require source voltages, collector-to-emitter, thus V_{CE} ratings must be equal to or larger than the source voltage; inductive loads will make this requirement higher. For the design engineer, a useful rating would be BV_{CER} which falls between BV_{CES} and BV_{CEO} in alloy transistors. On many test conditions, high dissipation can be experienced with the combination of test voltage and test current. Therefore, many tests are specified as sweep tests or pulse tests where the duty cycle is low enough that the maximum junction temperature is not exceeded. These tests should be performed with the transistor mounted on an adequate heat sink.

Collector-Emitter Breakdown Voltage with the Base Open (BV_{CEO}): This test is related to I_{CBO} and the gain characteristic h_{FE}. With the base open, a condition can be reached where h_{FE} will multiply the I_{CBO} at a given voltage and start an avalanche condition as the junction temperature rises due to self-heating. This can quickly reach breakdown conditions if not carefully tested by the sweep method.

A possible cause of transistor failure is lack of BV_{CEO}, especially at high voltages; this condition is often encountered in application such as series-regulated power supplies and power amplifiers. In switching circuits, this condition can exist when the transistor is switched from on to off, thus passing a region where the base has infinite resistance or is essentially open.

Collector-Base Breakdown Voltage (BV_{CBO}): This rating will show the limitation of the collector-base junction, but is a rating which is only occasionally used in actual circuit considerations. Many engineers make the error of selecting a transistor based on this parameter putting themselves into a high-priced, low-availability category, when actually the true ratings could have been defined by BV_{CES}. Circuits should be carefully analyzed to determine if BV_{CBO} or some collector-to-emitter rating is the controlling factor under the worst conditions.

Current Gain (h_{FE}): This is the most arbitrary of all test conditions listed on a data sheet. For alloy transistors, current-gain is a function of collector current and in most cases will decrease when I_C increases, see Fig. 4.

It is best to design around data sheet limits. However, circuit requirements could dictate current gain spreads. Under these circumstances, it would be beneficial for the design engineer to work closely with the manufacturer to obtain a special device. This parameter is one that will vary to some degree with life, and is therefore used as an end-of-life characteristic.

Base to Emitter Voltage (V_{BE}): This parameter denotes the input voltage at the specified test condition, required in the design of power converters and switching circuits. The test for this parameter is usually performed with the transistor in saturation.

Saturation Voltage ($V_{CE\ sat}$): Saturation voltage $V_{CE\ sat}$ (Fig. 5) is the minimum voltage necessary to maintain normal transistor action at a particular collector current. At collector voltages lower than $V_{CE\ sat}$, the base-collector diode is forward biased and the current-voltage relationship changes abruptly. Thus, the saturation voltage is the minimum collector-emitter voltage required to maintain full conduction when enough base drive is supplied; further applications of base drive will reduce $V_{CE\ sat}$. Since the $V_{CE\ sat}$—I_C curve is almost a straight line, some transistor manufacturers list the characteristic as saturation resistance ($V_{CE\ sat}$).

Transistor efficiency in converters is a function of switching speed and power dissipated in the fully-on condition. A very low saturation voltage is extremely desirable and is a function of the collector current and base current drive. Saturation voltage rises with an increase in collector current and is inversely related to the gain (h_{FE}) of the transistor.

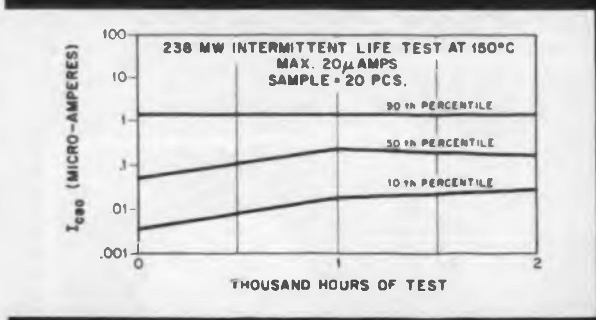
Common Emitter-Cut-Off Frequency (f_{ae}): Current gain frequency cut-off (f_{ae}) for the common emitter configuration, (also called the beta cut-off frequency) is the frequency where the small-signal, forward-current gain is 0.707 of the current gain value at a given reference frequency. The common base frequency cut-off F_{ab}, (generally not specified for power transistors) is appro nately equal to h_{fe} times F_{ae}.

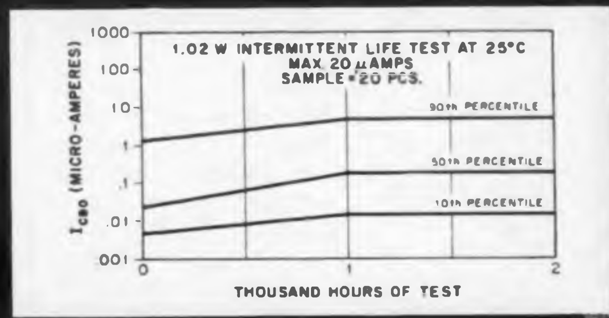
Power Transistor Circuit Design Check List

Without going into details of the external circuit requirements, the following questions should be considered during selection of a proper power transistor.

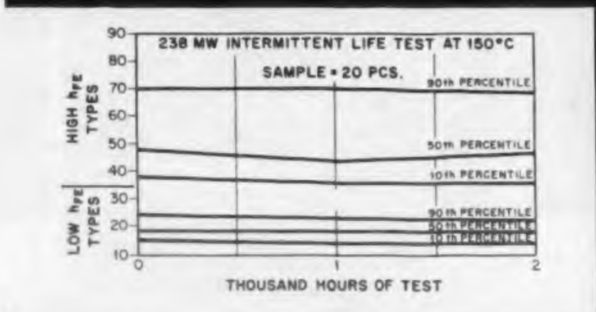
(continued on p 80)

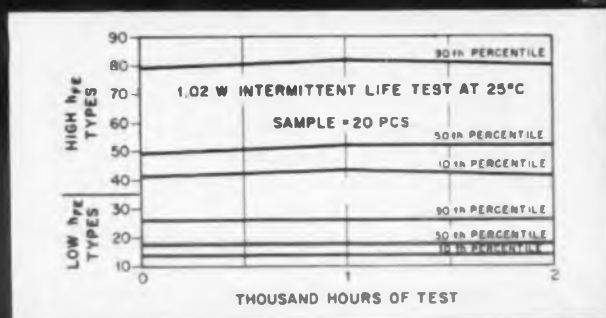
The industry's most thoroughly characterized and medium power silicon Mesa transistors...2N497A,





The "A" versions are exclusive from General Electric!





Higher power with cooler operation (cool transistors are reliable transistors)

Low input impedance (200Ω vs. the usual 500 means more signal gets into the transistor and more current flows out!)

Lower saturation resistance (10Ω vs. the usual 25 means more power when you turn the unit on!)

Absolute Maximum Ratings (25°C)

		2N497A	2N498A	2N656A	2N657A	
Voltages						
Collector to Base	V_{CBO}	60	100	60	100	volts
Collector to Emitter	V_{CEO}	60	100	60	100	volts
Emitter to Base	V_{EBO}	8	8	8	8	volts
Temperatures						
Storage	T_{STG}	−65 to 200°C				
Operating Junction	T_J	−65 to 200°C				

Total Dissipation
Free Air @ 25°C — 1 watt*
Case Temperature @ 25°C — 5 watts**

*Derate 5.72 mw/°C increase in ambient temperature above 25°C
**Derate 28.6 mw/°C increase in case temperature above 25°C

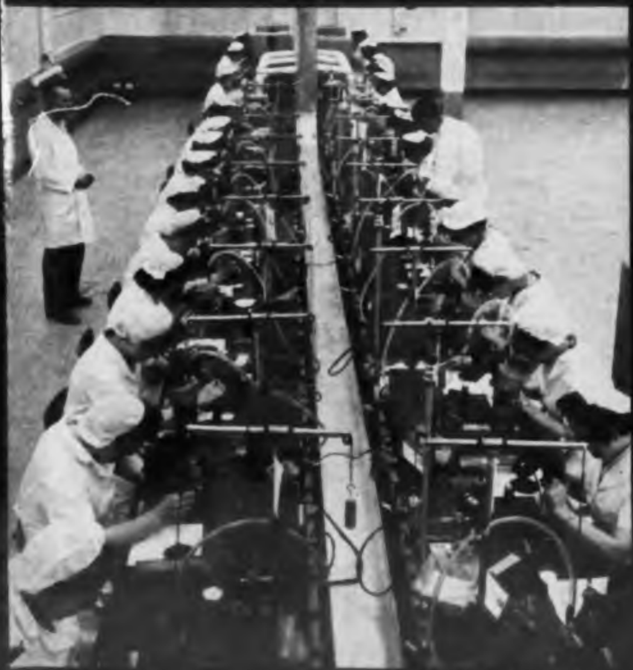
Electrical Characteristics (25°C) unless otherwise specified

D-C Characteristics		2N497A Min.	2N497A Max.	2N498A Min.	2N498A Max.	2N656A Min.	2N656A Max.	2N657A Min.	2N657A Max.	
Collector to Base Voltage (I_C = 100 μa, I_E = 0)	V_{CBO}	60		100		60		100		volts
Collector to Emitter Voltage (I_C = 250 μa)	V_{CEO}	60		100		60		100		volts
Collector to Emitter Voltage (I_C = 16 ma)	V_{CEO}	60				60				volts
Collector to Emitter Voltage (I_C = 10 ma)	V_{CEO}			100				100		volts
Emitter to Base Voltage (I_E = 250 μa, I_C = 0)	V_{EBO}	8		8		8		8		volts
Forward Current Transfer Ratio* (I_C = 200 ma, V_{CE} = 10V)	h_{FE}	12	36	12	36	30	90	30	90	
Base Input Resistance* (I_B = 8 ma, V_{CE} = 10V)	h_{IE}		200		200		200		200	ohms
Saturation Resistance* (I_B = 40 ma, I_C = 200 ma)	r_{CE} (sat)		10		10		10		10	ohms
Cutoff Characteristics										
Collector Current (I_E = 0, V_{CB} = 30V)	I_{CO}		10		10		10		10	μa
Collector Current (High Temperature) (I_E = 0, V_{CB} = 30V, T_A = 150°C)	I_{CO}		250		250		250		250	μa

*Pulse Test: 300 μsec. 2% Duty Cycle

Specifications also available for 2N497,498, 2N656,657 mesa transistors

tested
98A, 2N656A, 57A...come from General Electric



All assembly is done on a super-clean, super-reliability line similar to that which produces transistors for missile applications.

Positive internal atmospheric control achieved through the use of General Electric's buffered-sieve encapsulation technique, higher power dissipation with lower saturation resistance and lower input impedance are important features of this line of top quality one to five watt audio switches. Especially well suited for either high level linear amplifier or switching applications, these are the industry's most thoroughly characterized and tested medium power silicon double diffused NPN transistors available today. Just take a look at the extended life test charts illustrated for convincing evidence of long term stability and reliability.

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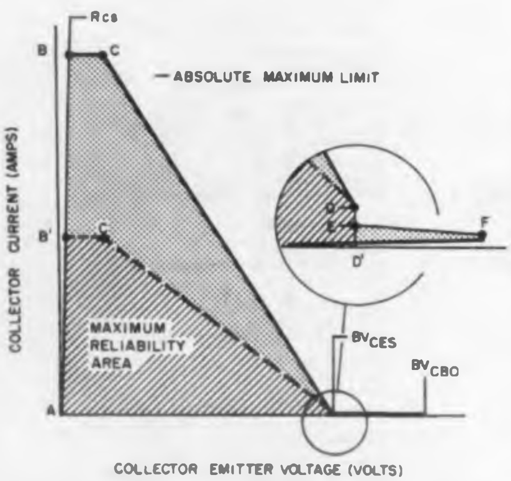

Fig. 6. The reliable area of collector operation is contained within the shaded region shown.

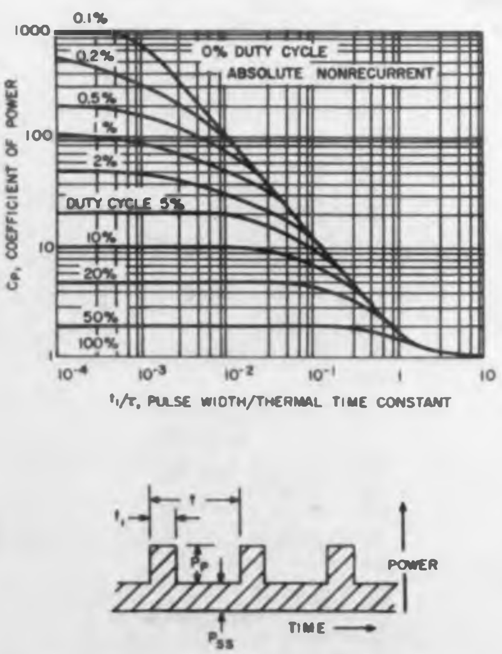

Fig. 7. Curves used in determining peak power of a power transistor.

1. What will the maximum load current requirement be?
2. What is the output voltage desired and what are the low and high line values of the source or input voltage?
3. What driving power is available? This factor is needed to determine the dc current gain required fo the maximum and minimum load currents.
4. What type of heat sink will be available?
5. What will the ambient temperature excursions be?
6. Are there any frequency requirements such as a response to a step function?
7. What are the cost limitations and availability requirements when considering large scale production?

In referring to the above questions, perhaps the most critical point is the collector-emitter voltage requirement for the specific design conditions. Knowing the voltage extremes and the maximum load current, the power dissipation must be considered in relationship to the heat sink available. With this knowledge, a search is then made for the thermal resistance or power dissipation capability of a suitable device. At this point, a decision might be required necessitating parallel operation for excessive load current requirements or series operation for high-voltage applications.[2] Series or parallel operation is well worth considering because of the lower price and better availability of less-specialized types. If heat sink considerations limit single power transistor dissipation capability, series operation may be attractive. For a given heat sink size and a stated maximum dissipation, the individual junction temperature rise for two transistors in series will be one-half the rise of a single unit. The same advantage is offered with parallel operation.

Assume a condition of 80 C case temperature and power dissipation sufficient to raise the junction temperature of a single unit to 105 C. This would indicate a power dissipation of approximately 30 w if the thermal resistance junction to case was 0.8 C per watt. This 30 w would be divided between two transistors if series operation was used therefore dissipating 15 w per unit or a junction temperature rise of 12.5 C per transistor. The junction temperature will now be 92.5 C for both devices instead of the single unit at 105 C.

Checkout for Reliable Circuit Design

A design is not complete until an examination is made of the reliability of the circuit. It is of utmost importance to examine the safe area of operation and the load line characteristic of each power transistor used in any equipment.

Definite areas of reliable operation can be predicted in devices such as germanium pnp power transistors. In Fig. 6, the region indicated as "maximum reliability" denotes safe operation with little chance of device burnout. The cross-hatched area is a derated zone of operation which may be considered safe for momentary excursions but may result in a collector-to-emitter short. To evaluate line or load surges which instantaneously place the transistor into higher dissipation, a set of curves based upon the thermal time constant, pulse width, and duty-cycle is included on the data sheet as shown in Fig. 7.

Determination of Peak Power: The peak allowable power is; from Fig. 7,

$$P_p = \frac{(T_j - T_A - \theta_{JA} P_{ss})}{\theta_{JC}\left(\frac{1}{C_p}\right) + \theta_{CA}\ (t_1/t)}$$

C_p is a coefficient of power as obtained from the data chart. T_j is junction temperature in C; T_A is ambient temperature in C; $\theta_{JC} + \theta_{CA}$; t_1 is pulse width; t is the pulse period; (t_1/t) is the duty cycle; P_{ss} is a constant power dissipation and P_p is the additional allowable pulse power dissipation above the amount of P_{ss}.

The above equation applies when a heat sink is used which has thermal capacity much larger than the transistors' thermal capacity.

The chart in Fig. 7a is normalized with respect to the thermal time constant, which is on the order of 50 msec for these power transistors. Consider a typical example as follows:

$P_{ss} = 10$ w $\quad T_A = 40$ C
Pulse width $(t_1) = 1$ msec
Duty Cycle $= 20\%$
$\theta_{CA} = 3$ C/w
$\theta_{JC} = 0.8$ C/w $\quad T_{j\,max} = 100$ C

Solution: Enter the graph at $t_1/\tau = 1$ msec/50 msec, and duty cycle 20%. Find $C_p = 5$. Solve equation

$$P_p = \frac{100 - 40 - (3 + 0.8)\ 10}{\frac{0.8}{5} + 3 \times 0.2}$$

$P_p = 29$ w in addition to the steady 10 w resulting in 39 w peak. ■ ■

Reference

1. "How to Design Economical High-Voltage Circuits", Motorola Semiconductor Products, Inc., Phoenix, Ariz.
2. Motorola Power Transistor Handbook, First Edition pg. 33-34.

A NEW UP-TO-DATE

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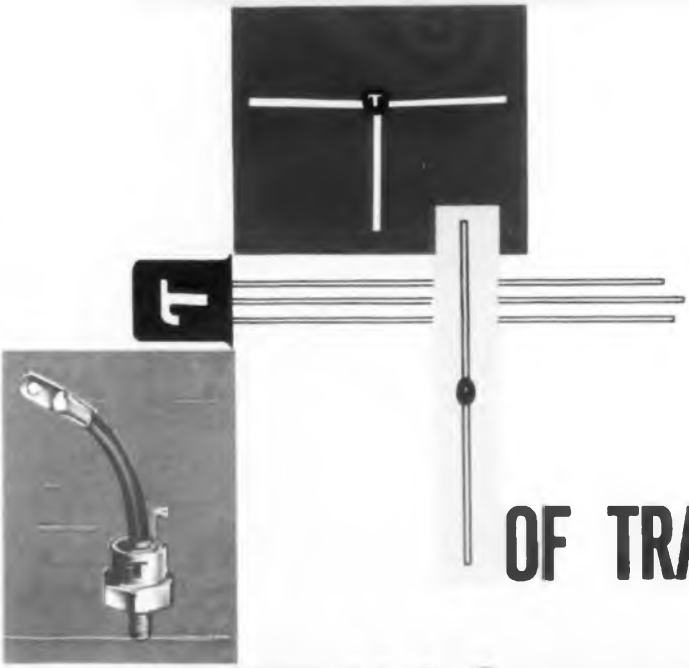

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FEATURING • What's new in Controlled Rectifiers • Breakthroughs in micro component packaging • How Transitron has applied Minuteman reliability to its broad line of semiconductors • A library of semiconductor literature • SPECIAL FOR PURCHASING AGENTS AND BUYERS, "25 Tips On How To Buy Semiconductors" • It's all here — UNDER THE FLAP

NOW AVAILABLE — NEW 50-AMP CONTROLLED RECTIFIER

The latest addition to the Transitron line, the 50-Amp Silicon Controlled Rectifier, is a three-terminal, four-layer device designed to control very large load currents with small gate current signals. A mechanically rugged and electrically stable device, the new Controlled Rectifier is provided in the 1 1/16" hex base stud-

mounted package and is hermetically sealed. Wherever high power handling ability is required, the 50-Amp Silicon Controlled Rectifier will find wide application ranging from frequency changing to welding control.

*1/5 Actual size

TCR550 SERIES (1 1/16" hex package) operating current range to 50 amps.				
Type	Minimum Peak Reverse Volt and Minimum Forward Breakover Voltage (volts)	Maximum Average Forward Current at 90°C case (amps)	Package Configuration	Package
TCR4050	400.	50.	1 1/16" hex	A
TCR3050	300.	50.	1 1/16" hex	A
TCR2050	200.	50.	1 1/16" hex	A
TCR1050	100.	50.	1 1/16" hex	A
TCR550	50.	50.	1 1/16" hex	A

PLUS FIVE OTHER VERSATILE PACKAGES

Transitron continues to offer the broadest line of Silicon Controlled Rectifiers in the industry. Available in six different and versatile packages, these rugged devices offer greater reliability and efficiency while replacing thyratrons, magnetic amplifiers, and other switching devices in many varied applications.

SILICON CONTROLLED RECTIFIERS					
Type	Minimum Peak Reverse Voltage and Minimum Forward Breakover Voltage (volts)	Maximum Average Forward Current (amps) at 25°C case	Maximum Average Forward Current (amps) at 100° case	Package Configuration	Package
TCR1020	100.	20.	10.	11/16" hex	B
TCR2020	200.	20.	10.	11/16" hex	B
TCR3020 TCR4020	300.	20.	10.	11/16" hex	B
TCR1010	100.	10.	5.0	11/16" hex	B
TCR2010	200.	10.	5.0	11/16" hex	B
TCR3010	300.	10.	5.0	11/16" hex	B
TCR4010	400.	10.	5.0	11/16" hex	B

CONTINUED INSIDE

Transitron

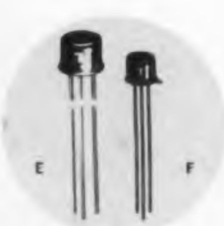
SILICON CONTROLLED RECTIFIERS – closely controlled electrical characteristics plus a high degree of mechanical ruggedness

11/16", 9/16", 7/16" HEX PACKAGES (B, C, D)

Transitron's Silicon Controlled Rectifiers are PNPN high power bistable controlled switching devices. They are analogous to a thyratron or ignitron, with far smaller triggering requirements and microsecond switching. The low conduction drop permits current ratings up to 20 amperes and provides high efficiency with low cooling requirements. Also, blocking voltages up to 500 volts permit the smallest packaging yet made possible for high power control. Operation at 125 C is permissible with derating.

TO-5 PACKAGE (E)

The TO-5 package configuration also has a low conduction drop which permits operations from 25 ma to 1 ampere (types 2N1595 - 2N1599) and 5 ma to 1 ampere (Types TCR 251 - TCR 4001). Operating and storage temperature range is from −65 C to 150 C. Typical turn-on time is 0.2 to 0.3 microseconds; turn-off time is 1.0 to 1.2 microseconds.



TO-18 PACKAGE (F)

Transitron's Silicon Controlled Switch is also a PNPN bistable unit featuring high gate sensitivity and low holding currents for low level switching from 1 ma to 200 ma. Further, these units are particularly useful in controlled rectifier trigger circuits as these switches offer precise and consistent control of the firing angle. Typical turn-on time is 0.2 microseconds; turn-off time, 1.0 microseconds.

For information on Transitron's complete line of Controlled Rectifiers and Controlled Switches check 155 Reader Service Card, or write for Bulletin TE-1356.

SILICON CONTROLLED RECTIFIERS

Type	Minimum Peak Reverse Voltage and Minimum Forward Breakover Voltage (volts)	Maximum Average Forward Current (amps) at 25°C case	at 100° case	Package Configuration	Package
2N683	100.	16.	8.	9/16" hex	C
2N685	200.	16.	8.	9/16" hex	C
2N687	300.	16.	8.	9/16" hex	C
2N688	400.	16.	8.	9/16" hex	C
2N689	500.	16.	8.	9/16" hex	C
2N1844	100.	10.	4.*	9/16" hex	C
2N1846	200.	10.	4.*	9/16" hex	C
2N1848	300.	10.	4.*	9/16" hex	C
2N1849	400	10.	4.*	9/16" hex	C
2N1850	500.	10.	4.*	9/16" hex	C
TCR1005	100.	5.0	3.0	7/16" hex	D
TCR2005	200.	5.0	3.0	7/16" hex	D
TCR3005	300.	5.0	3.0	7/16" hex	D
TCR4005	400.	5.0	3.0	7/16" hex	D
2N1600	50.	3.0	3.0*	7/16" hex	D
2N1601	100	3.0	3.0*	7/16" hex	D
2N1602	200.	3.0	3.0*	7/16" hex	D
2N1603	300	3.0	3.0*	7/16" hex	D
2N1604	400.	3.0	3.0*	7/16" hex	D
2N1772A	100	4.7	3.	7/16" hex	D
2N1774A	200	4.7	3.	7/16" hex	D
2N1776A	300	4.7	3.	7/16" hex	D
2N1777A	400	4.7	3.	7/16" hex	D
2N1772	100	4.7	3.	7/16" hex	D
2N1774	200.	4.7	3.	7/16" hex	D
2N1776	300.	4.7	3.	7/16" hex	D
2N1777	400.	4.7	3.	7/16" hex	D
2N1595	50.	0.6**	1.0*	TO-5	E
2N1596	100.	0.6**	1.0*	TO-5	E
2N1597	200.	0.6**	1.0*	TO-5	E
2N1598	300.	0.6**	1.0*	TO-5	E
2N1599	400.	0.6**	1.0*	TO-5	E
2N2011 (TCR1001)	100.	0.6**	1.0*	TO-5	E
2N2012 (TCR2001)	200.	0.6**	1.0*	TO-5	E
2N2013 (TCR3001)	300.	0.6**	1.0*	TO-5	E
2N2014 (TCR4001)	400.	0.6**	1.0*	TO-5	E
SILICON CONTROLLED SWITCHES					
2N948 (TSW31S)	30.	0.2**	0.2†	TO-18	F
2N949 (TSW61S)	60.	0.2**	0.2†	TO-18	F
2N950 (TSW101S)	100.	0.2**	0.2†	TO-18	F
2N951 (TSW201S)	200.	0.2**	0.2†	TO-18	F

*At 80°C case **At 25°C ambient †At 75° ambient

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SILICON DIODES - advanced techniques insure long-term mechanical and electrical stability

COMPUTER TYPES

Type	Maximum Inverse Operating Voltage (volts)	Maximum Average Forward Current @ 25°C (mA)	Maximum Recovery Time (mμsec)	Maximum Capacitance at 0 Volts (μμf)	Package
1N914*	75.	75.	4.	4.	A
1N916*	75.	75.	4.	2.	A

*Also available in micro package

1N914 AND 1N916 COMPUTER TYPE SILICON DIODES

Transitron now offers the industry superior reliability in diffused silicon computer diodes. Low capacitance and milli-microsecond switching are combined with low inverse currents, high breakdown voltages and good forward switching characteristics. A double plug package insures added strength and strain relief at both ends.

The 1N914 and 1N916 will find applications wherever fast switching and high reliability diodes are required.

For Complete Information on Transitron's Computer Type Silicon Diodes, check 156 Reader Service Card, or write for Bulletin TE-1350G

MICRO ZENER DIODES (SPECIFICATIONS AT 25 C)

Type	Nominal* Voltage (volts)	Test Current (mA)	Maximum Dynamic Resistance (ohms)	Maximum Inverse Current @ $E_b = -1$ Volt (μA)	Typical Forward Voltage @ 5.0 mA (volts)	Package
TMD-01	5.1	5	15	1.0	0.75	B
TMD-02	5.6	5	15	1.0	0.75	B
TMD-03	6.2	5	15	1.0	0.75	B
TMD-04	6.8	5	15	1.0	0.75	B
TMD-05	7.5	5	15	0.1	0.75	B
TMD-06	8.2	5	15	0.1	0.75	B
TMD-07	9.1	5	15	0.1	0.75	B
TMD-08	10.0	5	15	0.1	0.75	B
TMD-09	11.0	5	20	0.1	0.75	B
TMD-10	12.0	5	20	0.1	0.75	B

*Voltage Tolerance ±10%. For ±5% Voltage Tolerance use "A" suffix (i.e. TMD-01A).

FAST SWITCHING

Type	Maximum Inverse Operating Voltage (volts)	Maximum Average Forward Current @ 25°C (mA)	Maximum Recovery Time (μsec)	Package
TMD24	50.	50.	0.3	B
TMD25	100.	50.	0.3	B
TMD27	200.	50.	0.3	B

VERY FAST SWITCHING

TMD50	60.	20.	.004	B
NEW! COMPUTER TYPE DIODES AVAILABLE IN MICRO PACKAGE				
TMD54 (1N914)	75.	75.	.004	B
TMD56 (1N916)	75.	75.	.004	B

HIGH CONDUCTANCE TYPES

Type	Maximum Inverse Operating Voltage (volts)	Maximum Average Forward Current @ 25°C (mA)	Maximum Inverse Current @ 25°C (μA @ volts)	Package
TMD-41	50.	75.	0.25 @ 50	B
TMD-42	100.	75.	0.25 @ 100	B
TMD-45	200.	75.	0.25 @ 200	B

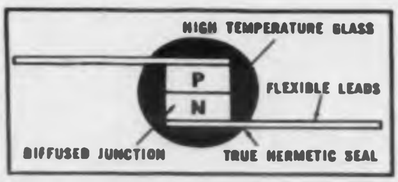
MICRO-STABISTORS

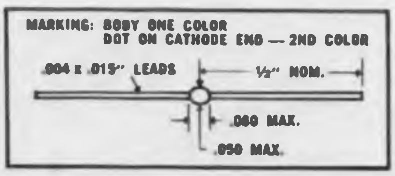
Type	Forward Voltage @ 1 mA DC (volts)	Maximum Forward Voltage @ 20 mA DC (volts)	Maximum Dynamic Resistance @ 1 mA @ 1 KC (ohms)	Maximum Inverse Current @ −2 volts DC (μA)	Package
TMD20	0.64 ± 10%	0.85	60	0.5	B
TMD40	0.55 ± 10%	0.85	60	0.5	B

SILICON MICRO DIODES WITH A TRUE HERMETIC SEAL!

With the introduction of all-glass packaging, Transitron now has been able to achieve TRUE hermetic sealing for its entire line of silicon microdiodes! . . . All units are completely compatible with present circuitry . . . All provide the same excellent performance as larger Transitron devices in ⅓th to ⅟₂₀th the space. Glass is melted **around** the silicon body that forms the working part of the device. Absolute hermetic sealing makes this the most reliable and efficient micro-regulator ever developed — ideal for voltage regulating and reference service wherever space and weight economies are required.

For Complete Information on these Transitron Micro Zener Diodes, check 157 Reader Service Card





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PNP 2N1131
2N1132
NPN 2N696
2N697
2N698
2N699
2N1252
2N1253
2N706
2N1420

Type	Maximum Collector Voltage V_{cb} (volts)
2N1131	40
2N1132	40
2N696	60
2N697	60
2N698	100
2N699	100
2N1252	30
2N1253	30
2N706	25
2N1420	60

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N1131 (multi-purpose medium power)
N1132 Write for Bulletin TE-1354-1131

2N696 (multi-purpose medium power)
2N697 Write for Bulletin TE-1354-696

2N698 (high voltage medium power)
2N699 Write for Bulletin TE-1354-698

N1252 (low storage time medium power)
N1253 Write for Bulletin TE-1354-1252

2N706 (high speed logic transistor, small signal)
Write for Bulletin TE-1353-706

N1420 (multi purpose medium power)
Write for Bulletin TE-1354-1420

SILICON TRANSISTORS

Maximum Collector Voltage V_{cb} (volts)	Minimum DC Common Emitter Current Gain, β	Typical Collector Saturation Voltage (volts @ mA)	Typical Cut-off Frequency (Mc)	Maximum Power Dissipation @ 100 C Case (watts)
40	15 @ 150mA	1.0 @ 150	50	1
40.	30. @ 150mA	1.0 @ 150	60.	1
60.	20. @ 150mA	0.8 @ 150	80	1
60.	40 @ 150mA	0.8 @ 150	100	1
100	20. @ 150mA	3. @ 150	80	1
100	40 @ 150mA	3. @ 150	100.	1
30	15. @ 150mA	0.8 @ 150	90.	1.
30	30 @ 150mA	0.8 @ 150.	110.	1
25	20. @ 10mA	0.3 @ 10	400	0.5
60	100. @ 150mA	0.7 @ 150.	100.	1.

ete Information on these Transitron Silicon Transistors check r Service Card, or write for Bulletins indicated.

MAN TYPES — As a result of the Minuteman in High-Reliability Programs, many significant ments have been effected in Transitron's various ductor lines. Among the families evaluated and d: Low Noise Type Silicon Transistors, Medium NPN Silicon Transistors, 7/16" Hex Base Inter- Power and High Power Silicon Transistors. ypes are now available in quantity from your on Distributor.

LIBRARY OF APPLICATIONS INFORMATION

Transitron now has available additional literature covering circuit design, operation, and application of various semiconductor types: —

- **THE BIASING of Silicon Controlled Rectifiers and Switches (AN-1356B-7B)**
- **THE TUNNEL DIODE CIRCUIT DESIGN HANDBOOK (AN-1359A)**
- **THE SILICON CONTROLLED RECTIFIER — Theory of Operation • Application Notes • Circuits (AN-1356A)**
- **THE BINISTOR — Circuit Design Information and Application Notes (AN-1360A)**
- **THE TRANSWITCH — Circuit Design Information and Application Notes (AN-1357A)**

PLUS
"25 Tips on How to Buy Semiconductors"
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Write directly to Transitron Electronic Corporation, Wakefield, Mass. for your copies. Or contact your nearest Transitron Industrial Distributor shown on the other side of this foldout.

APPLICATION ASSISTANCE

If you would like application assistance on immediate projects in the selection of

- **MICRO-COMPONENTS**
- **CONTROLLED RECTIFIERS**
- **SILICON TRANSISTORS**
- **SILICON DIODES**
- **OTHER TRANSITRON TYPES**

contact your nearest Transitron Field Office, or write directly to Transitron Electronic Corporation outlining your requirements.

WANT MORE INFORMATION?

If you would like to have more complete information on any of the new Transitron semiconductor types shown on these pages, please circle the appropriate Reader Service Number(s) on the Electronic Design Reader Service Card.

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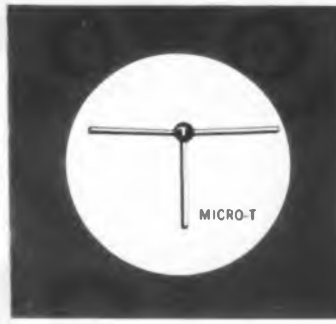

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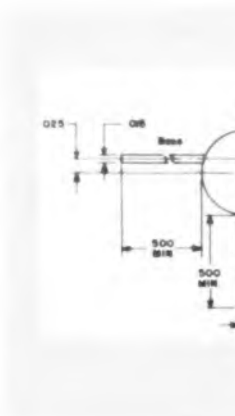
Bulletins PB-78, PB-79.



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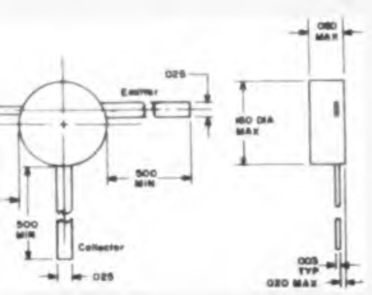


MICRO-TRANSISTORS

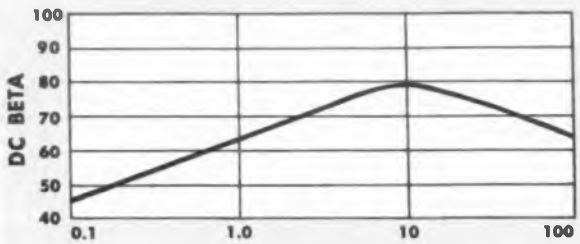
AMPLIFIER TYPES

Type	Maximum Collector Voltage (Volts)	Minimum AC Beta (h_{fe})	Typical Gain-Bandwidth Product (Mc)	Maximum Collector Leakage Current at 25°C (μA)	Maximum Power Dissipation at 25°C Ambient (mW)
TMT 839	45	20	45	1	150
TMT 840	45	40	45	1	150
TMT 841	45	80	65	1	150

SWITCHING TYPES

Type	Maximum Collector Voltage (Volts)	Minimum DC Beta (h_{FE})	Typical Gain-Bandwidth Product (Mc)	Maximum Saturation Resistance (Ohms)	Maximum Power Dissipation at 25°C Ambient (mW)
TMT 842	45	20	45	120	150
TMT 843	45	45	65	120	150

TYPICAL DC BETA VS. COLLECTOR CURRENT FOR THE TMT841



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Updated Transistor List Contains Many Improved Types

Over 600 new types are included in this year's Transistor Data Chart. A high percentage of last year's types are upgraded in electrical characteristics such as power dissipation and cut-off frequency. Improvements in transistor fabrication techniques have resulted in the availability of high-power, high-frequency devices plus fast-switching epitaxial transistors.

The increasing quantity of types, of course, presents a growing problem to the design engineer in search of a particular one. Less than two dozen former types were abandoned. The addition of types bearing new JEDEC numbers, with marginal improvements (if any) over existing types, adds to the selection problem.

ELECTRONIC DESIGN's organization of its Transistor Data Chart into basic types and its listing of types by the increasing value of a key characteristic make selection as straight-forward as possible.

If you would like a free reprint of this section, turn to the Reader-Service Card and circle 251.

July 19—Case for Switching Speed

Due to space limitations, we were forced to postpone publication of a provocative argument posed by Charles Askanas, Engineering Project Manager at Lumatron Electronics. Titled "Optimum Test Limit for Transistor Switching-Circuit Measurements," the article offers a justification for the use of 20 and 80 per cent test points rather than 10 and 90 per cent points, presently used to characterize switching devices. Be sure to read the analysis in the July 19 issue; your comments on the validity of the argument are invited.

Latest Listings of Military Approved Transistors

To encourage the use of improved transistor types in the design of new military equipment, MIL-STD-701A has been updated, with Department of Defense approval, by MIL-STD-701B. New types have been added, some older types have been dropped and several "guidance" types have been upped to the "preferred" category. MIL-STD-701B types are grouped in a convenient application chart shown in Table 1. A list of the DOD, as well as single-service types with specification numbers and issue dates is in Table 2.

Table 1

			Germanium PNP	Germanium NPN	Silicon PNP	Silicon NPN
Low power	Audio (<300 mw)	Preferred	2N526	......	......	2N335
		Guidance	2N652A 2N467 2N220	......	2N1026A	......
	Medium frequency (3 to 30 mc)	Preferred	......	......	......	2N338
		Guidance	2N1309	2N1308	2N1118	......
	High frequency (>30 mc)	Preferred	......	......	......	......
		Guidance	2N384 2N700A 2N1142	......	......	3N35 2N1613
Switching	Low speed (>5 μsec total time)	Preferred	......	......	2N329A	......
		Guidance	2N398	......	......	......
	Medium speed (1 to 5 μsec)	Preferred	2N404 2N428 2N396A	2N358A 2N388	......	......
		Guidance	2N599	2N1310	2N491 2N1119	2N337
	Fast speed (<1 μsec)	Preferred	2N705	......	......	2N697 2N706
		Guidance	2N559 2N1500 2N695 2N1195	......	2N1132	2N560 2N1893
	Bilateral switch (medium speed)	Preferred	......	......	......	......
		Guidance	......	......	......	......
Power	300 mw to 3 w	Preferred	......	......	......	......
		Guidance	2N1039 2N1041	......	2N1234	2N341
	3 to 30 w	Preferred	2N539	......	......	2N498 2N657
		Guidance	2N1184B	2N326	......	2N1485
	>30 w	Preferred	2N297A 2N1358	......	......	......
		Guidance	2N1120 2N1165 2N1046	......	......	2N389 2N424 2N1050 2N1016B

Table 2

Type	Specification	Date
2N43A	MIL-T-19500/18(USAF)	Amend 2. 10 November 1958
2N44A	MIL-T-19500/6(USAF)	Amend 1. 10 April 1958
2N78A	MIL-S-19500/90(USAF)	23 May 1960
2N117	MIL-T-19500/35(NAVY)	15 March 1958
2N118	MIL-T-19500/35(NAVY)	15 March 1958
2N119	MIL-T-19500/35(NAVY)	15 March 1958
2N118	MIL-T-19500/2(JAN)	12 December 1957
2N123	MIL-T-19500/30(USAF)	4 February 1959
2N128	MIL-T-19500/9A(JAN)	12 June 1959
2N129	MIL-T-19500/8(SigC)	21 July 1958
2N144	MIL-T-19500/29(USAF)	Dropped
2N158	MIL-S-19500/24A(JAN)	27 November 1959
2N167A	MIL-S-19500/11A(USAF)	23 May 1960
2N173	MIL-T-19500/12(NAVY)	Dropped
2N174	MIL-T-19500/13A(JAN)	8 January 1958
2N200	MIL-T-19500/5	Dropped
2N220	MIL-T-19500/1	14 June 1957
2N240	MIL-S-19500/25A(JAN)	5 November 1959
2N243	MIL-T-19500/34(USAF)	Dropped
2N244	MIL-T-19500/34(USAF)	Dropped
2N245	MIL-T-19500/14(USAF)	Dropped
2N246	MIL-T-19500/15(USAF)	Dropped
2N274	MIL-T-19500/26(SigC)	3 October 1957
2N297A	MIL-T-19500/36A(SigC)	17 November 1958
2N299	MIL-T-19500/39(SigC)	Dropped
2N300	MIL-T-19500/55(SigC)	21 July 1958
2N325	MIL-S-19500/40(JAN)	29 February 1960
2N326	MIL-S-19500/40(JAN)	29 February 1960
2N328A	MIL-S-19500/110(SigC)	Amend 1. 13 May 1960
2N329A	MIL-S-19500/111(SigC)	Amend 1 13 May 1960
2N331	MIL-T-19500/4A	16 January 1958
2N332	MIL-T-19500/37A(NAVY)	18 June 1959
2N333	MIL-T-19500/37A(NAVY)	18 June 1959
2N334	MIL-T-19500/37A(NAVY)	18 June 1959
2N335	MIL-T-19500/37A(NAVY)	18 June 1959
2N337	MIL-S-19500/69C(NAVY)	14 October 1960
2N338	MIL-S-19500/69C(NAVY)	14 October 1960
2N342	MIL-S-19500/16B(JAN)	24 February 1960
2N343	MIL-S-19500/16B(JAN)	24 February 1960
2N358A	MIL-S-19500/63B(JAN)	23 May 1960
2N384	MIL-S-19500/27A(JAN)	20 January 1960
2N388	MIL-T-19500/65(NAVY)	20 March 1959
2N393	MIL-S-19500/77A(SigC)	30 October 1959
2N396A	MIL-S-19500/64A(NAVY)	27 October 1959
2N404	MIL-T-19500/20(USAF)	Amend 2 3 March 1959
2N416	MIL-T-19500/56A(SigC)	3 February 1959
2N417	MIL-T-19500/57A(SigC)	3 February 1959
2N422	MIL-T-19500/66A(NAVY)	26 June 1959
2N425	MIL-T-19500/41A(SigC)	26 January 1959
2N426	MIL-T-19500/42A(SigC)	26 January 1959
2N427	MIL-T-19500/43A(SigC)	26 January 1959
2N428	MIL-S-19500/44B(SigC)	
2N431	MIL-T-19500/21(USAF)	Amend 1 10 April 1958
2N432	MIL-T-19500/22(USAF)	Amend 1 10 April 1958
2N433	MIL-T-19500/23(USAF)	Amend 1 10 April 1958
2N461	MIL-T-19500/45(USAF)	7 July 1958
2N463	MIL-T-19500/70(NAVY)	14 May 1959
2N464	MIL-T-19500/49B(SigC)	3 February 1959
2N465	MIL-T-19500/50A(SigC)	3 February 1959
2N466	MIL-S-19500/51B(SigC)	17 August 1960
2N467	MIL-T-19500/52B(SigC)	3 February 1959
2N489	MIL-T-19500/75(USAF)	1 July 1959
2N490	MIL-T-19500/75(USAF)	1 July 1959
2N491	MIL-T-19500/75(USAF)	1 July 1959
2N492	MIL-T-19500/75(USAF)	1 July 1959
2N493	MIL-T-19500/75(USAF)	1 July 1959
2N494	MIL-T-19500/75(USAF)	1 July 1959
2N495	MIL-T-19500/54A(SigC)	13 August 1959
2N496	MIL-S-19500/85(SigC)	Amend 1 22 March 1960
2N497	MIL-T-19500/74(NAVY)	30 June 1959
2N498		
2N499	MIL-T-19500/72A(SigC)	4 January 1960
2N501A	MIL-T-19500/62(SigC)	5 December 1958
2N502A	MIL-S-19500/112(SigC)	4 April 1960
2N526	MIL-S-19500/60C(JAN)	29 July 1960
2N537	MIL-S-19500/100(SigC)	30 November 1959
2N539	MIL-T-19500/38(NAVY)	28 May 1958
2N545	MIL-S-19500/84(NAVY)	24 February 1960
2N559	MIL-S-19500/152(SigC)	7 December 1960
2N560	MIL-S-19500/73A(JAN)	29 July 1960
2N574	MIL-T-19500/46(SigC)	22 May 1960

Type	Specification	Date
2N575	MIL-T-19500/47(SigC)	22 May 1960
2N599	MIL-S-19500/66(NAVY)	25 January 1961
2N624	MIL-T-19500/82(SigC)	10 August 1959
2N656	MIL-T-19500/74(NAVY)	30 June 1959
2N657	MIL-T-19500/74(NAVY)	30 June 1959
2N665	MIL-S-19500/58B(JAN)	12 July 1960
2N681	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N682	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N683	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N684	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N685	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N686	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N687	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N688	MIL-S-19500/108(NAVY) Controlled Rectifiers	22 March 1960
2N694	MIL-S-19500/160(SigC)	9 December 1960
2N695	MIL-S-19500/135(NAVY)	17 October 1960
2N696	MIL-S-19500/99A(SigC)	1 April 1960
2N697	MIL-S-19500/99A(SigC)	1 April 1960
2N700A	MIL-S-19500/123(SigC)	1 July 1960
2N702	MIL-S-19500/153(SigC)	7 December 1960
2N703	MIL-S-19500/153(SigC)	7 December 1960
2N705	MIL-S-19500/86(NAVY)	6 June 1960
2N706	MIL-S-19500/120(SigC)	2 June 1960
2N716	MIL-S-19500/154(SigC)	7 December 1960
2N1000	MIL-T-19500/79(SigC)	22 June 1959
2N1001	MIL-S-19500/81(SigC)	17 June 1959
2N1002	MIL-S-19500/83(SigC)	10 August 1959
2N1011	MIL-T-19500/67(SigC)	22 January 1959
2N1025	MIL-S-19500/78A(SigC)	7 December 1959
2N1026	MIL-S-19500/78A(SigC)	7 December 1959
2N1026A	MIL-S-19500/78A(SigC)	7 December 1959
2N1039	MIL-S-19500/89(NAVY)	21 July 1960
2N1041	MIL-S-19500/89(NAVY)	21 July 1960
2N1042	MIL-S-19500/137(SigC)	8 September 1960
2N1043	MIL-S-19500/137(SigC)	8 September 1960
2N1044	MIL-S-19500/137(SigC)	8 September 1960
2N1045	MIL-S-19500/137(SigC)	8 September 1960
2N1046	MIL-S-19500/88(NAVY)	21 July 1960
2N1072	MIL-S-19500/163(SigC)	5 January 1961
2N1082	MIL-S-19500/103(SigC)	18 December 1959
2N1094	MIL-S-19500/161(SigC)	9 December 1960
2N1118	MIL-S-19500/138(SigC)	9 September 1960
2N1119	MIL-S-19500/139(SigC)	9 September 1960
2N1120	MIL-T-19500/68(SigC)	10 February 1960
2N1142	MIL-S-19500/87(NAVY)	15 August 1960
2N1158A	MIL-S-19500/113(SigC)	4 April 1960
2N1183	MIL-S-19500/143(SigC)	10 October 1950
2N1183A	MIL-S-19500/143(SigC)	10 October 1950
2N1183B	MIL-S-19500/143(SigC)	10 October 1950
2N1184	MIL-S-19500/143(SigC)	10 October 1950
2N1184A	MIL-S-19500/143(SigC)	10 October 1950
2N1184B	MIL-S-19500/143(SigC)	10 October 1950
2N1195	MIL-S-19500/71B(JAN)	29 July 1960
2N1196	MIL-S-19500/164(SigC)	6 January 1961
2N1197	MIL-S-19500/165(SigC)	6 January 1961
2N1199A	MIL-S-19500/131(SigC)	25 July 1960
2N1200	MIL-S-19500/105(SigC)	28 December 1959
2N1201	MIL-S-19500/101(SigC)	30 November 1960
2N1302	MIL-S-19500/126(NAVY)	14 October 1960
2N1303	MIL-S-19500/126(NAVY)	14 October 1960
2N1304	MIL-S-19500/126(NAVY)	14 October 1960
2N1305	MIL-S-19500/126(NAVY)	14 October 1960
2N1306	MIL-S-19500/126(NAVY)	14 October 1960
2N1307	MIL-S-19500/126(NAVY)	14 October 1960
2N1308	MIL-S-19500/126(NAVY)	14 October 1960
2N1309	MIL-S-19500/126(NAVY)	14 October 1960
2N1310	MIL-S-19500/136(NAVY)	6 December 1960
2N1358	MIL-S-19500/122(SigC)	20 June 1960
2N1411	MIL-S-19500/133(SigC)	3 August 1960
2N1412	MIL-S-19500/76(NAVY)	4 February 1960
2N1500	MIL-S-19500/125(SigC)	11 July 1960
3N35	MIL-S-19500/80A(SigC)	30 October 1959


A BASIC GUIDE TO
PRECISION POTENTIOMETERS
RAYTRON
PRECISION
POTENTIOMETERS
INSTRUMENTS FOR INDUSTRY, INC.

Transient Control Device Protects Rectifiers From Surge Overloads

HIGH-VOLTAGE transients, appearing across power supplies when an inductive load is suddenly turned off, can be effectively reduced by a newly developed gas-tube device. Conventional means to avoid rectifier burnout include the use of relatively expensive, high piv diodes or Zener devices.

Low Cost Diodes Can Be Used With Transient Protector

Low cost, 200-v piv rectifiers can be used with transient control, developed by Ledex, Inc., Dayton, Ohio. Transient peaks as high as 1,400 v have been applied to rectifier and bridge arrangements using the transient control with no rectifier failures resulting. See Fig. 1. The heart of the device consists of a gas tube which ionizes at a critical voltage (200 v in present units) thus creating a low-impedance shunt for excessively large pulses. For most power-supply applications, the 200-v ionization potential is adequate; higher voltage ratings and low-

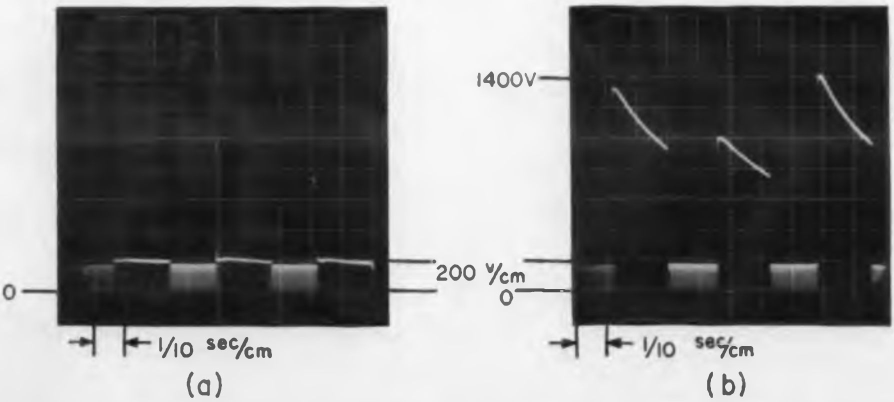


Fig. 1. Oscilloscope trace across inductive load at output of a bridge rectifier. In (a) is shown a 1,400-v pulse (200-v/division) appearing across the dc output while (b) shows the clipping action achieved by addition of the transient control.

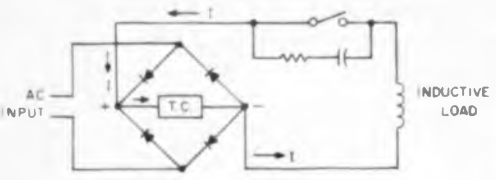


Fig. 2. Basic rectifier bridge circuit showing current flow resulting from suddenly opening the inductive load circuit.

er voltage ratings can be supplied on a custom basis if required.

Device Protects Against Line As Well As Load Surges

In the full-wave bridge circuit shown in Fig. 2, current *I* would flow as indicated from an inductive load when the switch is opened. Without the transient control, a high-voltage pulse would appear across the four diodes and breakdown is possible; should one diode become shorted, the diode on the adjacent leg of the bridge would be destroyed in a short time.

Should a transient occur at the ac input, the transient control permits current flow through the low impedance or conducting diodes rather than through the high-impedance bridge arms. Thus, positive or negative spikes are clipped at the 200-v level.

In addition to the transient control, Ledex is packaging a protected bridge rectifier, incorporating four rectifiers plus a built-in control rated as follows: 115 v ac input, 100 v dc output, maximum surge 50 amp for 8 msec.

Transient controls, part A-46800-001 are packed 10 to a carton; prices per carton are $20.50 for one carton, $18.50 ea for 2-9 cartons and $16.00 ea for 10-49 cartons. The protected bridge rectifier, part A-46501-001, is $8.15 ea in 1-9 quantities, $7.40 ea in 10-24 lots and $6.80 ea in 25-99 quantities. A value analysis kit RTC, containing one protected bridge rectifier and one transient control, is available at $11.00 ea.

For further information on these devices, turn to the Reader-Service Card and circle 252.

Only

"KEMET"

has the widest choice of High-Voltage

SOLID TANTALUM CAPACITORS

...at LOW Microfarad Values!

J-SERIES

(Polar Type)

.0047 to 330
MICROFARADS

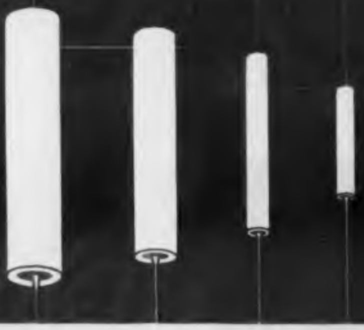
Temperature Range:
– 55 to +125° C

N-SERIES

(Non-Polar Type)

.0024 to 160
MICROFARADS

Temperature Range:
– 55 to +105° C



J-Series meets or exceeds MIL-C-26655A

KEMET offers you the only full line of high-voltage solid tantalum capacitors for a multitude of military/industrial applications. J-Series and N-Series are available in working voltages of 75, 60, 50, 35, 20, 15, 10, and 6—in standard E.I.A. values with ±5%, ±10%, and ±20% tolerances. Low leakage characteristics are excellent. Four J-Series case sizes conform to MIL-C-26655A—with or without insulating sleeve. Leads are solderable and weldable. All KEMET types have passed approved environmental tests. Whatever your solid tantalum capacitor needs, meet them with KEMET's complete line! Kemet Company, Division of Union Carbide Corporation, 11901 Madison Avenue, Cleveland 1, Ohio.

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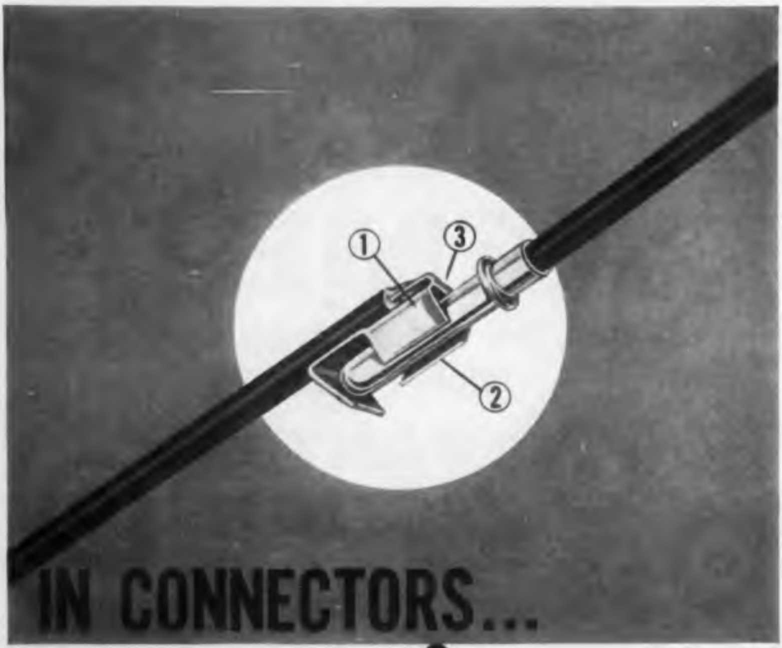
KEMET COMPANY UNION CARBIDE

CIRCLE 73 ON READER-SERVICE CARD



IN CONNECTORS...

it's the CONTACT that counts!

3 positive contact surfaces on each Alden top-connected contact give you:

- More reliable electrical contact
- More secure mechanical grip
- Minimum electrical resistance

Each lead has individual strain relief because wire is doubled back through contact tab. Punch press contact design permits rapid heat transfer — eliminates unreliable cold solder joints as in screw machine contacts. Danger of insulation pull back is eliminated by bringing wire insulation right into molded clip pocket.

These unique Alden molding techniques in connector design drastically reduce the number of parts required and make possible multi-contact connectors of amazing basic simplicity and reliability.

Resilient Alden contacts can be included in any type of molded insulation for any combination of contacts. Hundreds of standard off-the-shelf designs are quickly available — with or without leads — or as part of unit-molded cables.

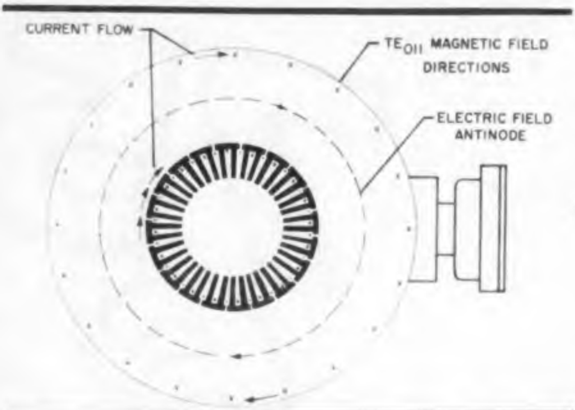
Our Customer Department will work closely with you on any connecting or cabling problems. A letter with description or sketch will enable us to provide recommendations or samples at once.

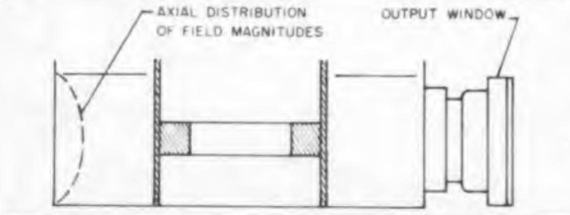
New, flameproof, high voltage connectors now available in high-density, flame-retardant polyethylene. Light, compact connectors for applications up to 30 KVDC and up to 250° F without distortion.

First major advance in connector reliability since potting offers fool-proof, tamper-proof connections for trouble-free operation. Alden "IMI" connectors and cables (wires, contacts, or other inserts) are integrally molded in a single hot shot of insulation so that material forming the connectors and covering the wires forms a single continuous, bonded insulation.

Standard assembled connectors in non-interchangeable layouts with from 2 to 11 contacts; miniature connectors, plain or shielded, for carrying power or signal; miniature plugs and sockets; signal connectors; and CRT connectors are all available for fast delivery.

ALDEN
PRODUCTS COMPANY
7139 North Main St., Brockton, Mass.
CIRCLE 74 ON READER-SERVICE CARD





Coaxial Cavity Increases Magnetron Frequency Stability

THE USE of the coaxial cavity principle in magnetron design results in 5 to 10 times better frequency stability. Model SFD-303 magnetron, designed for X-band use, operates at 50 per cent efficiency, delivers minimum peak power of 1 megawatt and an average power of 1 kw. Its light weight of 45 lb makes it ideal for long-range airborne radar systems. Greater frequency stabilization makes steady state operation possible at the optimum impedance point.

The SFD-303 coaxial magnetron, manufactured by SFD Laboratories, 800 Rahway Ave., Union, N. J., employs a new concept in anode design which results in the significant improvements in frequency stability. Typically, side-lobe ratios are greater than 10 db, missing pulses less than 0.2 per cent and pulling factor is less than 6 mc at the megawatt level. At 2-μsec pulse lengths, the rf band-width is less than 0.7 mc.

The principle on which the model 303 is based allows for high-frequency magnetrons to be built with large interaction areas so that the power dissipated per unit area of the anode and cathode is very low. Normally, when such large interaction areas are used, serious problems of mode control exist. Control of the mode in which oscillations begin is lost as the voltage pulse rises on the magnetron.

The approach which has here-to-fore been taken to the problem of mode control consists in designing the multi-cavity anode circuit to produce a relatively large frequency separation between the desired, or pi-mode, and its adjacent neighbors. Both strapped and rising-sun structures are based upon this philosophy. These techniques insure mode stability once the proper mode has been established, but do not insure its build-up in the presence of competing modes whose starting voltages fall in the same general range. To overcome the ease of starting such an unloaded mode the practice has been to introduce some asymmetry into the anode block to orient both components of the doublet equally to the output slot.

In the coaxial structure, the design insures correctly phased rf currents at the normally short-circuited ends of the resonators.

The figure shown illustrates the main features of the anode. Alternate resonators are cut through to the coaxial cavity which is dimensioned to resonate in the circular electric (TE_{011}) mode. The circumferential currents associated with this mode have the same phase at all points around the periphery of the cylinders. Since the resonators present a low impedance at their back ends, they are well matched to the impedance of the coaxial cavity as seen from the inner cylinder wall cut through positions.

Operation of the large cavity in the TE_{011} mode insures currents and voltages of the same phase in alternate resonators. Mutual flux linkage between adjacent resonators is relied upon to excite the other half of the resonators with equal, but oppositely phased, currents giving rise to a pure pi-mode.

The higher Q_o achieved by removing the straps in the resonator assembly yields higher efficiency in addition to greater frequency stability. It also raises the impedance of the anode so that less stored energy, accompanied by reduced power loss, is required to produce the same electric field in the interaction space.

In a conventional magnetron the anode surface can be increased only by increasing the anode height. This results in a long magnet with large magnet weight. With the new design the anode surface can be increased by increasing the number of resonators rather than increasing their height. This allows an extra degree of design freedom which results in weight reduction.

Model SFD-303 is available 120 days after receipt of order, with price dependent on quantity and delivery date.

For further information on this magnetron turn to the Reader-Service Card and Circle 253.

NEW PRODUCTS

Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader-Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.

Line Voltage Regulator Provides 100-Db Isolation — 255

Solid state ac line regulator series 700 provides 0.1% regulation and 100-db line isolation. Harmonic attenuation and transient rejection are 40 db. Input harmonics of 10% max are reduced to less than 0.25% in the output. Power rating is 1 kva. Response time is 100 μsec. Bench and rack models are made for use at 50, 60, and 400 cps. Both 115 and 230 v units are available.

Stevens-Evans, Inc., Dept. ED, 3801 Hicock St., San Diego, Calif.

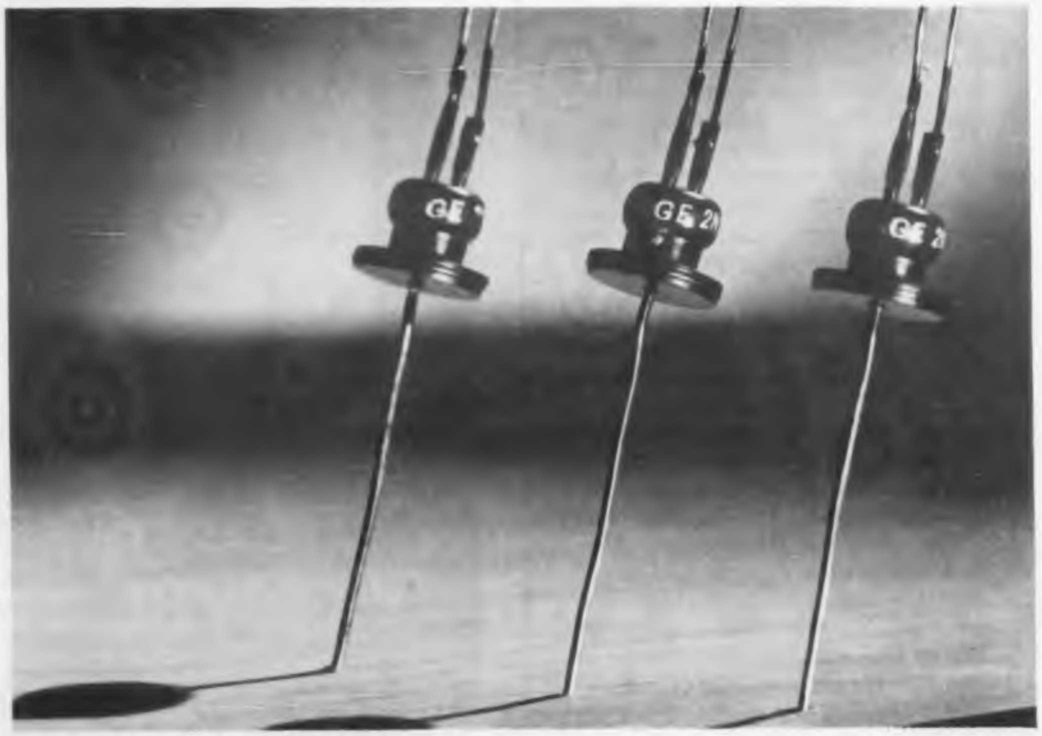
***P&A:** $1,200 to $1,500; 45 to 60 days.*

System Records 1,200 Bits Per In. — 256

High-density recording system PHD-1200 can reliably read and write digital tapes at 1,200 bits per in., 100 ips. Transient error rates are fewer than one bit in 10^8 and permanent error rates are less than one bit in 10^{10}. More than 20,000 passes of the same tape can be made without losing information or increasing transient dropout rate. System includes a digital magnetic tape transport, a dual read/write head assembly, read/write amplifiers, de-skewing buffer, manual control unit, and power supplies, cabled and mounted in a rack cabinet.

Potter Instrument Co., Inc., Dept. ED, Sunnyside Blvd., Plainview, N. Y.

***P&A:** $29,500, evaluation sample; 4 months.*



Silicon Controlled Rectifiers In Studless Housing — 257

Housed in a double-ended, studless package, silicon controlled rectifiers 2N1929 through 2N1935, handle up to 1.1 amp without heat sinks. Piv ratings range from 25 to 300 v; operating temperature range is −65 to +125 C. Maximum leakage current ranges from 4.0 to 0.9 ma.

General Electric Co., Rectifier Components Dept., Dept. ED, W. Genesee St., Auburn, N. Y.

***P&A:** 2N1933, $10 OEM; stock.*

PNPN Device Has Alloyed Junction 258

The Dynaquad is a germanium, three-terminal, pnpn structure packaged in a standard TO-5 case. Alloyed junction design is used for economy and reliability. The device has a rise time of 0.1 μsec, and provides an output voltage swing of 35 v. Applications include driver, flip-flop, counter, shift register and other logic circuits. Types 2N1966 through 2N1968 are in production.

Tung-Sol Electric Inc., Dept. ED, 1 Sumner Ave., Newark 4, N. J.

***P&A:** From $3.10; immediate.*

Voltage-Controlled Subcarrier Oscillator 259

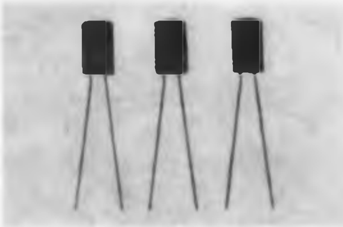
Transistorized subcarrier oscillator type 516/2, operating on IRIG channels 1 to 18 and A to E, measures 3/4 x 3/4 x 1-1/4 in. Input is 0 to 5 v or ±2.5 v. Input impedance is 300 K min, linearity ±0.5% of bandwidth. Output is 1 v rms nominal. Unit requires 28 v unregulated dc at 10 ma, and weighs 1.6 oz. Shock, acceleration and vibration tests are met.

Telemetering Corp. of America, Dept. ED, 8345 Hayvenhurst Ave., Sepulveda, Calif.

***P&A:** On request.*

NEW PRODUCTS

Carbon Film Resistor 670



Designed for printed circuits, carbon film resistor EC 25 is 1/4 in. in diameter by 13/32 in. long and mounts vertically. Rating is 1/4 w at 70 C derated to 0 at 150 C. Resistances range from 5 ohms to 500 K with a tolerance of 1%.

Mepco, Inc., Dept. ED, 37 Abbett Ave., Morristown, N. J.

Electron Beam Systems 673

Guns, controls, and power supplies are available in ratings from 3 kw at 10 kv to 9 kw at 30 kv. Systems of the LB-100 series are complete, and provide magnetic deflection of beam over 3 in. square area, pulsing, regulation, and variable focus and focal length. Temperatures above 6,200 are readily attained.

GVC Electron Heating Corp., Dept. ED, 81 Hicks Ave., Medford 55, Mass.

Instrument Switch 676

With up to six banks. Instrument switch type PW is available in 1-, 2-, 3- and 4-pole types and assemblies up to six banks. Maximum number of positions is 29 in one-pole versions, six in the four-pole version. Voltage rating is 250 v ac or dc, current rating 0.5 amp.

Interlab, Inc., Dept. ED, 116 Kraft Ave., Bronxville, N. Y.

***Price:** $6.96 to $41.72.*

Alternators 411

Semiconductor voltage regulation, holding the output to ±2% from 1,000 to 12,000 rpm, is provided by these alternators. Two types are offered: 15 v dc, 1,000 w; 100 v dc, 1,500 w. Construction features radially oriented ceramic magnets in the rotor.

Syncro Corp., Dept. ED, Oxford, Mich.

Transistor Testers 544

Automatic multi-parameter tester type 4 is one of a group of go no-go and absolute readout transistor testers. With automatic sorting and classification, it tests breakdown voltage, lower limiting voltage, dc pulse current gain, saturation voltage, and reverse current.

Fairchild Semiconductor Corp., Dept. ED, 545 Whisman Road, Mountain View, Calif.

***P&A:** $22,000; 90 to 120 days.*

Frequency Standard 551

Stable to 1 part in 10^{11} for one month, the Rubidium frequency standard is suitable for applications in the hf electromagnetic spectrum in communications, navigation and computational systems of aircraft and missiles. It weighs about 20 lb.

FMA, Inc., Dept. ED, 142 Nevada St., El Segundo, Calif.

Servo Motor 412

Designed for missile use, this 6-pole, 400-cps, size 15 servo motor offers the following characteristics: theoretical acceleration at stall, 22,700 radians per sec^2; minimum power output, 1.151 w; input power at stall, 6.1 w; motor dampening, 130 dyne-cm per sec.

Wright Machinery Co., Div. of Sperry Rand Corp., Dept. ED, Durham, N. C.

Balancing Computer 675

Cuts balancing time 80%. Used with a vibration analyzer, this computer determines location and amount of compensating weight to be added or removed. Used in single and two-plane balancing operations for both in-place or production balancing of rotating parts, the instrument saves up to 80% time.

International Research & Development Corp., Dept. ED, Worthington, Ohio.

Autotransformers 672

Handle 30 amp. Series W Variac autotransformers type W30, rated for 30 amp, provide continuous control of ac voltage from 0 v to 17% above line voltage. Available for 120- or 240-v, 50- to 60-cps operation, units withstand momentary overload of 1,000%. Type W30M is fully enclosed.

General Radio Co., Dept. ED, West Concord, Mass.

***Price:** W30, $75; W30M, $97.*

Gear Heads 688

Precision gear heads and speed reducers are available in size 5 to 18 servo mounts. Units have Class 2 gearing, with ABEC Class 1.5 bearings. End play and radial play are low; backlash is 30 min maximum. Housing is anodized aluminum alloy.

Elm Instrument Corp., Dept. ED, 30 Chasner St., Hempstead, L. I., N. Y.

Volt-Ohm Meters 448

Accuracy is 0.01% for voltage and resistance measurements or 0.2% for ac measurements to 1,000 v and for 10 ohms to 10 meg. Model 600 voltohmmeters are five-digit precision differential instruments with in-line display readout. Reference voltage is provided by Zener diode supply stable to 0.001% for a 10% line change.

Auto-Data, Dept. ED, 943 Turquoise, San Diego, Calif.

P&A: *$1,885 to $3,450; 30 to 45 days.*

Silicon Diodes 523

Diffused-junction silicon diodes in 53 types have high inverse voltages, high forward conductance, low leakage current, and high rectification efficiency. Operating from −65 to + 175 C, the medium current rectifiers are welded and hermetically sealed in a glass and metal case.

Raytheon Co., Semiconductor Div., Dept. ED, 215 First Ave., Needham, Mass.

P&A: *$0.43 to $3 ea, 100 to 999; immediate.*

Glass Diodes 458

Mesa diffused junction glass diodes 3G05 through 3G30 have rating ranging from 50 to 300 v. Forward conductance to 300 ma, voltage drop of 0.9 v at 25 C, and low leakage characteristics are other features. Temperature range is −55 to + 150 C.

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

P&A: *$1.07 to $2.80 ea, 1 to 99; stock.*

CIRCLE 77 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Storage Tube 591

Double-ended scan converter readout storage tube type K2070 provides resolution in excess of 1,000 lines at 50% modulation. Simultaneous or sequential reading and writing is possible; retention, erasure, and decay rate are controlled.

Electronic Tube Sales Dept., Allen B. Dumont Laboratories, Div. of Fairchild Camera and Instrument Corp., Dept. ED, 750 Bloomfield Ave., Clifton, N. J.

Multiplier-Modulator 583

Miniature analog multiplier-modulator model 100 provides 2% accuracy in case size of 1 x 1-1/2 x 3 in. Inputs are dc to 20 kc, ±1.5 v, output 100 to 20,000 cps, zero to 1.4 v rms. Distortion is less than 1%; response time as a modulator is less than 1 msec.

Transmagnetics Inc., Dept. ED, 40-66 Lawrence St., Flushing 54, N. Y.

Ratio Computer 586

Output is 1 ma or 10 mv suitable for driving pen writing or strip-chart recorders. Model 557-2B ratio computer accepts two independent dc signals as low as 10 mv. Accuracy of computed ratio is 1%. Uses include measurement of ratios from strain-gage type transducers, thermocouples, resistance bulbs.

Magnetic Instruments Co., Inc., Dept. ED, Thornwood, N. Y.

◀ CIRCLE 78 ON READER-SERVCE CARD

Variable Inductors 493

Encapsulated variable inductors, with single or bifilar windings, meet MIL-C-15305. Coils are tuned by a powdered iron core. Inductance variation is ±20% from nominal, with temperature coefficient of −50 to +100 ppm per deg C. Distributed capacity is 1.5 pf max.

Vanguard Electronics Co., Dept. ED, 3384 Motor Ave., Los Angeles 34, Calif.

Angle Repeater 497

Accurate within 6 min. Panel-mounted model PPR-20 displays the angular position of remote unit to within 6 min of arc. Range is 0 to 360 deg, slewing rate 180 deg per sec. Unit has solid-state construction and rapid response. Panel size is 1-3/4 in. OD by 1-1/2 in. long.

Theta Instrument Corp., Dept. ED, 520 Victor St., Saddle Brook, N. J.

P&A: *$1,500; 3 weeks.*

Vane-Axial Blower 575

Delivers 140 cfm of air against a static pressure of 5 in. of water at 25,000 ft. Sea level output is 77 cfm against 5 in. of water. No pressure-sensing or speed-regulating switches are needed in the system. Motor is wound for 200 v ac, 400 cps, three phase.

Globe Industries, Inc., Dept. ED, 1784 Stanley Ave., Dayton 4, Ohio.

CIRCLE 79 ON READER-SERVICE CARD ➤

Pressure Transducer 609

High-range absolute pressure transducer 737 meets government specs in miniature size. Ranges from 0 to 4,000 up to 0 to 10,000 psi are made, with resolution to 0.2%, resistances 1 K to 10 K ±5%.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Shaft Extensions 533

Available in 1/8, 3/16, and 1/4 in. shaft sizes, these precision shaft extensions have male and female ends in the same or any combination of these sizes. Length of extension is 1-5/8 in. Diameters are concentric to 0.0005 in.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., East Rockaway, L. I., N. Y.

P&A: *$45 to 75.00; from stock.*

Wide Band-Pass Filters 537

Types NB-1 and NB-1B are four-crystal networks contained in a hermetically sealed package less than 1 cu-in. and 2.5 cu-in. respectively. The center frequency of both types is 10.7 mc ±3 kc with a 6 db bandwidth of 200 kc + 10 kc, −0 kc and an ultimate rejection of 100 db min. Singly they provide a 60 to 6 db bandwidth ratio of 2.25 to 1.

Midland Manufacturing Co., Dept. ED, 3155 Fiberglas Road, Kansas City 15, Kan.

Availability: *From stock.*

Torque Motor 536

Providing 6 lb of linear force from a few watts of power, the firm's model 11 torque motor operates in high humidity and temperature. Unit can operate while immersed in fluids, resists shock to 67 g, and operates from −66 to +400 F. Device weighs 12 oz and meets MIL specs.

Midwestern Instruments, Inc., Dept. ED, P. O. Box 7509, Tulsa 18, Okla.

Potentiometer Tester 534

Plots results on X-Y recorder. This potentiometer tester, type 2398, supplies necessary signals to plot resistance vs shaft rotation on an X-Y recorder. It operates in two ranges, from 1 ohm to 1 meg and from 10 ohms to 10 meg, and provides 120 db resistance measurement capability.

F. L. Moseley Co., Dept. ED, 409 N. Fair Oaks Ave., Pasadena, Calif.

Ceramic Bases 539

For mounting components. Alumina ceramic bases are said to be extremely rugged, useful at temperatures as high as 1,000 C. Parts are custom fabricated. Complete subassemblies with metalized ceramic bases brazed into metal parts are available.

Metalizing Industries, Inc., Dept. ED, 338 Hudson St., Hackensack, N. J.

NEW PRODUCTS

Component Holders 540

Shock and vibration resistant. Shock tests in excess of 200 g resulted in no visible shifting of components. Peak acceleration at 500 cps vibration is 200 g; and at 2,000 cps, 90 g; 487 designs are available.

Masterite Industries, Dept. ED, 851 W. Olive St., Inglewood, Calif.

Availability: *from stock.*

Curve Follower 590

Function generator converts manual set-point control to automatic program control. The Data-Trak curve follower can drive ganged pots to provide up to 12 control signals. Dust-tight case is 19 in. wide.

Research, Inc., Dept. ED, Box 6164, Minneapolis 24, Minn.

Proportional Solenoid 535

Occupying less than 1-1/2 cu in., and weighing less than 4-1/2 oz, this proportional solenoid, model 15, provides relatively small, high-force displacements proportional to input signals. Unit operates in temperatures to 400 F, is submersible in fluid or gas, and can be mounted to provide force in any direction.

Midwestern Instruments, Inc., Dept. ED, P. O. Box 7509, Tulsa 18, Okla.

Oscilloscope 584

Sensitivity is 50 μv per cm; low noise level permits resolution of signals down to 10 μv. Model 403-B commercial oscilloscope permits display of nonamplified outputs from strain gages, pressure pickups, accelerometers and other transducers. Its 21 sweeps range from 1 μsec to 5 sec per cm.

Allen B. Du Mont Laboratories, Dept. ED, 750 Bloomfield Ave., Clifton, N. J.

Current Recorder 704

Five-ampere current recorder has better than 2% over-all accuracy, and a frequency response of 25 to 500 cps. Safe working voltage is 750 v rms, input resistance is 0.02 ohm. At standard chart speed of 1 in. per hr, paper supply lasts 31 days.

Rustrak Instrument Co., Dept. ED, 130 Silver St., Manchester, N. H.

Price: *$105.*

Volt-Ohm-Milliammeter 585

Models 267 and 268 are designed for general laboratory work and production line testing. Sensitivity is 5,000 ohms per volt for both models. Microampere ranges are 0 to 50 for model 267 and 0 to 60 for model 268.

Simpson Electric Co., Dept. ED, 5200 W. Kinzie St., Chicago 44, Ill.

Availability: *Immediate from distributors.*

NEW PRODUCTS

Time-Delay Relay 592

Solid-state time-delay relay SI-01-TD, weighing less than 3 oz, has no moving parts. Supply voltage is 18 to 30 v dc; delay is 30 ±6 sec. Equivalent contact rating is 40 v, 10 ma. Operating temperature range is −55 to +125 C.

Espey Manufacturing & Electronics Corp., Saratoga Industries Div., Dept. ED, Saratoga Springs, N. Y.

Oven Assembly 547

Three-vacuum oven assembly model 8435 is for bake-out of semiconductors and other devices at 200 or 300 C. A single pump evaluates to 1 x 10^{-3} mm Hg. Control is sensitive to within ±1/2 C. Each oven has individual controls. Work chamber is 18 x 18 x 18 in.

Electric Hotpack Co., Inc., Dept. ED, Cottman Ave. at Melrose St., Philadelphia 35, Pa.

Navigation Gyro 548

For missile applications and other high performance uses, type C70 2527-001 floated-rate integrating gyro has an angular momentum of inertia of 500,000 gm-cm^2 per sec. Vertical drift is 0.003 and aximuth drift is 0.015 deg per hr, short term.

General Precision, Inc., Kearfott Div., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

Pulse Counter 543

Differential pulse counter F 160 has separate coils for addition and subtraction. Simultaneous add and subtract commands are accepted without error. Count rate is 25 per sec max. Front plate size of the five-digit counter is 2 x 3-3/4 in.

Presin Co., Inc., Dept. ED, 2014 Broadway, Santa Monica, Calif.

***P&A:** $62.50; stock.*

Potentiometer Transducer 587

Miniature, low-pressure transducer, model L-96, has less than 1% error at vibration levels exceeding 35 g. Available in 0 to 10 to 0 to 350 psi absolute or gage pressure ranges. Performance is said to be unaffected by temperature variations. The unit weighs 4 oz and measures 1 in. in diameter and 2 in. long.

Servonic Instruments, Inc., Dept. ED, 1644 Whittier Ave., Costa Mesa, Calif.

Medium-Power Relay 550

Rated at 15 amp, the GF series relay is for motor loads of up to 1/2 hp and can be used in a wide range of ac and dc applications. Contacts are spst to 4pdt. Standard relays with 1/4-in. diameter silver contacts are rated at 15 amp at 115 v ac or 28 v dc.

American Machine & Foundry Co., Potter & Brumfield Div., Dept. ED, Princeton, Ind.

***P&A:** $3.40 to $7.10; from stock.*

Integrating Gyro 549

Floated-rate integrating gyro type C70 2516 010 is suitable for missiles. Angular momentum is 100,000 gm-cm² per sec; short term vertical drift is 0.02 deg per hr; short term azimuth drift is 0.03 deg per hr; mass unbalance shift is 0.5 deg per hr.

General Precision, Inc., Kearfott Div., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

Drive Regulators 588

Variable-speed drive regulators and exciters use silicon controlled rectifiers and diodes to provide 0.1% regulation at base speed, with response times up to twice that of tube-type regulators. Drives range from 1 to 350 hp.

Reliance Electric & Engineering Co., Dept. ED, 24701 Euclid Ave., Cleveland 17, Ohio.

NEW PRODUCTS

Booster Amplifier 541

This dual-channel booster amplifier is able to drive both stators of a precision size 11, 400-cps resolver. Known as model 1012, the device has unity gain, an accuracy of 0.05%, and less than 5 min phase shift. The unit occupies 1 cu in., weighs 1 oz, and operates from −55 to +125 C. Different mounting configurations are available.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.

***P&A:** $250-280 each; 30 days.*

Germanium Transistor 545

For critical computer switching applications. Type 3907/2N404 germanium transistor meets mechanical and environmental stability requirements of MIL-S-19500B. Specifications are: collector-to-base voltage, −25 v max; collector-to-emitte rvoltage, −24 v max with V_{EB} at −1 v; operating ambient temperature, −65 to +85 C.

Radio Corporation of America, Dept. ED, Somerville, N. J.

***Availability:** Immediate.*

Magnetic-Tape Rewinder 581

Spools 10.5-in. reel in 90 sec. Average rewind speed is 500 ips. The TR-300 magnetic-tape rewinder has a universal hub variable from 3 to 3-3/4 in. which accepts NAB or IBM tape reels without adapters. Tape guides handle tapes 1/2 or 1 in. wide.

Electronic Engineering Co. of Calif., Automation Div., Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.

***P&A:** $690; 6 weeks.*

Solenoid Valves 578

For up to 3,000-psi oil pressure, two-way solenoid valves are available in normally open and normally closed types. Both are pilot operated poppet valves in cartridge form and can adapt to any type of manifold or sub-plate. The poppet and plunger are the only moving parts.

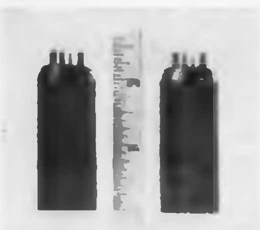
Fluid Power Accessories, Inc., Dept. ED, Box 64, Glenview, Ill.

Plugs and Receptacles 572

Phenolic molding compounds are used in the manufacture of these multiple plugs and receptacles, available in a variety of shapes and terminal arrangements. Applications include appliances, electronic equipment and other industries.

Hooker Chemical Corp., Durez Plastics Div., Dept. ED, Niagara Falls, N. Y.

Multivibrators 571



One-shot multivibrators are offered in two types: the T-166 contains a built-in noise rejection circuit and the T-167 is designed to have a pulse-width variation of 5% max from −45 to +65 C. A pulse width of 2 μsec to 1 sec can be generated by either unit.

Engineered Electronics Co., Dept. ED, 1441 E. Chestnut Ave., Santa Ana, Calif.

***P&A:** $38.40; $44.50; 2 weeks.*

CIRCLE 89 ON READER-SERVICE CARD ➤

For high speed logic switching with assured reliability, the General Instrument 2N708 npn silicon planar switch features the unique Molecular Shield™ surface-passivation process. ■ Here's a planar that is stable, reliable and uniform... lot by lot... with excellent gain characteristics as well as extremely low leakage current. Designed for switching applications, this type, as well as others in the popular 2N706 class, utilizes the latest planar techniques. ■ Extensive tests have proved that this type of transistor construction offers definite circuit advantages. Life tests, for example, indicate little degradation as a result of operation and storage at high temperatures. ■ The immediate availability of the 2N706 series in production quantities should be of interest to designers now using our silicon mesa transistors. The 2N708 is also available in limited quantities. For microtransistors, pancake-package transistors... for all your silicon planar and mesa transistors, call the sales office or franchised distributor nearest you. Or write for complete details to General Instrument Semiconductor Division, 65 Gouverneur St., Newark 4, N.J.

Abbreviated Specifications—General Instrument NPN Silicon Planar Transistors

Type	V_{CBO}	V_{CER}	h_{FE}	T_s
2N706	25v	20v	20	60 nsec
2N706A	25v	20v	20	25 nsec
2N706B	25v	20v	20	25 nsec
2N708	40v	20v	30	25 nsec

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION

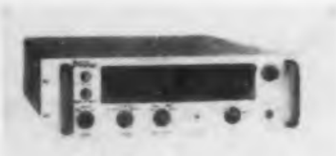
GENERAL INSTRUMENT CORPORATION

Time-Code Generator 579

Any 17-bit time code containing three binary words for seconds, minutes or hours can be generated. Model 6202 time-code generator, for ground or airborne use, has a stability of 10^7 per day. One code format can be supplied as an amplitude-width-modulated code on a 1,000-cps sine wave and as a dc level shift.

Epsco-West, Dept. ED, 240 E. Palais Road, Anaheim, Calif.

Five-Digit Voltmeter 705



Accuracy is 0.01%. This five-digit voltmeter has a range of ±0.0001 to ±999.99 v dc. Speed is 20 readings per sec avg; outputs are BCD and 10-line decimal; all switching is electronic; dimensions are 5-1/4 x 19 x 20 in.

Electro Instruments, Inc., Dept. ED, 8611 Balboa Ave., San Diego 11, Calif.

Power Inductor 706

Variable power inductor is designed for complex load banks, accurate voltage control for tuning and phase-angle control circuits and breadboard filter circuits. It is available in two overlapping ranges from 10 to 40 and 40 to 160 mh. Dc resistance in either range is less than 5 ohms with dc and rms current of 0.5 amp max.

Servomechanisms/Inc., Dept. ED, 200 N. Aviation Blvd., El Segundo, Calif.

Servo Amplifiers 582

Have no moving parts. Six types of Power-Max integral horsepower, position servo amplifiers are available. Positioning accuracy is typically better than 0.3%. Dc inputs include analog programer output, positioning potentiometers, selector switch and fixed-resistor networks, electromagnetic flow-meters and static switching circuits.

Electromation Co., Dept. ED, 4254 Glencoe Ave., Venice, Calif.

Availability: *stock.*

Resistor Networks 589

Lug-type resistor networks are made in lengths to 6 in., with up to 13 resistors. Values can be matched to 0.005%; individual tolerances are 0.01%. Values range from 1 ohm to 2 meg, with ratings to 3 w and 1 kv.

Reon Resistor Corp., Dept. ED, 155 Saw Mill River Road, Yonkers, N. Y.

Photoelectric Reader 671

Sorts by color. Photoelectric reader model 150 provides a resistance range of about 25 K to 250 K from white to black surfaces at a distance of 1/8 in. from the lens. Volume is 2/3 cu in. Range is flush to 1-1/2 in.; weight is 1 oz.

Melpar, Inc., Dept. ED, 3000 Arlington Blvd., Falls Church, Va.

CIRCLE 91 ON READER-SERVICE CARD

Vertical Sensing Element 580

Two-axis, proportionally damped, bubble-type A1800-01A-A vertical sensing element drives gyro torque motors. Vertical accuracy is +15 min of arc, repeatability is 5 min and tilt angle is 0.75 deg nominal at full-scale output.

General Precision, Inc., Kearfott Div., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

Power Supply Cabinet 542

Shock and vibration, category D per MIL-E-4970A, are withstood by this power supply cabinet. Designated model 2C, the cabinet is weather-proof and suitable for outdoor use. The cabinet is offered on nine of the firm's standard power supply models providing dc currents up to 1,500 amp from 15 to 135 v.

Christie Electric Corp., Dept. ED, 3410 W. 67th St., Los Angeles 43, Calif.

Bellows Couplings 674

Allow 5-deg misalignment. Solid, split-hub, and combination miniature bellows couplings transmit 200 oz-in. max torque. The phosphor bronze units have zero backlash, permit 5-deg max misalignment, and 3,000 rpm max speed. Surface is palladium flash-plated.

FAE Instrument Corp., Dept. ED, 16 Norden Lane, Huntington Station, L. I., N. Y.

AC Power Supply 514

This variable-voltage power supply has an output from 0 to 140 v ac with regulation of ±6% at 75 w. Maximum no-load output is 142 v rms. Front panel meter reads 0 to 150 v with 1% full scale accuracy. Unit measures 9-3/8 x 4-7/8 x 5-1/2 in.

Lafayette Radio Corp., Dept. ED, 165-08 Liberty Ave., Jamaica 33, N. Y.

Price: *$19.75.*

Miniature Pentode 521

Improved linear deflection is featured in the 6HB6, a T6-1/2 miniature pentode. Designed for receiver applications, the tube has a transconductance of 25,000 μmhos.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton 58, Mass.

P&A: *$0.72 ea, 100 or more; immediate.*

Recycling Timer 516

This compact recycling timer, designated series Dual-Trol, produces a series of on-off electrical pulses. It consists of two timing modules, one for the on and the other for the off signal, which can be adjusted to vary the timing interval. Ten replaceable modules are available with timing ranges from 6 sec to 3 hr. Units are rated at 10 amp and measure 7-1/2 x 5-1/8 x 5-9/16 in.

Industrial Timer Corp., Dept. ED, 1407 McCarter Highway, Newark 4, N. J.

P&A: *$77.50; six to eight weeks.*

CIRCLE 93 ON READER-SERVICE CARD ➤

Angular Accelerometers 466

Resolution is 0.01% of full scale. The AA series angular accelerometers for sensing roll, pitch and yaw cover from 0.5 to 500 radians per sec² in five models. They can be used with carrier amplifiers or 400-cps power systems and are suitable for missile instrumentation and control.

Dynamic Measurements Co., Dept. ED, 106 Terwood Road, Willow Grove, Pa.

Image Orthicon 428

With rugged construction as well as high sensitivity, type GI-7409 image orthicon is designed for military applications such as in missiles, satellites, fire control and drone guidance.

General Electric Co., Cathode Ray Tube Dept., Dept. ED, Syracuse, N. Y.

Infrared Bolometer 426

Mosaic infrared bolometer permits imaging or photographing extensive areas at one time through the use of passive heat emission. A complete image can be provided in a fraction of a second.

Barnes Engineering Co., Dept. ED, 40 Commercial Road, Stamford, Conn.

Program Drill 465

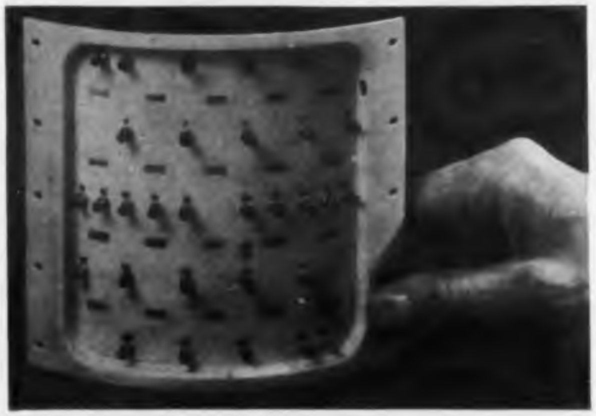
Drills up to 200 holes in any pattern through a load of one or more printed-circuit boards, up to 8 x 12 in. Model 120 automatic program drill, having a repeat accuracy of 0.002 in., is a high-speed electric drill with a pneumatically operated spindle and movable work table controlled by paired stop-pins set in a revolving control disk.

Develop-Amatic Engineering, Dept. ED, 923 Industrial Ave., Palo Alto, Calif.

...Specify Silicones

No Heat-loosened Terminals Here

Repeated soldering does not loosen terminals mounted on silicone-glass laminate made with Dow Corning resins. Lightweight and rugged, silicone-glass laminates provide greater strength at elevated temperatures than many metals . . . keep their excellent dielectric properties despite storage, environmental aging, rapidly changing ambients, vibratory shock and high humidity. These are the reasons why Lear, Inc., Grand Rapids, Michigan selected silicone-glass laminate for the capacitor mounting board in their Stable Platform Model 2013J.



CIRCLE 801 ON READER SERVICE CARD

Easy Way to Repair Encapsulations

It's easy to replace defective parts encapsulated in Silastic® RTV, the fluid silicone rubber that cures without heat. First, you cut a slit in the Silastic RTV jacket; second, replace the component; third, patch the cut by pouring fresh Silastic RTV over the repair . . . there's no measurable loss in dielectric properties or physical strength. Encapsulation with Silastic RTV offers these advantages, too: resistance to moisture, fungus, corrosive atmospheres, corona and ozone, excellent dielectric properties, good heat dissipation and an operating temperature range of −60 to 250 C. Silastic RTV assures top value protection.

CIRCLE 802 ON READER SERVICE CARD

Heat-sink Sealant Ups Performance

When transistors and diodes are mounted with Dow Corning compound as the heat-sink sealant, heat dissipation improves up to 50%. That's because this grease-like silicone compound doesn't dry out, harden, melt or lose its initial properties from −70 to 200 C . . . even after long time exposure. Dow Corning silicone compound has excellent thermal conductivity and increases the heat transfer between diode-and-washer and washer-and-chassis . . . improves device performance. Applied to lead terminals and connector pins after soldering, Dow Corning compound protects against corrosion, corona and shorts.

CIRCLE 803 ON READER SERVICE CARD

CORPORATION MIDLAND, MICHIGAN

branches: ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D.C.

CIRCLE 800, 801, 802, 803 ON READER-SERVICE CARD

Automatic Checkout Systems 451

Programed, digital automatic checkout systems provide quantitative, qualitative and go/no-go testing at all levels of maintenance and production. They direct input-output switching, select measurement scales and compare system responses to predefined limits. Magnetic or punch tape can be used.

Curtiss-Wright Corp., Electronics Div., Dept. ED, P. O. Box 10044, Albuquerque, N. M.

Panel Meters 450

Accuracy is 2% of full scale for dc and rf rectifier and ac moving-iron type panel meters. The ac rectifier type has an accuracy of 3%. Series 201 and 301 are 2-1/2 and 3-1/2 in., round or rectangular. All types have three-year warranty.

Daystrom, Inc., Weston Instruments Div., Dept. ED, 614 Frelinghuysen Ave., Newark 12, N. J.

Tape Transport 410

Messages of 10 sec to 3 min in length may be stored in the cartridge of the Repeater Reel magnetic-tape transport. Messages may be played over and over because the tape is spliced to form one continuous loop. Applications include monitoring and surveillance of mechanical and automatic operations.

Metric Processing Corp., Dept. ED, 143 Roseland Ave., Caldwell, N. J.

NEW PRODUCTS

High-Low Temperature Chamber 483

Range is −100 F to +600 F. Temperature can be lowered from 70 F to −100 F in 5 min, and raised to 600 F in 45 min. Heating unit is electric resistance type, operating on 15 amp, 115 v ac. Refrigerant is liquid CO_2. Sealed construction is said to permit continuous operation at −100 F without condensation. Unit measures 21-1/2 x 14 x 18 in. Test space measures 9 x 11 x 10 in.

Bemco, Inc., Dept. ED, 11631 Vanowen St., North Hollywood, Calif.

***P&A:** $440.00 FOB North Hollywood; from stock.*

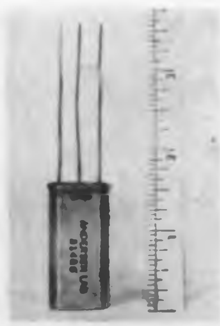
Controlled Switches 527

Fast recovery silicon controlled switches operate from 50 to 800 ma average, 10 amp peak. Complete recovery occurs in 2 μsec; rise time is 0.1 μsec. Voltage ratings of the pnpn devices range from 30 to 200.

Solid State Products, Inc., Dept. ED, 1 Pingree St., Salem, Mass.

***P&A:** $10 to $29 ea, 100 to 999; stock.*

Delay Lines 460



Lumped-constant electromagnetic delay lines are designed for microminiature circuit applications. Delay is 0.35 μsec ±5%; risetime is 0.03 μsec max; impedance is 1,500 ohms; temperature range is −55 to +125 C. Unit shown occupies 0.3 cu in. Requirements of MIL-STD-202-B are met.

Andersen Laboratories, Inc., Dept. ED, 501 New Park Ave., W. Hartford 10, Conn.

Low-Level Switch 482

Solid-state device is designed to switch input signals of up to 1 v with a resolution of 5 μv. Designated type SW-101, the unit switches up to 1,000 times per sec. Switching transient is less than 4 mv; gating power is less than 2.5 mw, and error is less than 50 μv. No external transformer is required. The unit occupies less than 1/2 cu in. and weighs 8 g.

Alpha-Tronics Corp., Dept. ED, 1033 Engracia, Torrance, Calif.

Availability: *30 days.*

Multicoder 432

For all IRIG channels with sampling rates for PDM systems. Transducer-source resistances up to 5 meg may be used. Other features of the multicoder are: input of 28 v at 1-1/4 w, input resistance greater than 100 meg at 70 C, input impedance at 1,000 cps of 150 K.

Applied Electronics Corp. of N. J., Dept. ED, 22 Center St., P. O. Box 43, Metuchen, N. J.

Absolute Pressure Transducer 485

Designed for use with corrosive media, the model 723 absolute pressure transducer is a bourdon-tube, potentiometer-type instrument with a stainless steel isolation bellows. Range is from 0 to 350, to 0 to 3,500 psia. Typical static error band is ±1%. Resistance is 1 K to 10 K. Nominal resolution is 0.25 to 0.45%. Power rating is 1.5 w continuous at 165 F. Units are 1-3/8 in. in diameter and 3 in. long. Weight is 7 oz.

Bourns, Inc., Instrument Div., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

NEW! Solid State time/delay/relays

...with traditional **AGASTAT**® reliability!

Now available . . . solid state time/delay/relays with the accuracy essential for critical missile and computer applications! These new AGASTAT relays are the result of over 25 years' time delay engineering and manufacturing experience . . . specialized experience which has made AGASTAT the standard of reliability throughout industry.

Advanced design combines specially selected semiconductors and other components in a "modular-sandwich" configuration. Result: the standard modules mean flexibility; uniformity; and rapid delivery of "custom" produced prototypes. The solid state AGASTAT is hermetically sealed . . . resistant to vibration and shock. Special circuitry protects against input polarity reversal, provides immunity to voltage transients and continuously modified inputs.

What are your requirements? These solid state relays are only 1-5/16" sq. . . . available in six standard types, with delay on pull-in or drop-out; timing ranges from 0.01 sec. to 10 hours, fixed or adjustable. Operation—18-32 vdc; -55c to 125c; load capacity to 5 amperes. *Write* Dept. S1-47 for data sheet. Or ask for a quotation on your special application requirements.

AGASTAT TIMING INSTRUMENTS
ESNA ELASTIC STOP NUT CORPORATION OF AMERICA
ELIZABETH DIVISION • ELIZABETH, NEW JERSEY

IN CANADA: ESNA CANADA, LTD., 12 GOWER ST., TORONTO 16, ONTARIO, CANADA

CIRCLE 99 ON READER-SERVICE CARD

NEW PRODUCTS

Brakes and Clutches 486

Size 5 brakes and clutches have torque ratings of 6 oz-in. min engaged and 0.05 oz-in. max disengaged at 28 v dc. Brake torque is 2 oz-in. Units consume 1.16 w and have a 2.8 msec response time at 28 v. Minimum engagement voltage is 6 v dc. Designed for use in analog navigation computers, units weigh 0.97 oz and meet MIL specs.

Clifton Precision Products Co., Inc., Dept. ED, 5050 State Road, Drexel Hill, Pa.
Availability: *Off-shelf delivery.*

Hermetic Sealing Glass 532

Precision electronic components can be hermetically sealed in this glass, Kovex 50. The glass is said to provide a matched seal with metal. Annealing point is 502 C; softening point, 700 C; thermal expansion coefficient, 48 x 10^7; density, 2.27; power factor, 0.25; dielectric constant, 4.98; loss factor, 1.24.

Mansol Ceramics Co., Dept. ED, Belleville, N. J.

Static Relay 463

Sensitivity is 0.5 μw. The ultRelay static relay with meter-movement sensitivity handles up to 750-w, 650-cps loads, and is virtually unaffected by shock and vibration. Power amplification ratios are 90 to 100 db. Operating temperature range is −40 to +160 F.

Airborne Accessories Corp., Industrionic Div., Dept. ED, 5456 W. Washington Blvd., Los Angeles 16, Calif.
Price: *$85.*

Heat Sink 499

For TO-18 package. Heat sinks for mesa transistors in the TO-18 package use a threaded nut for secure contact with transistor weld flange. The two-piece, stud-mounted sinks are of aluminum having high thermal efficiency. No. 1107 is anodized, No. 1106 has caustic etch finish.

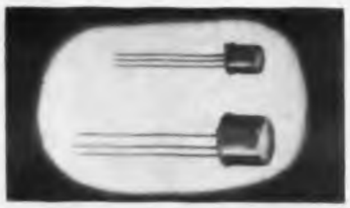
Thermolloy Co., Dept. ED, 2130 Irving Blvd., Dallas 8, Tex.

Silicon Controlled Rectifiers 500

Rated at 25 amp at 100 C, diffused silicon controlled rectifiers of the TI-150 series are housed in stud package. Rated breakover voltages, both forward and reverse, are 50, 100, 200, 300, and 400 v respectively for the TI-150, 151, 152, 153, and 154.

Texas Instruments Inc., Dept. ED, P. O. Box 5012, Dallas 22, Tex.
Availability: *Immediate.*

Silicon Transistors 502



In TO-18 case, pnp alloy junction silicon transistors 2N935 through 2N946 are electrically equivalent to TO-5 types such as 2N1917 through 2N1922, 2N1025, and others. They are suited for switching, communications, and instrumentation uses.

Sperry Semiconductor Div., Sperry Rand Corp., Dept. ED, Norwalk, Conn.

CIRCLE 101 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Bulkhead Connector 517

This compression-sealed unit has a normal leakage rate of less than 10^{-7} cc per sec, with rates of 10^{-9} cc per sec available on special order. Bodies and pins are fused with glass, meeting MIL-C-5015 specifications. Various contact arrangements with 12 to 32 pins are available. Unit mates with any standard MS socket.

Escon, Inc., 735 Branch Ave., Providence, R. I.

Module Cage 507

Instrumentation module cage holds up to 24 printed circuit cards, or up to 12 modules 1.375 in. wide. Standard 22-pin or 24-pin connectors mount at rear. Modules are available for strain gage, telemetry, and recorder uses.

Wiley Electronic Products Co., Dept. ED, 2045 W. Cheryl Drive, Phoenix, Ariz.

Connector Cables 506

Color-coded connector cables are made for interconnection of audio equipment. Plugs are provided. Basic colors of white, green, yellow, red and blue are available. Colored marking strips and color dots may be easily applied.

Zoron, Inc., Dept. ED, 612 W. Monroe St., Chicago, Ill.

Time Delay Relay 518

Of almost crystal can size, this time delay relay, Model M-100, has spdt output contacts rated at 0.25 amp. Input voltage is 24 to 32 v dc. Adjustable time ranges are from 5 msec to 30 sec, ±5% under 10 sec and ±10% over 10 sec. Units are hermetically sealed, rated at one million operations, and available in a variety of mounting styles.

Electronic Products Corp., Dept. ED, 4642 Belair Road, Baltimore 6, Md.

Module Cooling Unit 520

Designed to cool digital modules, particularly the firm's S-PAC series, the model CU-30 cooling unit utilizes three axial-flow fan units mounted in parallel within the chassis. It has a removable dust filter. The airduct may be adjusted to draw air from either the front or rear of the cabinet. Unit measures 19 x 5 x 8 in.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

***P&A:** $127.00; delivery from stock.*

Differential Mv Commutator 459

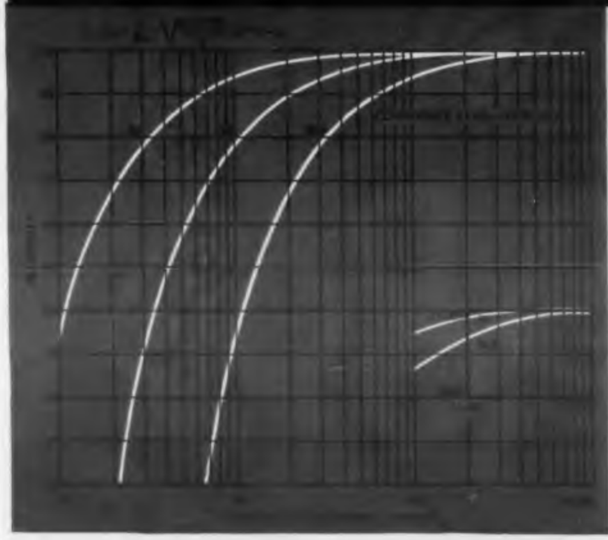
Range is dc to 20 kc for the differential millivolt commutator, packaged for missile and ground support applications. Specifications include: power, 1 w at 28 v; input impedance, 100 K; sensitivity, 10 mv full-scale input; resolution, better than 20 μv; linearity, better than 0.25%.

Applied Electronics Corp. of N. J., Dept. ED, 22 Center St., P. O. Box 43, Metuchen, N. J.

Leak Detector 519

For testing hermetically sealed components. Leaks in the 10^{-11} cc-per-sec range can be detected with the type 24-510 leak detector. Up to 10,000 transistors can be tested in each cycle, requiring less than an hour. Components are soaked in a nontoxic radioactive gas, are air washed, then are tested for traces of radioactivity.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.



NEW PRODUCTS

Sea-Water Depth Transducer 456

Range is 350 to 1,000 psia for model 734 sea-water depth transducer. Other features include: resistances of 5 to 10 K ±5%, resolution of as low as 0.15%; vibration limit of 35 g at 2,000 cps, static error band of ±0.5%, dimensions of 2 in. in diameter by 1.44 in., and weight of 16 oz.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Appliance Wire 528

Teflon TFE and FEP insulation is 10 mils to 1/32 in. thick on appliance wire AWG 16 to 26. Temperature ratings are 105 to 200 C max, with voltage ratings to 600 v. Wire is U/L-approved.

Tensolite Insulated Wire Co., Inc., Dept. ED, W. Main St., Tarrytown, N. Y.

Ultrasonic Delay Lines 531

Almost temperature-independent. These delay lines are manufactured of Code 8875 glass. This material has a nominal time delay temperature coefficient of zero ±0.75 ppm per C. Attenuation coefficient is low enough to permit time delays of 350 μsec or higher at frequencies below 10 mc.

Corning Glass Works, Dept. ED, Corning, N. Y.

Frequency Standard 461

For 360 to 1,300 cps with accuracies of 0.002%. Type 27 frequency standard measures 11/16 in. in diameter and 2-15/16 in. long. It weighs 1-3/4 oz, requires 20 to 30 v dc at 5 ma and operates over a temperature range of −65 to +125 C. Vibration conditions of MIL-E-5272B Procedure II are met.

American Time Products, Div. of The Bulova Watch Co., Inc., Dept. ED, 61-20 Woodside Ave., Woodside 77, N. Y.

Potentiometer 457

Rated at 15 w at 25 C with maximum operating temperature of 265 C. Model 3030 wirewound potentiometer offers resistances of 10 ohms to 10 K and nominal resolution of as low as 0.6%. Weight is 0.9 oz; size is 1.07 x 0.52 x 1.27 in. Applications include in power supplies.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Price: $8 to $10.

Synchros 530

Bu/Weps specification MIL-S-20708A are met by this series of synchros over a temperature range of −55 to +85 C. The series is designed for use in fire control, radar, navigation, missile functions, and similar applications.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N. J.

Image Orthicon 433

For near infrared use, type Z5395 image orthicon is suitable for both military and industrial applications. It can be used to penetrate hazy atmospheres for mapping and surveillance, as well as in passive detection systems.

General Electric Co., Cathode Ray Tube Dept., Dept. ED, Syracuse, N. Y.

Static Inverter 462

Rated at 175 va, model 143-101-171 static inverter has an output of 115 v ac, 400 cps, single phase from an input of 25 to 30 v dc. Output voltage and frequency are maintained within ±1% from no load to full load; harmonic distortion is held to within 4%. Uses include missile and aircraft ground support equipment.

American Electronics, Inc., Precision Power Div., Dept. ED, 1598 E. Ross Ave., Fullerton, Calif.

Inductance Bridge 484

Designed for 400 to 20,000 cps operation, this inductance bridge is basically a calibrated variable frequency oscillator coupled to a modified Maxwell bridge. The bridge, model 63B, provides direct-reading calibration of both the inductance and resistance dials, with a resolution of 0.01%. Inductance range is 0.02 μh to 11h; resistance range, 0.002 ohm to 110 K. Accuracy is about 0.25%.

Boonton Electronics Corp., Dept. ED, Morris Plains, N. J.

Image Orthicon 430

With ultraviolet sensitivity, type GL 7969 image orthicon is suited for missile detection systems, spectrographic detection and medical instruments. Light-level capacity can be as low as 10^{-6} ft-c. Resolution is high.

General Electric Co., Cathode Ray Tube Dept., Dept. ED, Syracuse, N. Y.

Fast-Responding Pico-ammeter 431

For nuclear applications, this pico-ammeter has a dynamic range of 10^{-12} to 10^{-3} amp in 19 ranges and an accuracy of better than 3% of full scale at all outputs. Speed of response is less than 1 msec to 64% of final value at 10^{-9} to 10^{-3} amp.

General Electric Co., Dept. ED, Schenectady 5, N. Y.

Variable Inductor 492

For low audio range. Miniature saturable-core reactor model EL-215 operates at 1 w from 30 to 450 cps min, and 250 to 3,750 cps max. Used to determine frequencies in filter and oscillator circuits, it is effective as a low-frequency sweeping device. The potted unit operates in temperatures from −55 to +85 C.

Vari-L Co., Inc., Dept. ED, 207 Greenwich Ave., Dept. ED, Stamford, Conn.

Voltage Reference 491

Solid-state, shielded voltage reference standards of series 220 provide 5.7, 8.5, or 10.5 v dc at 10 ma. Operating from 115 v, 60 cps line, regulation is ±0.001% for ±10% line variations Capacitance from line to output is less than 1 pf.

Viking Industries, Inc., Dept. ED, 21343 Roscoe Blvd., Canoga Park, Calif.

***P&A:** $150; 3 weeks.*

Timing and Control Systems 434

Programed timing and control systems provide initiation and termination of various switching functions at preselected times. Programing is from punched tape, punched cards, magnetic tape, hard wire, patch panels or thumbwheel switches. Digital design and modular construction are used.

Curtiss-Wright Corp., Electronics Div., Dept. ED, P. O. Box 10044, Albuquerque, N. M.

Size 11 Resolvers 529

Small, light weight size 11 resolves are intended for such applications as computation, angle data transmission and automatic control. Models CR4-0987-001 through CR4-0987-005, have a 0.1% function error, ±3 min inter-axis error, and 0.1% transformation ratio unbalance.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N. J.

Submersible Pan-Tilt 489

Operating to 1,000 ft depth, model 3003-2 submersible pan and tilt mechanism permits remotely controlled underwater positioning with 360 deg of pan and 90 deg of tilt. Remote readout of pan and tilt position is available.

Ward Associates, Dept. ED, P. O. Box 9067, San Diego 9, Calif.

***P&A:** $3,000; 60 days.*

NEW PRODUCTS

Thermoelectric Generator 498

Eight-watt thermoelectric power generator is designed for operation of remote, unattended industrial field instrumentation. Fuel is natural gas, propane or butane. Rugged, reliable unit may be continually exposed to weather. Weight is 65 lb, width 12 in., height 17 in.

Texas Instruments Inc., Dept. ED, P. O. Box 6027, Houston 6, Tex.

Ultrasonic Probe 512

Operating to 100 kc, with useful response to 1 mc, probe VP-10 provides an inexpensive means of measuring ultrasonic levels. The probe will stand a static pressure of 100 psi, and is unaffected by high temperatures. Output at cavitation is several volts, permitting use with simple equipment for waveform and level display.

Vibrasonics, Inc., Dept. ED, 10 High St., Boston, Mass.

Low-Noise Preamplifier 501

For radiation detectors. Preamplifier model 100A, featuring charge-sensitive feedback, is used with semiconductor radiation detectors. Charge sensitivity variation is less than 10% from 0 to 1,000 pf. Noise is equivalent to 600 electrons rms, rise time less than 0.1 μsec.

Nuclear Industries, Inc., Dept. ED, 10 Holland Court, Valley Stream, N. Y.
Price: *$295.*

Broadband Amplifier 515

This 100-w broadband amplifier can provide a cw signal from 200 kc to 275 mc. Input and output imepdances of 50 and 90 ohms, respectively, are compatible with standard transmission lines and fittings. Broadband rf transformers for different impedance levels can be supplied. The cabinet measures 21 x 22 x 47 in., and has recessed casters.

Instruments for Industry, Inc., 101 New South Road, Hicksville, N. Y.

P&A: *$6,500; about 8 weeks.*

Power Transistors 522

Silicon power transistors 2N2015 and 2N2016 have saturation resistance of 0.25 ohm max, power dissipation up to 150 w. Beta is 15 to 50 at 5 amp, 7.5 min at 10 amp. The devices operate at case temperatures from −65 to +200 C.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N. J.

Silicon Chopper 503

One-gram silicon chopper operates from less than 1 mv to ±20 v. Driving voltage is a square wave with amplitude of 5 to 25 v, peak to peak. Signal Current is 10 ma max, linearity less than ±0.5% deviation from best straight line. Operating temperature is −55 to +150 C.

Solid State Electronics Co., Dept. ED, 15321 Rayen St., Sepulveda, Calif.

P&A: *$88; stock.*

CIRCLE 114 ON READER-SERVICE CARD ▶

NEW PRODUCTS

High-Power Transmitter 415

Output is 1 to 2 kw at 200 to 400 mc. Designed for missile and space applications, the transmitter withstands temperatures of 400 or 500 F as well as severe shock and vibration. The rf circuitry is broad-banded for operation over a 10-mc range around a selected nominal frequency.

Space Electronics Corp., Dept. ED, 930 Air Way, Glendale, Calif.

Electroluminescent Panels 508

Metal, glass and plastic e-l panels are now available in quantity. Metal panels can be made up to 2 sq ft, glass panels 30 in. square; plastic panels are made in a wide variety of shapes and forms. Metal panel life is about 15,000 hours. Light output is about 10 ft-l at 600 v, 60 cps.

Westinghouse Electric Corp., Dept. ED, Box 2278, Pittsburgh 30, Pa.

Temperature Chamber 427

Range is −100 to +350 F for the Mark II temperature chamber. Features include: internal working dimensions of 11 x 12 x 5 in., liquid carbon dioxide refrigeration, resistance element heater, aluminum liner and fan with external blower motor.

Associated Testing Laboratories, Inc., Dept. ED, Wayne, N. J.

Price: $285.

Decade Resistance 490

Five-dial decade resistance box has ranges from 0.0 to 9,999.9 to 999,990 ohms in steps of 0.1 to 10.0 ohms. Temperature coefficient is less than 0.002% per deg C. Current rating ranges from 10 ma to 0.5 amp.

Voltron Products, Inc., Dept. ED, 1020 S. Arroyo Parkway, Pasadena, Calif.

Price: $115 to $130.

Trimmer Potentiometer 414

The 25-turn, 3/4-in. sq model 51 trimmer potentiometer is available in ranges from 50 ohms to 200 K. It dissipates 3 w without external heat sink or other hardware. Military specs for altitude, humidity and other environmental conditions are met. Weight is 5 g.

Spectrol Electronics Corp., Dept. ED, 1074 S. Del Mar Ave., San Gabriel, Calif.

Camera Tube 429

With tri-alkali photocathode, type 7967 camera tube is claimed to provide 50 times more sensitivity than standard image orthicons. It operates with an illumination of up to 10^{-6} ft-c. The magnesium-oxide semiconductive target has almost no lateral leakage. Resolution is better than 300 TV lines at low light levels or 1,200 lines at higher levels.

General Electric Co., Cathode Ray Tube Dept., Dept. ED, Syracuse, N. Y.

Miniature Humistor 435

Over-all length is 1/4 in. and header diameter is 5/32 in. Model H-160-3 humistor detects and measures vapor or gases exhibiting an electric di-pole movement. Readout is through a megohmmeter or a megohm bridge. The device can be completely immersed in water and withstands temperatures from 0 to 100 C.

Conrad-Carson Electronics, Inc., Dept. ED, El Cajon, Calif.

P&A: *$10; from stock in small quantities.*

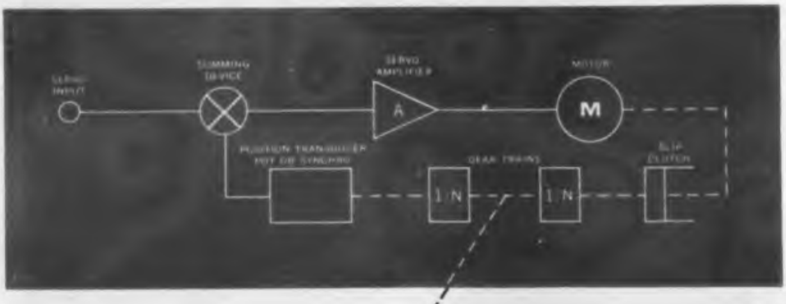
Remote Alarm 488

A **solid-state** remote alarm monitor, model 901, samples and encodes any number of data points and keys a single channel of any transmission medium. The signal is decoded and displayed at the receiver. Operation is continuous. Compact plug-in construction is employed, 17 points occupying a 3-1/2 x 5-3/16 x 6-15/16 in. package. Units resist moisture, fungus, and high temperature.

Compudyne Corp., Dept. ED, Hatboro, Pa.

PROBLEM:

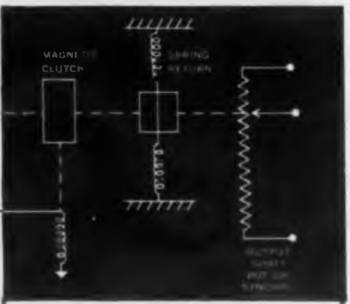
To provide an output Potentiometer-Transducer which can be readily engaged with a minimum angular error to a servomechanisms gear train when energized by an external command signal. The transducer must accurately return to a specified null position when the command signal is removed.



A SOLUTION:

Provide an electro-magnetic clutch, spring return mechanism and rotary potentiometer. Assemble these parts into the required package with the resultant difficulties brought about by the mounting and coupling problems with a consequent increase in cost.

COMMAND SIGNAL



TIC

unitized package

THE OPTIMUM SOLUTION:

Technology Instrument Corporation's west coast engineering facilities developed and offer a unitized package consisting of an electro-magnetic clutch, spring return mechanism and rotary potentiometer as one compact assembly. The clutch will transmit high torque without slippage and has negligible angular engagement error. TIC's unique spring return mechanism will accurately return the output transducer to the desired null, yet requires low driving torque. TIC's unitized assembly replaces three (3) individual components with their inherent assembly difficulties.

GENERAL INFORMATION:

Shaft Position Transducers can be linear or nonlinear potentiometers, synchros, linear transformers or digitizers. Spring return mechanism can be supplied designed to return to any desired point. A built-in slip clutch can also be furnished if the input torque can exceed the rating of the clutch.

TIC UNITIZED PACKAGE HAS MANY APPLICATIONS, SUCH AS:

Auto pilots, altitude controllers, machine controllers, measurement and control problems, speed control, process control of temperature and flow, differential measurement, expanded scale servos, or any other problem requiring an output, commencing at some specified servo position determined by an external command signal.

TIC

©12-60

TECHNOLOGY INSTRUMENT CORPORATION

555 Main Street, Acton, Massachusetts • COlonial 3-7711

CIRCLE 117 ON READER-SERVICE CARD

In-Wall Amplifier 418

For flush-mounting in frame or masonry walls, model 2030 in-wall amplifier requires a depth of 4 in. A 30-w, all-transistor unit, the amplifier includes a voltage-regulated power supply and has four microphone inputs. All 12 transistors are accessible through removable front plate.

Rauland-Borg Corp., Dept. ED, 3535 W. Addison St., Chicago 18, Ill.

Storage Tube 510

Writing speed of 400,000 ips and a brightness in excess of 200 ft-l is obtained with a potential of 5 kv in the WL 7682 storage tube. One writing gun and one flood gun are used in the electrostatically focussed and deflected tube. Storage time is 30 sec to 30 min. Display area is 4 in. with an OD of 5-1/4 in. max.

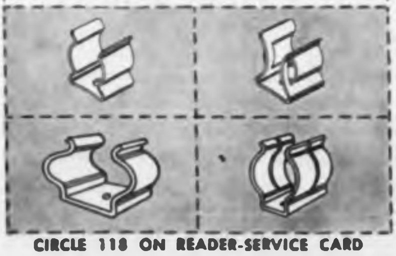
Westinghouse Electronic Tube Div., Dept. ED, P. O. Box 284, Elmira, N. Y.

Multichannel Digital System 487

Low-level data signals are displayed and recorded on paper tape by this multichannel digital system, model ER-3295. Consisting of five separate units, the instrument scans consecutively 98 three-wire inputs from various transducers. Resolution is ± 1 μv. A digital voltmeter provides visual readout. A slave scanner can be added to increase input capacity.

Kin Tel Division, Cohu Electronics, Dept. ED, Box 623, San Diego, Calif.

***P&A:** About $11,500, fob; San Diego; 90 days.*



Terminal Boards 445

Microminiature series 251 terminal boards can be encapsulated with terminals wired to connector contacts or supplied with a cap to facilitate customer wiring prior to encapsulation. Floating-type connector contacts are polarized. For use with the firm's Super-Flex tapes, the boards are made for computer, radar and communications use.

Cicoil Corp., Dept. ED, 3833 Saticoy St., Van Nuys, Calif.

Voltage Divider 511

Decade voltage divider has total resistance of 1 K, 10 K and 100 K. Linearity of the five-dial unit is 0.01%, temperature coefficient 0.001%. The Kelvin Varley circuit is used. Box measures 3-3/4 x 4 x 5 in. and weighs 1 lb.

Voltron Products, Inc., Dept. ED, 1020 S. Arroyo Parkway, Pasadena, Calif.

P&A: *$150; 30 days.*

DC Power Supply 449

Rated at 100 kv, 10 ma, continuous duty. Model 5492 power supply has a highly regulated output, automatic rate of voltage rise and is short-circuit proof. Provisions are made for remote control operation and remote metering. Plug-in shielded cable is used for connections.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 119 ON READER-SERVICE CARD ▶

High-Voltage Rectifiers 416

Ratings are to 50,000 piv and 1 amp dc per block for the SDI series double diffused silicon rectifier assemblies. They are designed in single wave: half wave, center tap or full wave; three phase: half wave, full wave or star; protective networks and tube replacements.

Solitron Devices, Inc., Dept. ED, 500 Livingston St., Norwood, N. J.

Pressure Transducer 405

Potentiometer-type pressure transducer model 12112 is offered in ranges from 1 to 200 psia and psig. Typical resolution is 0.25% to 0.33%. Platinum-alloy winding element has resistance of 5 to 15 K. Repeatability, hysteresis and friction are under 0.5%. Applications include space and missile environments.

Princeton Machine and Development Co., Dept. ED, P. O. Box 187, Princeton Junction, N. J.

Sound Meter 417

Range is 35 to −142 db; response is from 40 to 8,000 cps. Model 450 sound meter measures 2 x 3 x 6 in., weighs 2 lb and operates from a 22.5-v battery. It meets ASA Standard A, B and C weightings. The amplifier is stabilized against voltage and temperature changes.

H. H. Scott, Inc., Dept. ED, 111 Powdermill Road, Maynard, Mass.

***Price:* $150.**

Power Switching Transistors 504

Capable of switching 400 w, these pnp switching transistors, types 2N637, 2N637A, 2N637B, 2N638, 2N638A, and 2N638B, are designed for high current operation in dc-dc converters and dc-ac inverters. The series has three different voltage breakdown ratings for use in both 12-v and 28-v supplies. Average power dissipation is 60 w max. Current gain is controlled, eliminating need for matching.

Bendix Corp., Dept. ED, Red Bank Div., Holmdel, N. J.

Pressure Transducer 453

For missile applications. Type 4-328 pressure transducer operates from between 0 to 15 and 0 to 99 psia. Output is 50 mv; linearity and hysteresis are less than ±0.5% of full range output. Thermal zero shift is within 0.005% per deg F. Weight is 5.5 oz.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Smoothing Chokes 505

Designed for aircraft and missiles, these hermetically sealed smoothing chokes have inductances from 0.2 mh to 5,100 h, at dc currents from 6 ma to 25 amp. Units have straight-pin, hooked-pin, or flexible Teflon lead connectors, and may be mounted on chassis, printed-circuit board, or stacked. Dimensions range from 1.12 x 0.91 x 0.87 in. to 1.77 x 1.46 x 1.49 in. Weight is 1.2 to 8 oz.

Arnold Magnetics Corp., Dept. ED, 6050 W. Jefferson Blvd., Los Angeles 16, Calif.

***P&A:** $5.00 to $20.00; two weeks.*

Attenuators 446

Rated at 20 w audio, 5 w dc. These L and T pad attenuators measure less than 1-3/16 in. deep. Insulation used combines rapid heat transfer with high dielectric strength. Wiper contacts are rigidly attached to the shaft. A wide range of impedance ratings is furnished.

Centralab, Div. of Globe-Union Inc., Dept. ED, 900 E. Keefe Ave., Milwaukee 1, Wis.

ENGINEERING REPORT ON BENDIX COMPONENTS

PRECISION SIZE 5 MOTORS NOW AVAILABLE FROM STOCK

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TYPICAL MOTOR CHARACTERISTICS

Voltage	
Fixed phase	26 volts
Control phase	26 volts
Frequency	400 cycles
Stall Current*	
Fixed Phase	100 ma
Control Phase	100 ma
Stall Impedance*	
Fixed Phase	260 = 184.5 + J183.5 ohms
Control Phase	260 = 184.5 + J183.5 ohms
Stall Power Input* (Total)	3.69 watts
Stall Torque	0.138 oz.-in.
No Load Speed	9900
Torque-to-Inertia Ratio (Stall Acceleration)	44,400 rad/sec²
Operating Temperature Range	−55°C. to +70°C.
Weight	0.88 oz.

*With rated voltage applied to each phase.

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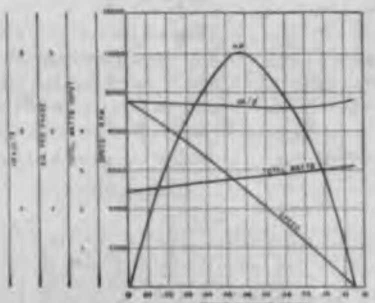


For information on these motors—or similar motors in sizes 8, 10, 11, 15, 20, and 28—write:

Eclipse-Pioneer Division

Teterboro, N. J.

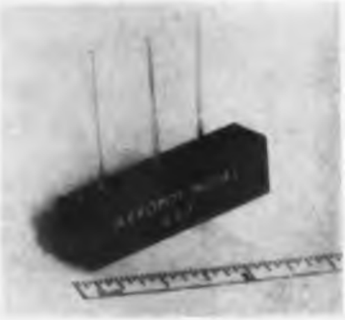
Bendix

District Offices: Burbank, and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

CIRCLE 123 ON READER-SERVICE CARD

NEW PRODUCTS

Trimmer Potentiometer 464



Range is 20 ohms to 100 K. Model 427 trimmer potentiometer is designed for etched circuit boards and has gold-plated copper leads of 0.1-in. spacing. Power dissipation is 1 w to 70 C; tolerances are ±10 or ±5%; requirements of MIL-R-27208 are met.

Aero Electronics Corp., Dept. ED, 1745 W. 134th St., Gardena, Calif.

***Availability:** 1 to 2 weeks.*

Bar Switches 454

Parity-code bar switches, series DP and series OP, provide odd or even parity in the five-bit output. Conversion from octal or decimal digits to binary code is by means of binary-coded contact closures. Full 10-button decimal banks with 1-2-4-8 output contacts are offered in the DP series; seven-button banks with 1-2-4 contacts are offered in the OP series.

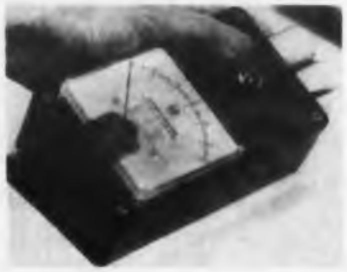
Computer Control Co., Inc., Dept. ED, 2251 Barry Ave., Los Angeles 64, Calif.

Instrument Carrier 455

For submarine use, the V-Fin instrument carrier is for applications such as seismic investigation, echo sounding, pressure and temperature studies. It can be used in acoustic systems over the range of 10 to 6,000 cps. Hydrophone sensitivity is −88 db. Molded in Fiberglass, the unit weighs less than 14.5 lb and has an instrument compartment of 12 x 2-1/2 x 1-1/8 in.

Braincon Corp., Dept. ED, 312, Marion, Mass.

Electronic Tachometer 406



Speeds to 12,000 rpm are calibrated accurately with this miniature electronic tachometer. A photoelectric cell responds to illumination changes and transmits a signal to a pulse-triggered computer which determines the rpm and displays the result on a direct-reading meter. Drills, presses, power drives, motors and other equipment can be checked. No external power source is needed.

Pioneer Electric & Research Corp., Dept. ED, 743 Circle Ave., Forest Park, Ill.

Price: $95.

Waveform Analyzers 452

With digital output, these waveform analyzers are capable of measuring amplitude rise-time, ring, decay time and sag. They are suitable for applications where large quantities of measurements are required such as in automatic checkout systems and production test systems.

Curtiss-Wright Corp., Electronics Div., Dept. ED, P. O. Box 10044, Albuquerque, N. M.

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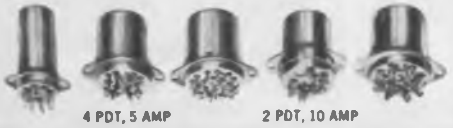

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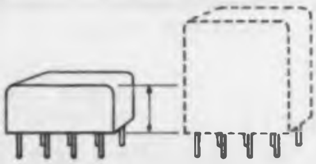

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Regulation is ±0.1% for line and ±0.4 v for load. Model MTR28-10 power supply provides 24 to 32 v dc at 10 amp. Ripple is 2 mv. Features include a magnetic amplifier and a transistor series regulator. No tubes, vibrators or moving parts are used.

Perkin Electronics Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.

IF Preamplifiers 408

For low-noise operation, series H modular if preamplifiers can be furnished with balanced or unbalanced input. Output impedance is 50 ohms. Tube units operate from −55 to +85 C and germanium transistor units, from −20 to +50 C. Silicon types can also be furnished. Design is miniature.

Orion Electronic Corp., Dept. ED, 108 Columbus Ave., Tuckahoe, N. Y.

***P&A:** $200 to $250; 2 to 3 week.*

Plotting Board 409

Vertical-horizontal plotting board type 1587 provides two simultaneous plots of any four independent voltages against time. Plotting surface is 30 x 30 in. The unit operates with analog and digital computers, coordinate converters, radars and other analog devices.

Milgo Electronic Corp., Dept. ED, 7620 N. W. 36th Ave., Miami 47, Fla.


MICROWAVES

MICROWAVES

Research, Anyone?

A bad case of scientific heartburn was induced among diners at this year's PGMTT symposium banquet, when the after-dinner speaker reported some amazing tales of Soviet derring-do in microwaves. The speaker was actually a representative of the United States Information Agency playing the bogus role of a Russian scientist to perfection. To everyone's relief, he finally admitted that the Russians had not supported a 1-sq-km space platform with microwave power—not yet.

Meanwhile, back at the lab, ELECTRONIC DESIGN checked into U. S. progress in direct conversion of microwave power. Our status: a wealth of interesting proposals and some research effort—but possibly not enough. Two small projects, funded with less than $200,000 are paying off. But they constitute the total American participation in direct conversion of microwave power. The details are in the article beginning on the opposite page. Any good ideas here that are not being exploited because of inadequate support by government and industry?

Direct Microwaves-to-Electricity Power Seen Near

Inverse magnetron converter developed by Raytheon. Left to right: cathode, anode-cavity structure, coaxial rf input and cover. Final version of this device may approach 60 per cent efficiency and generate up to 1 kw cw in the 1- to 2-Gc range. Wright Air Development Div. is presently emphasizing development of this type of microwave power converter over other possible inversely operated tubes. The weight of the final version, including magnet, will be approximately 35 lb.

Manfred Meisels
Technical Editor

OFF-THE-SHELF hardware for direct conversion of microwaves into electrical power may be a reality within two years, according to scientists at the Wright Air Development Div., which is now sponsoring two research projects in this area.

Raytheon's Spencer Laboratory, Burlington, Mass., is investigating the inverse operation of magnetron-type tubes, while at Purdue University, West Lafayette, Ind., the emphasis is on inverse operation of klystrons, and both vacuum and semiconductor diodes. Efficiencies of 60 per cent are believed possible with the inverse magnetron and semiconductor diode approaches.

Power requirements for such converters are fairly modest—1 kw cw for the magnetron and perhaps 75 w for the semiconductor diodes. Proposed applications include powering electronic gear aboard satellites and transmitting power to unmanned equipment atop mountains and in other remote areas.

These applications and the proposed conversion methods differ markedly from those for the microwave powered helicopter (also a Raytheon project) in which heat exchangers and gas turbines would achieve power conversion. Power requirements here are measured in megawatts, though Raytheon is reportedly looking into thermionic and thermoelectric generators as an alternative to the mechanical conversion cycle. Regardless of the application and ultimate conversion scheme used, ultra-high-power microwave tubes such as Raytheon's Amplitron or General Electric's multiple-beam klystron and Orthotron would be employed at the transmitter.

The direct conversion methods now being actively studied fall into three categories.

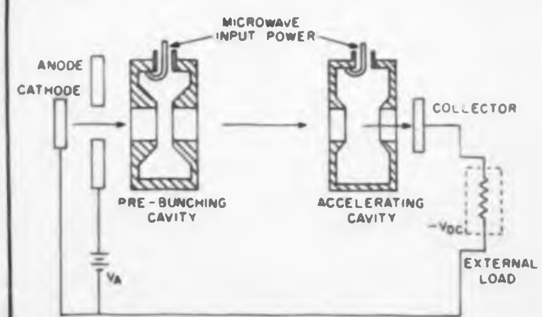
- Inverse operation of conventional microwave tubes
- Vacuum diodes
- Semiconductor diode arrays

Of these, inverse operation of microwave tubes appears most likely to yield moderate-order powers (approximately 1 kw) with acceptable efficiency. For low power, semiconductor diode arrays look promising. Light weight and small size would make them attractive for many satellite applications.

The inverse magnetron tube being developed by Raytheon as an outgrowth of earlier work with the backward-wave type Microfier has already shown efficiencies of 32 per cent. In tests at 1.28 Gc, pulsed outputs of 4 kw were obtained over a 0.1 per cent duty cycle. WADD scientists feel that cw operation at 60 per cent efficiency will eventually be obtained.

The tube consists of 30 radial vanes which form 29 anode cavities. Microwave fields applied to the tube accelerate the electrons from cathode to anode. Current is drawn to the anode when the rf interaction voltage exceeds the dc potential of the tube and Hartree threshhold voltage.

Raytheon has built nine progressively improved tubes of this type for WADD. In its ultimate version, a 1-kw tube is expected to weigh about 35 lb, including the magnet. Continuous heating of the cathode would



Inverse klystron microwave power converter. Electron beam between cathode and collector is accelerated by microwave input. Efficiency is reduced by need to divert some of the input to the pre-bunching cavity. A separately heated cathode is required.

not be required as operation is sustained by secondary electron emission resulting from back bombardment.

Inverse operation of klystrons for direct conversion is also considered feasible. Recently initiated work at Purdue University has been confined to inverse operation of commercially available tubes. Preliminary tests at 3 Gc are inconclusive as the emphasis has been on gathering data for design of a special-purpose tube rather than on extracting power from a commercial version.

A proposed inverse klystron, illustrated here, has been theoretically analyzed by WADD with mixed conclusions. Such a unit could be designed for high powers and frequencies. However, a separate heater supply is necessary. Spreading of the electron beam and entrance angle, as well as the need to supply power to both cavities of the tube would result in low efficiency and degraded performance.

An inversely operated traveling-wave-tube converter has also been analyzed at WADD. The electron beam in this device would gain energy from the microwave field rather than surrendering it as is the case in normal twt operation. By gradually increasing phase velocity of the rf traveling wave to account for increasing beam velocity, the electrons can be accelerated while continuing to be phase locked with the traveling wave. This can be accomplished with a tapered helix of gradually increasing pitch.

Limitations of the inverse twt include need for a separate heater supply and limited power handling capability of the slow wave structure. Efficiency of such a device might approach 40 per cent.

Cyclotron and Plasma Converters Believed Theoretically Possible

A cyclotron resonance converter has also been analyzed at WADD. In the basic design, electrons emitted from a central anode are spiraled outward by the cyclotron action of the rf input and a suitably adjusted magnetic field. The electrons thus gain energy from the field and strike properly oriented collector plates. By placing the collectors at a low velocity point of the electron trajectory, efficiencies of up to 60 per cent could result, as there would be little power dissipated via electron bombardment. Back bombardment of the cathode, however, could enable heaterless operation.

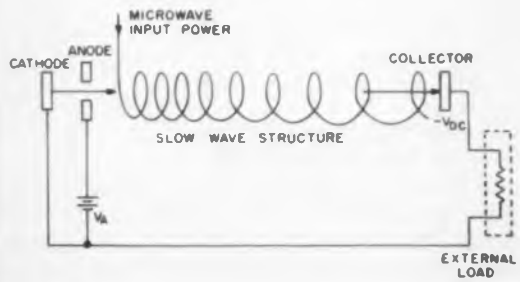
Prospects for plasma converters have also been analyzed by WADD. One approach would be to create a plasma by using the microwave input and then apply a magnetic gradient to cause ion and electron drift in opposite directions. The electrons would be connected to an external load and the positive ions used to bombard a cathode to cause electron emission.

While a plasma converter would be small and easy to fabricate, the wide distribution of electron energies in the plasma would probably result in efficiencies no greater than 25 per cent.

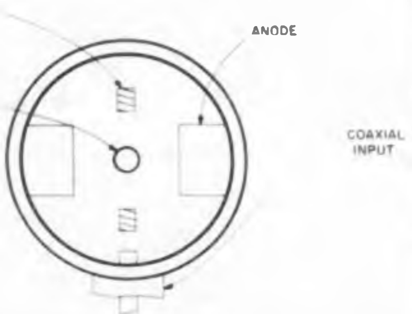
Having analyzed these approaches to medium-power direct conversion, WADD has settled on the inverse magnetron as the most feasible—at least for the immediate future.

Multiple-Diode Arrays In Development at Purdue

Equally imaginative designs for low-power converters have also been proposed. The obvious approach of vacuum diode rectification may prove useful despite electron transit time limitations. It has been shown that rectification can take place even when the cathode-to-anode spacing is equal to several hundred periods. Realistically, a spacing equal to a few periods could achieve



Inverse traveling-wave-tube microwave power converter. Electron beam is accelerated by absorbing energy from rf wave in the helix. The gradually increasing pitch of the helix keeps the traveling wave in phase with the accelerating electrons. A separate heater is required for the cathode.



Proposed cyclotron resonance microwave power converter. Rf input, in conjunction with magnetic field (perpendicular to plane of drawing), accelerates electrons to the collector plates. Studies indicate that the device could approach 60 per cent efficiency. Back bombardment of cathode would eliminate need for heater.

efficiencies of up to 25 per cent. In this mode of operation, out-of-phase electrons would absorb energy from the rf input and be returned to the cathode. The resulting secondary emission could allow heaterless operation of the diode.

Experiments at Purdue with lighthouse tubes operating as diodes have shown efficiencies of up to 20 per cent at 3 Gc. Maximum output was approximately 1 w.

Much higher efficiency and power output are anticipated for arrays of semiconductor diodes wired as full-wave rectifiers. The group at Purdue has operated arrays of 64 diodes placed directly in the waveguide. A 360-diode array employing 1N830 silicon point-contact diodes is now being assembled for testing. The diodes will be mounted in a flared section of 10-cm guide. Outputs of between 10 and 15 w at 2.5 Gc with perhaps 75 per cent efficiency are hoped for.

Future plans call for even larger arrays developing up to 100 w. These could be distributed among several parallel sections of guide joined by a magic T or similar device.

Theoretical studies of large junction diodes as possible microwave rectifiers are also under way. In addition, nonlinear effects in bulk semiconductor materials in strong rf fields have been noted at Purdue. It has been suggested that an understanding of these effects could lead to a rectifier consisting of a large semiconductor crystal properly oriented within a waveguide. ■ ■

Designing the "Parant"

Instead of worrying about noise temperature and noise pickup in antenna leads, authors Frost and Clark circumvented these problems by integrating the parametric amplifier within the antenna structure. The resulting parant, designed for Doppler tracking of satellites, eliminates open connecting lines between antenna and amplifier. Input to the parametric amplifier is applied directly from the signal-induced potentials at the ends of the antenna. Dipole parants have been built for 54-, 108-, and 220- mc operation. Etched circuit antennas for 500 mc and slotted antennas useful at 2 Gc are being designed.

Albert D. Frost, Ronald R. Clark

University of New Hampshire,
Durham, N. H.

WHEN the need for low-noise reception warrants the use of parametric amplifiers, noise pickup in the leads between the antenna and receiver can significantly degrade system performance. Since reducing the distance between antenna and receiver is only a partial solution, it was decided to eliminate this source of noise altogether by integrating the parametric amplifier with the antenna.

Experiments were performed with half-wave and quarter-wave dipoles because the antenna elements could be most conveniently adapted to serve as the network elements of a parametric amplifier. This was accomplished by adding a concentric inner conductor to the dipole, thus forming a coaxial cavity. Units operating at 108 mc and 54 mc are illustrated in Figs. 1 through 4.

Coupling between the inner region and the outer cylindrical surface of the antenna occurs through incidental fringing capacitance and through shunt varactor diodes. The inner region, through its spectrum of TEM resonances provides the resonant storage necessary for parametric amplification.

Fig. 1. Half-wave dipole parant designed for 108-mc signal. Stripline section at center connects internal pickup loop to the coax connector. Square aluminum pipe is used for outer element of the antenna.

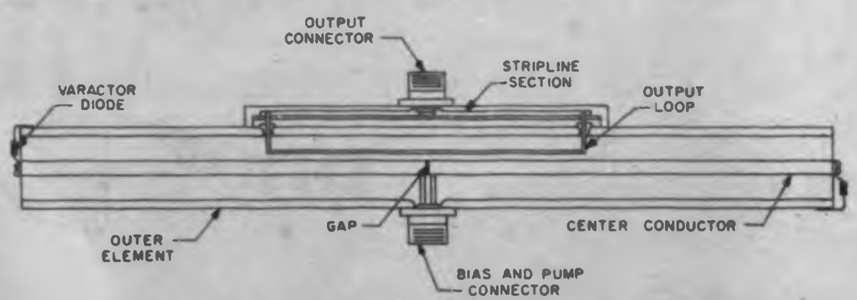


Fig. 2. Construction details of the half-wave parant. Two matched varactor diodes provide parametric amplification in conjunction with the coaxial cavity formed by the addition of the hollow center conductor. Higher order TEM modes provide resonant storage for the pump and idler frequencies.

Parant Operates as A Degenerate Amplifier

The parant is operated in the degenerate amplification mode (input frequency = output frequency). The fundamental TEM mode provides the signal frequency; the fifth order mode provides idler storage; and the sixth order mode matches the pumping frequency. A high order even TEM coaxial mode was chosen for pumping to minimize parasitic self-oscillations at or near the signal frequency.

The output signal is extracted from the coaxial region by a rectangular loop appropriately oriented in a radial plane. Coupling to the idler frequency is minimized by

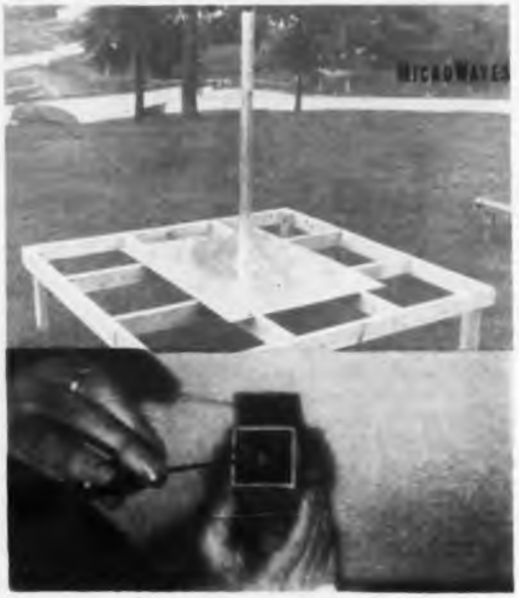


Fig. 3. Quarter-wave dipole parant designed for 54-mc operation. Design is similar to the half-wave unit, but note use of a ground plane. Bottom view shows internal construction and varactor diode connected between the inner and outer elements.

cutting loop length to a half-wavelength of the idler. The position of the loop with respect to the standing-wave current pattern in the center conductor also reduces coupling to this mode.

The diode is pumped through the center conductor, which also provides a dc path for the diode reverse bias.

Suitable external circuitry associated with the parant was designed to provide the following:

- Tuning of the idler, pump, and signal modes
- Pump input
- Dc bias

Networks for the half-wave, 108-mc parant and for the quarter-wave, 54-mc parant are shown in Figs. 5 and 6, respectively. Circuit values were chosen to match the characteristics of the 1N894 varactor diodes used in the antennas described here.

Both the half-wave and quarter-wave parants provide stable gains of up to 15 db over passive dipoles. (See gain-frequency curves in Figs. 7 and 8).

Antenna Can Be Electronically Switched at High Speeds

Diode reverse bias can be adjusted to vary the parant's gain over a range of 45 db.

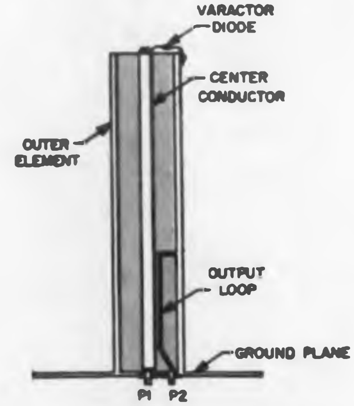


Fig. 4. Construction details of the quarter-wave parant. The antenna is single-ended and uses only one diode. However, additional diodes can be wired in parallel with the first, if desired. Construction of the quarter-wave antenna is simpler than that of the half-wave parant.

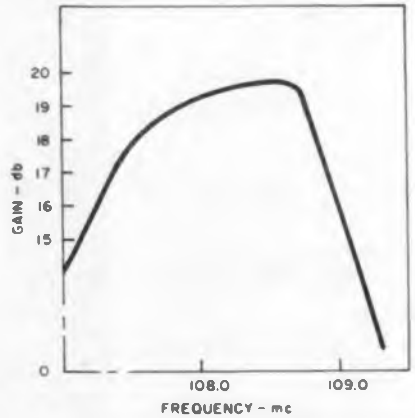


Fig. 7. Gain-frequency characteristic of the half-wave parant. Pump frequency was 600 mc.

Fig. 9. Tuning network for the half-wave, 108-mc parant. Unit is conveniently mounted at center section of the antenna.

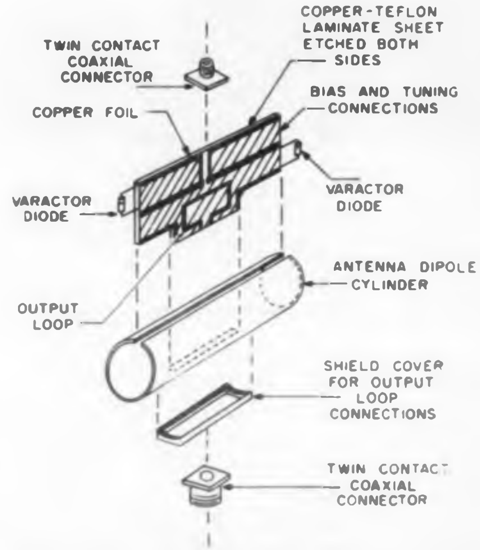


Fig. 10. Etched circuit, half-wave parant. This design approach should prove useful for antennas operating up to 500 mc. The etched circuit board replaces inner conductor of the lower-frequency parants. Resonant region is achieved by the strip-line construction. Distributed elements would be used for tuning.

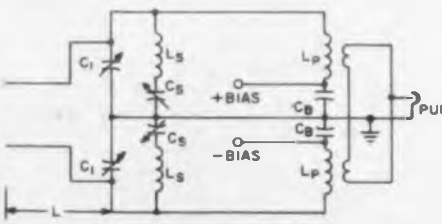


Fig. 5. Tuning networks and bias blocking circuits for the half-wave, 108-mc parant. Length *L* represents the distributed impedance of the leads and connectors between the antenna and the circuit. Capacitors C_I and C_S tune the idler and signal frequencies, respectively.

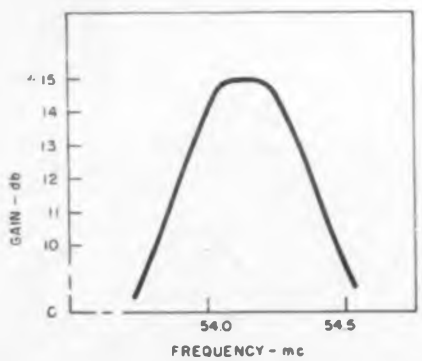


Fig. 8. Gain-frequency characteristic of the quarter-wave parant. Pump frequency was 302 mc.

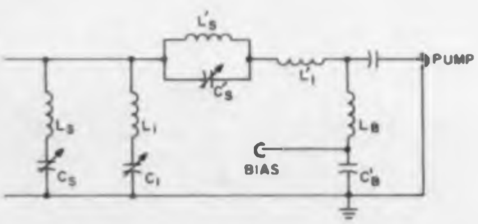


Fig. 6. Tuning networks for the quarter-wave, 54-mc parant. Single-ended characteristic of the antenna eliminates circuit balancing problems inherent in the half-wave design. Only one capacitor is required for tuning the idler or signal frequencies.

This change is due to the inhibition of parametric amplification and the combined effect of detuning and resistive shunting of the interior coaxial cavity. By pulsing the bias, an unmodulated signal can thus be conveniently chopped at rates up to 200 kc with 50-db isolations. This ease of switching makes the parant a versatile beginning for many complex types of receiving systems.

The half-wave parant of Fig. 1 was constructed of 1.75 in. square aluminum pipe with a wall thickness of 0.125 in. The flat side walls and increased wall thickness as compared to earlier models built of circular pipes permit convenient use of stripline fittings and more effective support of the inner conductor. The circular pipe was, however, retained for the inner conductor. Length was calculated by the equation

$$L = 0.48\lambda \frac{L/D}{L/D + 1} \qquad (1)$$

where

L = antenna length for half-wave dipole
D = antenna diameter
λ = free-space signal-wave length.

This expression was found empirically valid for conventional dipoles in which the signal is derived across a mid-point gap of negligible width and coupled to a matched resistive load. The gap in the inner conductor as shown in Fig. 2 provides the necessary dc isolation between the two diodes of the half-wave parant, but it is also an important factor in the design of tuning circuits for the signal, idler and pump frequencies.

The effect of this gap on the resonance of the inner region is dependent on the relative magnitude of its susceptance, though generally it shifts the resonant frequencies upwards.

Distributed Impedance Is A Factor in Design

Also across this gap are the composite impedances of the radial connections from gap to plug, connectors, leads (see Fig. 5) and internal wiring as far as capacitor C_l in the tuning network. These act as an irregular transmission line to provide, together with C_l, a series resonance as viewed from the gap. Their detuning effect is relatively minor at the 108-mc signal frequency of the antenna, but quite important at the 490-mc idler frequency.

The gap is physically located at a point where the longitudinal current density and voltage gradient are high for the odd order modes. Its location with respect to the oven order modes is at a low-current, high-impedance point.

Tuning of the idler and signal frequencies, occuring at odd TEM modes, is accomplished by adjustment of series resonant branches composed of lumped and/or distributed impedance elements. With a signal frequency of 108 mc and a consequent pump frequency near 600 mc, the circuit elements are largely distributed.

The pump signal coupling loops provide an in-phase voltage across the center conductor gap. Thus, any out of phase excitation arising from signal or idler frequency components will not produce a net output along the pumping signal line. Loading and signal loss are thereby avoided.

A tuning network assembled for the half-wave parant is shown in Fig. 9. Early models of the parant were tuned by the insertion of dielectric strips into the coaxial region. It was felt that the adjustable tuning network described here is more suitable for a developmental model, but the use of dielectrics for fixed tuning may be attractive when assembling a large number of parants designed for constant-frequency operation at a single frequency.

Matched-diode selection for the half-wave parant emphasized voltage sensitivity and static capacity. These two characteristics were matched as closely as possible within the tolerances obtainable with the low-priced diodes employed. Matching of reverse resistance and forward conduction point was performed less critically.

Quarter-Wave Parant Considered Simpler to Design and Fabricate

The quarter-wave parant is a more workable design from the standpoint of simplicity in construction and operation. It is essentially a half-section of the half-wave parant with the outer conductor welded to a conducting ground plane.

Its singled-ended configuration, as compared to a symmetrical half-wave dipole, permits more freedom of design for external circuitry and better control of cavity resonances. There is no balancing problem, either of external circuitry or diodes. Circuitry can be placed under the ground plane and there adjusted without affecting fields within the antenna itself.

The quarter-wave parant shown in Figs. 3 and 4 was designed for a 54-mc signal thus allowing lumped circuit elements to be used. Tuning networks for the signal and idler resonances (see Fig. 6) are connected across the base of the cavity, as are the dc bias and pumping inputs. In designing these networks, the following precautions should be observed.

- Dc bias must be applied between the center conductor and the dipole cylinder without shorting out the pump signal.
- The bias circuit must not lower the Q of the idler and signal-tuned circuits.
- Idler and signal power must not be dissipated in the pump and bias circuits.

Etched-Circuit and Slot Parants Being Designed for Higher Frequencies

Parants for use at higher frequencies are now being developed at the Antenna Sys-

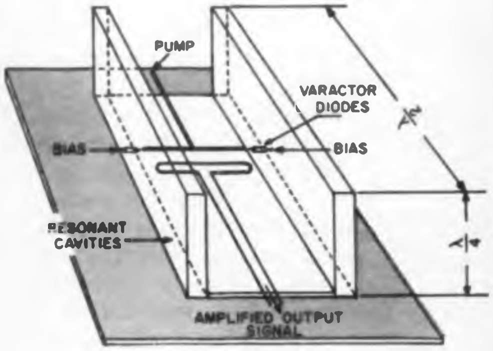


Fig. 11. Dual slot parant for use up to 2 Gc. Cavities behind slots in ground plane provide resonant storage for parametric amplification. Initial model of this design is undergoing operational tests.

tems Laboratory of the University of New Hampshire. In the region between 200 and 500 mc, an etched circuit antenna using essentially distributed elements for tuning appears feasible. The design shown in Fig. 10 is now being fabricated. A slot antenna, such as illustrated in Fig. 11 would operate at frequencies in the 1.5- to 2-Gc range. An initial model of this type has been completed and development is being continued.

As a simple dipole, the parant can be employed alone or together with Yagi arrays, parabolas, corner reflectors, etc. Multiple units with in-phase pumping and adjusted for equal gain merit consideration in high speed electronically-scanned arrays or in direction finding systems using a Wullenweber antenna or Luneberg lens. ■ ■

Acknowledgment

The parant concept was evolved in connection with Doppler tracking at the University of New Hampshire of early U. S. and Soviet satellites and is being developed under the sponsorship of the Electronics Research Directorate, Air Force Cambridge Research Laboratories.

New Definitions Of Receiver Noise Performance

Shortly before the 1961 National Symposium of the IRE's Professional Group on Microwave Theory and Techniques, five authorities in the field of noise measurement undertook to agree on a workable set of definitions of receiver noise. Whether Messrs. William Mumford and Rudolf Engelbrecht of Bell Telephone Laboratories, Hermann Haus, Massachusetts Institute of Technology, Robert Adler, Zenith Radio Corp., and Matthew Lebenbaum, Airborne Instruments Laboratory, have indeed said the last word in this long-standing controversy remains to be seen. Their significant report to the symposium, abstracted here, is nevertheless strongly commended to the interest of microwave designers.

THE noise performance of a system is evaluated in terms of its output signal-to-noise power ratio under operating conditions, S_o/N_o. Output power is expressed as the signal power at the input multiplied by the signal gain, G_s.

The output noise power can be expressed in terms of the signal gain, G_s, input signal power, S_i, output signal bandwidth, B_o, and an operating noise temperature, T_{op}. Hence, the output signal-to-noise ratio is:

$$\frac{S_o}{N_o} = \frac{G_s S_i}{G_s k T_{op} B_o} = \frac{S_i}{k T_{op} B_o} \qquad (1)$$

Two receiving systems have the same output signal-to-noise ratio if they have the same $S_i/kT_{op}B_o$ ratio.

In a single response receiver (in which one frequency at the input corresponds to a single output frequency, regardless of the complexity of the gain-frequency characteristic) the output noise power, N_o, is defined as

$$N_o = G_s k B_o (T_g + T_e) \qquad (2)$$

The term T_g is the input generator noise temperature. T_e is called the "Effective Input Noise Temperature." For a two-port transducer, this is the temperature which, when the input is connected to a noise-free equivalent of the transducer, would result in the same output noise power as that of the actual transducer connected to a noise-free input source.

To measure T_e, the designer can observe the output noise power for two different temperatures of the generator. If the ratio of the two output noise powers is Y,

$$T_e = \frac{T_g(hot) - Y T_g(cold)}{Y - 1} \qquad (3)$$

The term T_{op}, occurring in Eq. 1 can be expressed as

$$T_{op} = T_g + T_e \qquad (4)$$

An alternative definition of receiver noise, that of the Noise Figure, remains useful. Since, however, the literature contains several conflicting definitions of Noise Figure, the authors recommend the definition in the IRE standards on electron tubes.[1] In terms of Noise Figure, F, the operating noise temperature can be written as

$$T_{op} = T_g + 290(F - 1) \qquad (5)$$

In a multiple response receiver, such as a superheterodyne receiver with response at the image frequency or a parametric amplifier with response at the idler frequency, there are two distinct contributions to noise:

- N_{go} — output noise due to the noise power available from the impedance connected to the amplifier input.
- N_N — All other contributions to the input noise power. These are due to noise generated within the receiver components and noise resulting from any frequency conversions within the receiver.

Letting B_N be the limiting noise bandwidth common to all responses,

$$N_{go} = kB_N(T_{g1}G_1 + T_{g2}G_2 + \ldots\ldots + T_{gn}G_n) \qquad (6)$$

where G_n is the transducer gain of the n^{th} response. That is, the ratio of output power to the corresponding input power available to the n^{th} input response.

N_n can be characterized by a temperature, T_b, common to all responses, so that

$$N_n = kB_N T_b(G_1 + G_2 + \ldots\ldots + G_n) \qquad (7)$$

The total output noise is then

$$N_o = kB_N[G_1(T_{g1} + T_b) + G_2(T_{g2} + T_b) + \ldots\ldots + G_n(T_{gn} + T_b)] \qquad (8)$$

T_b is obtained from Eq. 3.

The operating noise temperature is given by

$$T_{op} = \frac{N_o}{kB_o G_s} \qquad (9)$$

Since most modern noise generators provide broadband noise, their use in direct measurement of noise injects the noise equally into all responses. That is,

$$T_g = T_{g1} = T_{g2} = \ldots\ldots = T_{gn} \qquad (10)$$

Eq. 8 thus reduces to

$$N_o = kB_N(T_g + T_b)(G_1 + G_2 + \ldots\ldots + G_n) \qquad (11)$$

To measure T_b in terms of Noise Figure, use

$$T_b = 290(F_b - 1) \qquad (12)$$

where F_b is the multiple channel or "broadband" Noise Figure.

To evaluate F_b, use

$$F_b = \left[\frac{T_g(hot)}{290} - 1\right] - Y\left[\frac{T_g(cold)}{290} - 1\right] \qquad (13)$$

When the input signal occupies only one

response, $G_s = G_1$. If the system is designed for lowest operating noise temperature, i.e., noise bandwidth B_N matches signal bandwidth B_o, the operating noise temperature is given by

$$T_{op} = T_{g1} + T_b + \frac{G_2}{G_1}\left(T_{g2} + T_b\right) + \frac{G_3}{G_1}\left(T_{g3} + T_b\right) + \ldots + \frac{G_n}{G_1}\left(T_{gn} + T_b\right) \quad (14)$$

For the special case when, under operating conditions, the generator noise temperatures applied to all input responses are equal, Eq. 14 reduces to

$$T_{op} = \left(T_g + T_b\right)\left(1 + \frac{G_2}{G_1} + \ldots + \frac{G_n}{G_1}\right) \quad (15)$$

When the received input signal is distributed over more than one input response, only the term G_s of Eq. 9 is affected. When the portions of the input signal are uncorrelated, with powers of $S_{i1}, S_{i2}, \ldots, S_{in}$,

$$G_s = \frac{S_{i1}G_1 + S_{i2}G_2 + \ldots + S_{in}G_n}{S_{i1} + S_{i2} + \ldots + S_{in}} = \frac{S_o}{S_i(total)} \quad (16)$$

Substituting G_s into Eqs. 8 and 9 yields

$$T_{op} = \frac{N_o}{kB_oG_s} = \frac{B_N[G_1(T_{g1} + T_b) + \ldots + G_n(T_{gn} + T_b)]}{B_o\left[\dfrac{S_{i1}G_1 + S_{i2}G_2 + \ldots + S_{in}G_n}{S_{i1} + S_{i2} + \ldots + S_{in}}\right]} \quad (17)$$

It is concluded that to evaluate the signal-to-noise ratio of any receiving system, the designer must know T_{op}, B_o, and the total input signal power S_i (having the same distribution over the various input responses assumed in the evaluation of T_{op}).

The multiple-channel effective input noise temperature, T_b, (i.e., T_e for a single response receiver) is computed by Eq. 3, the gains of the various responses, and the noise bandwidth, B_N.

With these terms, the designer can calculate his particular system's operating noise temperature, T_{op} by inserting them in the general Eq. 17, or an appropriate simpler form. ■ ■

Reference

1. *Proceedings of the IRE*, July, 1957, Vol. 45, p 1000.

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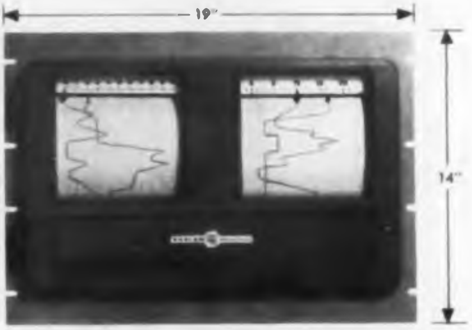
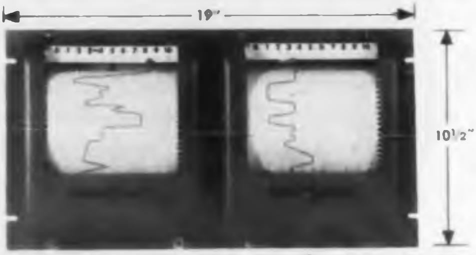
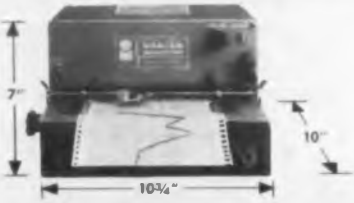


G-22 FOUR CHANNELS IN 14", DEPTH ONLY 11½" BEHIND FRONT PANEL



G-11A TWO CHANNELS IN 10½", DEPTH ONLY 5⅝" BEHIND FRONT PANEL



G-10 ONE CHANNEL <½ CU. FT.

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MICROWAVE PRODUCTS

Reflex Klystron 702

Operates to 120 Gc. Reflex klystron QKK971 operates from 100 to 120 Gc with power output of 10 mw min, and a minimum life of 250 h. Anode voltage is 1,700 v, current 50 ma. Heater requires 2.5 v at 1.5 amp, and reflector voltage is −100 to 300 v. The integral-cavity tube has vernier tuning.

Raytheon Co., Microwave and Power Tube Div., Dept. ED, Foundry Ave., Waltham 54, Mass.

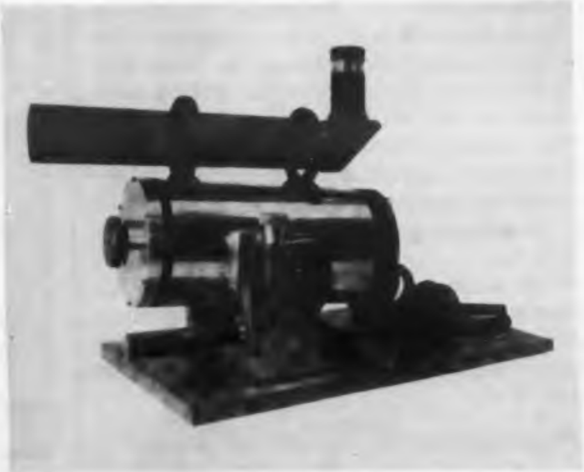
***P&A:** $3,500; 90 days.*

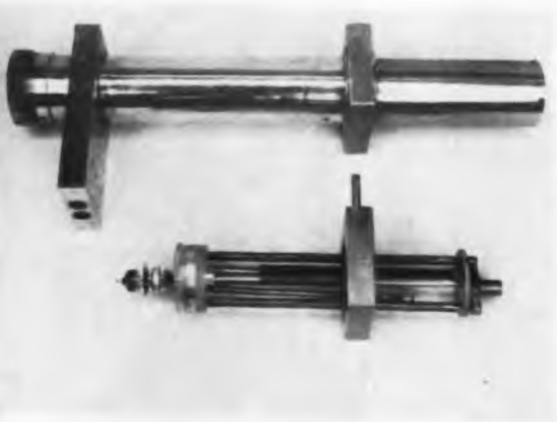
Optical Maser Head 703

Precision positioning of optical maser head model TO-2000 provides aiming accuracy within 10 sec of arc. Operating from 150 to 400 K, the head handles up to 4,000 J, and will accommodate rods up to 0.2 in. diameter. Included are three pink ruby rods, sighting telescope, tube and rod cooling, sync output, and manual and automatic triggering. Power supply is available.

Trion Instruments, Inc., Dept. ED, 7300 Huron River Drive, Dexter, Mich.

***P&A:** $3,695; 30 days.*





Oscillator Cavity 594

Calibration accuracy to ±2 mc and 0.1% resettability are provided by this oscillator cavity. Operating frequency is 400 to 1,000 mc. Used with 2C36 or similar uhf triodes, 10 mw into a 50-ohm load is provided. Output attenuator is calibrated from 120 to 0 db below 1 mw. Power output is monitored by bead and disk thermistors. The cavity withstands extreme shock.

Frequency Standards, Dept. ED, P. O. Box 504, Asbury Park, N. J.

***P&A:** $250 to $350 each; 90 to 120 days.*

Backward-Wave Oscillator 593

Operating from 18 to 26.5 Gc, backward-wave oscillator type BW-4289 provides a voltage-tunable signal for local oscillator and test equipment applications. Power output is 5 mw min. Tube is 5 in. long, 3-1/2 in diameter, and weighs 5 lb with integral permanent magnet. The rf output is fitted with flexible waveguide.

Sylvania Electric Products Inc., Dept. ED, 1100 Main St., Buffalo 9, N. Y.

***P&A:** $3,000; 60 days.*

MicroWaves PRODUCTS

Variable Attenuator 470

Range is 25 db. Model 1146 is a continuously variable attenuator with less than 0.5 db insertion loss and adjustment range of 25 db over the 500 to 1,000 mc range. Attenuation is essentially constant with frequency (±0.4 db max); unit handles 8 w average power. Connectors are BNC or TNC.

Radar Design Corp., Dept. ED, Pickard Drive, Syracuse 11, N. Y.

***P&A:** $ 210 ea; 8 week.*

Waveguide Isolators 378

Broad-band ferrite load isolators in five models cover spans between 2.60 and 12.4 Gc. Insertion loss of the type 101 units is 1 db max, isolation 20 to 40 db min. They are designed for use with medium-power equipment.

Caswell Electronics Corp., Dept. ED, 414 Queens Lane, San Jose, Calif.

***P&A:** $165 to $310 ea; 1 to 30 days.*

Water Loads 379

Magnetron output termination of low vswr for cw and pulsed testing is provided by these water loads. Available with or without a variable-phase magnetron pulling slug, loads may be pressurized to 30 psig. Seven types operate between 2.6 and 71.0 Gc.

Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

Coaxial Isolator 390

Broad-band ferrite coaxial isolator C992-100-409 operates from 2 to 4 Gc. Bandwidth isolation is 15 db, insertion loss 1 db, vswr less than 1.25:1. The 2-lb isolator is 6.16 in. long. Type N female coaxial connectors are standard, with other types optional.

General Precision, Inc., Kearfott Div., Microwave Products, Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Microwave Garnet 404

Low-loss, microwave garnet, MCL-300 is intended for use in the uhf and L-band regions. This material is available in bars, cylinders and disk form. Typical applications include 3- or 4-port low-loss circulators, either in full waveguide or coaxial. Curie temperature is 125 C.

Microwave Chemicals Laboratory, Inc., Dept. ED, 282 Seventh Ave., New York 1, N.Y.

Traveling-Wave Tube 356

A periodic-permanent, magnet-focused, low-noise traveling-wave tube, the HA-54 is for operation in the S-band. When operated from 2.4 to 3.4 Gc the tube has a noise figure of 13 db max, small signal gain of 25 db min and saturation power output of 5 dbm min. It measures 18 in. long with a 2 in. OD and weighs 3-1/2 lb.

Huggins Laboratories, Inc., Dept. ED, 999 E. Arques Ave., Sunnyvale, Calif.

***P&A:** $2,500 ea; 8 to 10 weeks.*

MICROWAVES PRODUCTS

Monitoring Diode 401

RF power monitoring diode MA-462 is for measurement applications in the X-band region. It is housed in a hermetically sealed, reversible polarity cartridge and is guaranteed for operation to 150 C. It meets the environmental conditions of MIL-S-19500B. A rectified output voltage with controlled variation is provided for input power levels between 10 μw and 10 mw cw.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.
***Availability:** Immediate.*

Y-Circulator 358

For the 2-Gc region, this Y-Circulator is 2 in. in diameter. It can be magnetically tuned with electromagnets or permanent magnets which become an integral part of the package. Standard configuration is with TNC connectors at 120 deg spacing. A 6% bandwidth is obtained across a frequency range of 2 to 4 Gc. Insertion losses are less than 0.4 db with an isolation of −20 db (−30 db at f_o) and vswr of 1.3 (1.1 at f_o).

Hycon Manufacturing Co., Dept. ED, 700 Royal Oaks Drive, Monrovia, Calif.
***Availability:** Immediate.*

Coaxial Mixer Diode 403

The MA-445 **series** of coaxial silicon mixer diodes are rated conservatively at 1-erg burnout. Primary applications include use in single-ended or balanced hybrid mixers and communication and radar applications in the 10- to 18-Gc frequency range. Specifications for the MA-445 are: conversion loss, 7.5 db max; output noise ration, 2.5 max; if impedance, 325 to 625 ohms.

Microwave Associates, Inc., Semiconductor Div., Dept. ED, Burlington, Mass.
***Availability:** Immediate.*

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Crystal Detectors 354

For K and R band waveguide systems, models K422A and R422A have sensitivity of 0.05 v per mw and flat response within 2 db. Maximum vswr is 2.5. Both models have feed-through terminations which may be removed when greater sensitivity is required. Model K422A is for 18 to 26.5 Gc and the R422A is for 26.5 to 40 Gc.

Hewlett Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

P&A: *Single units are $200; matched pairs are $420.*

C-Band Oscillator 353

A microminiature, C-band oscillator 3/4-in. in diameter and 3/8 in. long, model 9180 is for both plate pulse and cw service. The plate pulse service unit can be built in the 4 to 6 Gc spectrum with a tuning range of any 300 mc segment of that section. Peek pulse power is 50 to 100 w. The cw version can tune any 100 mc segment of the 4.0 tp 5.5 Gc spectrum. Power output is approximately 5 mw.

Trak Microwave Corp., Dept. ED, Tampa, Fla.

Pulse Modulator 360

The PM-87 pulse moderator is designed to test, for life and performance, super power klystrons, continuous-duty radar transmitters and similar equipment. Peak power is 64 megawatts continuous; average power is 75 kw. Continuously adjustable pulse range is 75 kv to 250 kv with pulse current of 260 amp at 250 kv. Frequency is 30 to 360 pps; pulse height deviates from flatness ±2%. Rise time at 10 to 90% voltage is 0.8 μsed; decay time is 1.5 μsec at the same voltages.

Ling-Temco Electronics, Inc., Dept. ED, 1515 S. Manchester Ave., Anaheim, Calif.

Availability: *30 to 60 days.*

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Communications System 469

Operates at 6 Gc. The 50 series is a solid-state microwave package including rf, multiplex, telegraph carrier and alarm equipment. Modular construction and circuit cards are used throughout. Klystron provides 1 w output, is rated for 20,000 hr of continuous operation. Up to 600 voice channels may be used, with 18 frequency-shift channels per voice circuit. Monitoring equipment can serve 22 stations with 8 points continuously scanned at each station.

Motorola Inc., Communications Div., Dept. ED, 4501 W. Augusta Blvd., Chicago 51, Ill.

Mixer Diode 467

Noise figure is 7 db. Glass packaged diode type 1N831A, useful in strip-line circuits, can be conveniently mounted in coaxial circuits for broad-band, low-noise mixer applications. Operating from 1 mc to 4 Gc, burn-out rating is 250 mw cw. The device exhibits a noise figure of 7.0 db max for a 30-mc if noise figure of 1.5 db at 3,060 Gc.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

P&A: *On request; stock.*

Delay Line 468

For X-band. Waveguide line lengths of 13 to 1,228 ft are contained in a mobile unit. The step-variable line is composed of coiled, rigid waveguide. Improved bending techniques result in minimum distortion of the waveguide and reduction of discontinuities. Length is changed quickly and accurately through use of high-isolation waveguide switches.

Turbo Machine Co., Dept. ED, Lansdale, Pa.

RF Detector 367

Model XD-6A rf detector consists of two separate detection circuits in a single package. Each section has an operating range of 100 kc to 1 Gc. Input impedance is 50 ohms for each section; vswr rating is 1.2 to 1 max at 1 Gc. Unit comes complete with BNC connections on both inputs and both outputs. TNC and N-type connectors are also available.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Shielded Grid Triode 402

Designed as a switch tube in hard-pulse modulations, the ML-7845 delivers more than 4 megawatts pulse power output for radar, communications and similar applications. The cathode is unipotential and oxide-coated. When cooled by forced air the anode is capable of dissipating 3 kw with 150 cfm air flow. When the tube is immersed in a suitable dielectric gas such as sulfur hexafluoride, its maximum ratings are 75 kv dc and 80 kv peak.

Machlett Laboratories, Inc., Dept. ED, Springdale, Conn.

***P&A:** $2,415; 30 days.*

Junction Circulator 380

Broad-band junction circulator model SL-43-3, operating at 2.2 to 2.7 Gc, is one of a line covering 1 to 35 Gc. The devices have better than 20 db isolation, less than 0.5 db insertion loss, and vswr less than 1.2:1 over a 15 to 20% frequency band. S, X, and SL band models with insertion loss of 0.15 db or less are available.

Cascade Research Div., Lewis and Kaufman Electronics Corp., Dept. ED, 5245 San Fernando Road West, Los Angeles 39, Calif.

***Availability:** 2 weeks.*

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Cavity Amplifiers 365

Miniature cavity amplifiers, series 20, are entirely gold-plated and designed for heat sink type mounting and operation. Frequency range covered is 215 to 2,325 mc. All units can be used as building blocks stacked side by side on 4 surfaces.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.
Availability: *20 days.*

Waveguide Fittings 361

Broached or unbroached waveguide fittings are manufactured to MIL-F-3922 from forgings, castings or bar stock for microwave applications. Magnesium and oxygen free copper flanges are available.

Pem Machine Tool Co., Inc., Dept. ED, 1456 Chestnut Ave., Hillside, N. J.
Availability: *From stock.*

Variable Attenuator 471

For field equipment. Type 170 series of panel-mounting attenuators is made for operation over full waveguide bandwidth, or with direct-reading dials for narrow-band use. Frequency range of type X170 is 8.5 to 10.5 Gc, with accuracy ±2 db from 0 to 50 db. Insertion loss is 0.75 db max, vswr 1.15:1 max. Average power handling capability is 1 w, peak lower 1 kw.

General Microwave Corp., Dept. ED, 47 Gazza Blvd., Farmingdale, N. Y.

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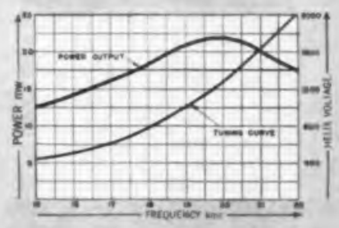
OD 3.7-5.9	3.7-5.9	30-45
OD 4-8	4-8	10-70
OD 5.2-8.3	5.2-8.3	10-40
OD 6-11	7-11	10-40
OD 6-12	6-12	10-30
OD 7-13	8.2-12.4	10-15
OD 10-15	10-15.5	10-20
OD 12-18	12.4-18	10-25
OD 15-22	15-22	10-20

But don't give up if the tube you need isn't listed here . . . these are just the BWOs we usually keep on the shelf in quantity, ready to ship today. We also produce, in either experimental or production quantities, oscillators covering partial, octave, and even greater-than-octave bandwidths.

Would you like a copy of our honest-to-goodness catalog, with complete performance curves, specifications, and operating data? Just drop us a note. Here's a sample set of curves, on the Type OD 15-22 backward wave oscillator:



We'd also like to hear from you if you're interested in permanent-magnet-focused tubes or traveling wave amplifiers.

WESCON BOOTH 123

STEWART ENGINEERING COMPANY
Santa Cruz 5, Calif.

CIRCLE 152 ON READER-SERVICE CARD

Hybrid Mixer 373

Compact hybrid mixer V-8306C performs without adjustment over 7.0 to 8.0 Gc. It is designed for waveguide coupling in both local oscillator and signal arms. Typical noise figure of 8.0 db includes a 3-db image and 1.5 db if strip contribution. Maximum vswr in both signal and local oscillator arms is 2.0. Isolation is 20 db min. Made of aluminum it weighs 6 oz.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

Price: $495 fob Palo Alto.

Waveguide Isolator 386

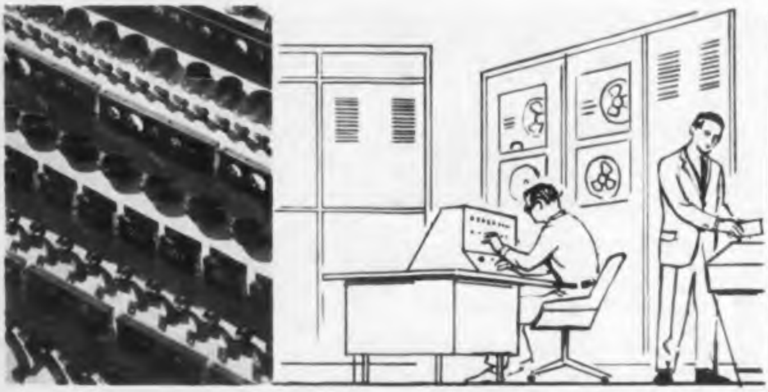
X-band waveguide isolator C994-100-932 provides isolation greater than 70 db. Insertion loss is 1.0 db max, vswr 1.2:1 max. Center frequency is ±100 mc, power handling capability 1 w avg. The 9-oz isolator is 3 in. long.

General Precision, Inc., Kearfott Div., Microwave Products, Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Ceramic Seals 381

Coaxial ceramic seals for traveling-wave tubes consist of dense alumina insulator sealed to a monel inner conductor and surrounded by a nickel outer conductor. Metallization process results in good rf match characteristics.

Ceramics International Corp, Dept. ED, 39 Siding Place, Mahwah, N. J



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Wassco GLO-MELT DIVISION
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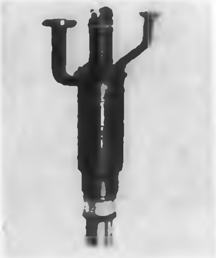
CIRCLE 163 ON READER-SERVICE CARD

Traveling-Wave Tube 372



A 3-mw pulse amplifier traveling-wave tube, the VA-126 is rated at 5 kw average power. Frequency range is 5.4 to 5.9 Gc. Efficiency is 30%; gain is 35 db. The liquid-cooled unit is self-centering in its electromagnet for ease in mounting.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

Video Receiver 371

Self contained, battery operated, X-band cw crystal video receiver, model R115, employs video chopping. It is designed for direct connection to an antenna and provides a dc output proportional to the X-band signal input. Nominal sensitivity is −45 dbm.

AEL, Inc., Dept. ED, 121 N. 7th St., Philadelphia, Pa.

Step Attenuator 385

Operating from dc to 500 mc, the D170 step attenuator has six switch positions permitting selection of attenuation from 0 to 41 db in 1-db increments. Accuracy is within 0.3 db; vswr is 1.10:1 max, power handling capability 1 w. Impedance is 50 ohms.

General Microwave Corp., Dept. ED, 47 Gazza Blvd., Farmingdale, N. Y.

NEW LITERATURE

Planar Semiconductors 261

Reliability, performance, cost and adaptability of planar diodes and transistors are discussed in this 12-page color brochure. Technical data, including performance curves and electrical specifications, are included. Planar transistors, manufactured with a protective oxide coating, are compared with their mesa equivalents. Fairchild Semiconductor Corp., 545 Whisman Road, Mountain View, Calif.

RF Interference Filters 262

Radio-frequency interference filters designed to reduce conducted interference in shielded-enclosure test activities and ground-support equipment applications are described in this eight-page publication. Entitled "Shielded Room and Ground Support Equipment Filters", the booklet covers the firm's complete line. Genistron, Inc., Sales Dept., 6320 W. Arizona Circle, Los Angeles 45, Calif.

Environmental Data 263

Common conversion factors, formulas, and data on vibration, shock, pressure and other dynamic phenomena are given in this pocket folder. It is intended primarily for the environmental engineer. The folder has 27 sections, each devoted to a particular topic from the basic trigonometric formulas to a graph of piezoelectric transducer response. Endevco Corp., 161 E. California Blvd., Pasadena, Calif.

Electroplating 264

A method of electroplating without requiring immersion tanks is described in this eight-page brochure. Localized areas, it is said, can be plated, with little masking required. Sifco Metachemical, Inc., 935 E. 63rd St., Cleveland 3, Ohio.

Plugs, Connectors and Switches 265

Banana plugs, phone jacks, alligator clips, test leads, cable connectors, toggle switches and miscellaneous related items are described and illustrated in this 32-page catalog. Physical and electrical specifications and prices are included. GC Electronics Co., Rockford, Ill.

NEW moderately priced high-precision SLOTTED LINES

- Rated residual VSWR under 1.010; rated error in detected signal under 1.005.

An AMCI Type 2181 Slotted Line with interchangeable precision tapered-reducers provides for accurate measurements in several transmission line sizes from Type BNC to 1⅝" or larger. An untuned rf probe is supplied as part of the slotted line. Several tunable detector probes are available as optional accessories

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*Including an input adapter to Type N and an untuned rf probe but excluding output tapered reducers and tunable probes. Prices are F.O.B. Boston, Mass., and are subject to change without notice.

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ALFORD Manufacturing Company 299 ATLANTIC AVE. BOSTON, MASS.

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NEW LITERATURE

Measuring Instruments **266**

In 96 pages, Catalog S describes over 250 instruments, counting systems, radionucleides and nuclear accessories. Much of the catalog is devoted to new products. Illustrations and technical data are included for each device. Nuclear-Chicago Corp., 359 E. Howard Ave., Des Plaines, Ill.

Toroidal Cores

Basic design information tips and formulas for toroidal cores are given in this 14-page handbook. Included are temperature curves, analysis of core loss, dc resistance, eddy current loss resistance, hysteresis loss resistance and self-capacitance. *Request on company letterhead from Connolly and Co., Dept. ED, P. O. Box 295, Menlo Park, Calif.*

Silicon Diodes **267**

Eighty-six glass silicon diodes are cataloged in this four-page brochure, as well as 35 general purpose and 51 computer types. Technical specifications are given. Computer Diode Corp., 250 Garibaldi Ave., Lodi, N. J.

Long-Life Vacuum Tubes **268**

Specifications, descriptions and dimensional drawings for the firm's vacuum tubes are given in this 26-page handbook. Manufacturing techniques and quality control procedures are also described. State Labs, Inc., 215 Park Ave. S., New York 3, N. Y.

Low-Pressure and Flow Switches **269**

Complete specifications, details and prices on low-pressure switches and velocity-actuated flow switches are described in this 30-page catalog. Design information and dimensional diagrams are included. The Henry G. Dietz Co., Inc., 12-16 Astoria Blvd., Long Island City 2, N. Y.

Flashtubes for LASERS **270**

Flashtubes capable of driving LASERS are described in this four-page booklet. Information on operation and application is included. Data on power requirements and capabilities of three assemblies are given. General Electric Co., Dept. LP-15, Nela Park, Cleveland 12, Ohio.

DC Power Supplies 271

The firm's model CVQ transistorized power supply is described in this eight-page brochure. Theory of operation of the 100-w, regulated supply is discussed. Specifications are included. Sola Electric Co., Busse Road at Lunt, Elk Grove Village, Ill.

Clutches and Brakes 272

Electromagnetic clutches and brakes, mechanical clutches, torque indicators, torque standards and multi-speed transmissions are described in 40-page manual No. 361. Engineering and applications information is included. Autotronics, Inc., Dept. 30, Florissant, Mo.

Photoelectric Systems 273

Applications of photoelectric systems in automation are described in this 20-page bulletin, No. 611. Light sources, photo units, electronic controls and timers are discussed, with electrical and physical specifications included. Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J.

Temperature-Measuring Paints 274

Paints and crayons which can be used to measure surface temperatures are described in this folder. Pigments change color at specified temperatures, indicating whether surface is hotter or colder than desired. Princeton Div., Curtis-Wright Corp., Princeton, N. J.

Semiconductor Technical Bulletins 275

A series of technical bulletins on semiconductors are available. No. 60S17-1, "Index of Technical Bulletins", lists technical data sheets on the firms semiconductor products. No. ICE-235, "RCA 2N404 Family", gives data on six transistors. No. ST-1945, "Reliability of the RCA-USAF-2N404 at High Stress Levels", presents test data on the 2N404 transistor. No. ICE-229, RCA Silicon Rectifier Interchangeability Guide", lists available silicon rectifiers. No. ICE-228, "Application Guide-RCA VHF Silicon Transistors", includes information on transistor design, construction and circuitry. No. ST-2106, "Micromodule Reliability Status Report", presents reliability information on the firm's micromodules. Radio Corp. of America, Semiconductor and Materials Div., Somerville, N. J.

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Permit positioning foil-wrapped components A & B closely, minimizing interaction due to magnetic fields . . . making possible compact and less costly systems.

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Composite photo to demonstrating that magnetic shielding qualities of Rigid Netic Alloy Material are not significantly affected by vibration shock (including dropping or bumping) etc. Netic is non-retentive, requires no periodic annealing.

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Choose the Ideas which suggest a solution to a problem of your own or stimulate your thinking or which you think are clever.

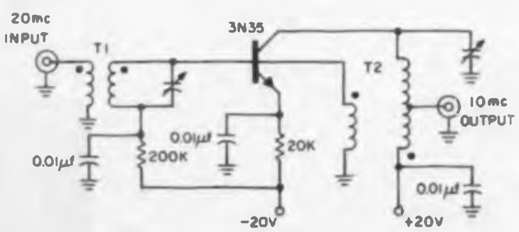
The Ideas chosen as the most valuable in each issue will be eligible for the $1,000 Idea of the Year award.

So vote for the Ideas you find most valuable. And, after you've voted, why not send in an Idea of your own?

Simple Circuit Halves 20-Mc Supply Frequency — 734

A simple circuit was required to supply a 10-mc signal from a 20-mc source. The circuit shown fulfilled the requirement quite adequately.

Transformer T_1 is resonant at the 20-mc input frequency. Transformer T_2 is resonant at 10 mc, with a portion of the 10-mc energy coupled back into the transistor. The loop gain is low enough to keep the circuit from oscillating with the drive removed.



Frequency divider has two resonant circuits—the input circuit at 20 mc, the output at 10 mc.

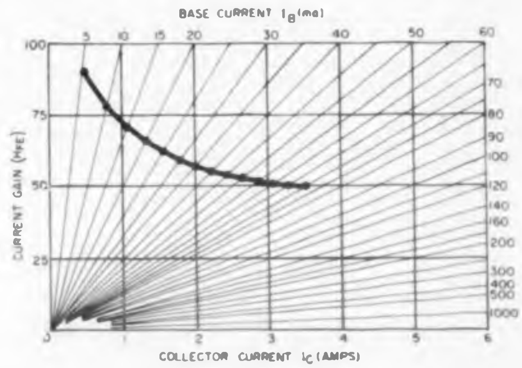
Herbert F. Verse, Jr., Research Engineer, Jet Propulsion Laboratory, Pasadena, Calif.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 734.

Power Gain Plot Can Be Made Directly From Measurements — 733

When plotting the large current gain of power transistors the plot can be made rather quickly by eliminating the division step.

Current gain is given by $H_{FE} = I_c/I_b$. The graph paper is used as shown in the figure, with base current values laid out beforehand on the graph. The intersection of the measured base current line and the collector current abscissa yields a correct point on the H_{FE} vs I_c curve.



Current gain H_{FE} is plotted directly from I_b and I_c measurements by laying out base current "guidelines" beforehand.

John T. Lamb, Research Engineer, The Tappan Co., Mansfield, Ohio.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 733.

Fourth $50 "Most Valuable of Issue" Award For Curve-Tracing Attachment

Chester B. Shapero, self-employed research engineer of Cupertino, Calif., has won ELECTRONIC DESIGN's fourth $50 Most Valuable of Issue Award.

Mr. Shapero receives the award for his Idea for Design, "Low-Cost Scope Traces Transistor Characteristic Curves," which appeared in the April 12 issue. The idea described a circuit which enabled a low-cost oscilloscope to be used for displaying transistor characteristic curves.

How You Can Participate

Rules For Awards

Here's how you can participate in Ideas for Design's Seventh Anniversary Awards: All engineer readers of ELECTRONIC DESIGN are eligible.

Entries must be accompanied by filled-out Official Entry Blank or facsimile. Ideas submitted must be original with the author, and must not have been previously published (publication in internal company magazines and literature excepted).

Ideas suitable for publication should deal with:

1. new circuits or circuit modifications
2. new design techniques
3. designs for new production methods
4. clever use of new materials or new components in design
5. design or drafting aids
6. new methods of packaging
7. design short cuts
8. cost saving tips

Awards:

1. Each Idea published will receive an honorarium of $20.
2. The Idea selected as the most valuable in the issue in which it appears will receive $50.
3. The Idea selected as the Idea of the Year will receive a Grand Prize of $1,000 in cash.

The Idea of the Year will be selected from those entries chosen Most Valuable of the Issue.

Most Valuable of the Issue and Idea of the Year selections will be made by the readers of ELECTRONIC DESIGN. The readers will select the outstanding Ideas by circling keyed numbers on the Reader-Service cards. Payment will be made eight weeks after Ideas are published.

Exclusive publishing rights for all Ideas will remain with the Hayden Publishing Co.

SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

Ideas-for-Design Editor
ELECTRONIC DESIGN
850 Third Ave.
New York 22, N. Y.

Idea (State the problem and then give your solution. Include sketches or photos that will help get the idea across.)

(Use separate sheet if necessary)

I submit my Idea for Design for publication in ELECTRONIC DESIGN. I understand it will be eligible for the Seventh Anniversary Awards—$20 if published, $50 if chosen Most Valuable of Issue, $1,000 if chosen Idea of the Year.

I have not submitted my Idea for Design for publication elsewhere. It is entirely original with me and does not violate or infringe any copyrights, patents or trademarks or the property rights of any other person, firm or corporation.

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For Additional Entry Blanks, circle **750** on Reader-Service Card.

Long Period Multivibrator Reduces Timing Capacitor Size 748

Building a transistorized monostable multivibrator for pulse widths of 10 msec or more can be a problem if space is at a premium. The problem arises because the finite β of Q_1 (circuit *a* in the figure) places an upper limit on resistor R. This, in turn, means that C must be large, both electrically and physically, to yield the large RC product required for long pulse widths.

The maximum permissible value of R is given approximately by:

$$R = \frac{V_1 - 1.3}{V_1/R_L \cdot \frac{1}{\beta}}$$

The quantity 1.3 accounts for the drop across CR_1 and the base-to-emitter junction of Q_1 when the transistor is on. V_1R_L is the collector current of Q_1 when Q_1 is on. Not considered is the effect of the collector-to-emitter drop of Q_1 when it is on, and the bleeder current required to hold Q_2 off.

As an example, consider the typical values below:

$$V_1 = 30 \text{ v}$$
$$R_L = 3.3 \text{ K}$$
$$\beta = 40$$

Then,

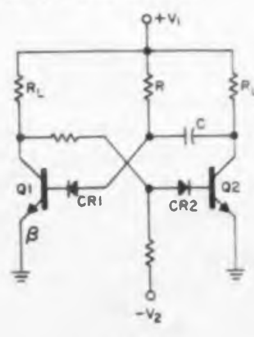
$$R = \frac{30 - 1.3}{\frac{30}{3.3} \cdot \frac{1}{40}} = 126.3 \text{ K}$$

If a pulse width of 20 msec is required, the time constant is derived from:

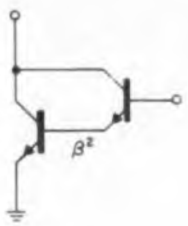
$$t \approx 0.68\ RC$$

Choosing a standard value for R of 120 K, we have

$$C = \frac{20 \times 10^{-3}}{0.68 \times 120 \times 10^{3}} = 0.245\ \mu f$$



(a) Maximum value of R in this monostable multivibrator is limited by the value of β for transistor Q_1. Thus, for long pulse widths, capacitor C must be large.



(b) Replacing Q_1 with two-transistor Darlington connection effectively squares the value of β. This allows a larger R, and reduces both the value and size of C.

Compared to the other components in the circuit, this capacitor is physically very large. This is especially true if the capacitor must be both accurate and stable.

However, the size of the capacitor can be considerably reduced if transistor Q_1 is replaced by the two-transistor Darlington connection. The over-all β is now 40 x 40 = 1,600, and R can be 40 times larger than before. Hence, C can be 40 times smaller. Using a practical value of R = 1 meg, we have

$$C = \frac{20 \times 10^{-3}}{0.68 \times 1 \times 10^{6}} = 0.0294\ \mu f$$

Obviously, a much smaller capacitor will be required.

W. E. Zrubek, Design Engineer, Westinghouse Electric Corp., Baltimore, Md.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 748.

One-Shot Pulse Output Has Greater Than 100% Duty Cycle 746

Greater than 100 per cent duty cycle pulse generators can be designed by connecting two one-shot multivibrators in series.

Such a generator was needed to produce display pulses variable from microseconds to seconds. The pulses were to be triggered by a four-decade, preset counter when the counter reached a preselected number. The maximum frequency of the display was 100 kc.

At the end of the display pulse time, the counters were to be reset, ready to be triggered again, within 10 μsec. Thus, if the preset selector is set to a low number such as 0002, and if the counter receives pulses at a 100-kc rate, coincidence is again reached 20 to 30 μsec after the counter is reset to zero.

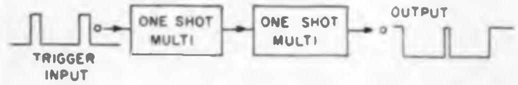
Thus, if the output display pulse time is 1 sec, the pulse generator has to operate with a duty cycle of 99.998 per cent or better. That is, it must be retriggered within 20 μsec after the elapse of the 1-sec pulse.

A single one-shot multi was ruled out because of duty cycle limitations. However, the problem was simply solved by connecting two ordinary one-shots in series.

The first multi triggered the second, with the output of the second multi initiating the zero set of the counters. The display pulse time was the sum of the periods of the two multivibrators.

By the time the period of the second multi is over, the first multi is ready to accept a trigger. The duty cycle of this combination is better than 100 per cent.

Arpad Somlyody, Circuit Design Analyst, Burroughs Corp., Electronic Components Div., Plainfield, N. J.



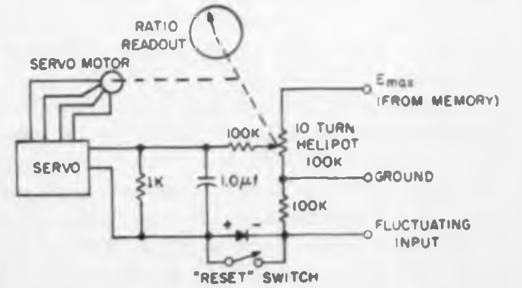
Pulse output with greater than 100 per cent duty cycle can be obtained by connecting two one-shot multivibrators in series.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 746.

Servo Circuit Compared Antenna Pattern Nulls, Peaks 735

In developing an automatic antenna pattern computer a simple and reliable method was required to compare the pattern nulls with the lobe peaks. In addition, not only was the greatest magnitude lobe peak to be selected, but also the "deepest" null.

The maximum lobe peak is easily measured and selected for greatest amplitude with a simple voltage memory device, such as a capacitor. Locating the "deepest" null, how-



Automatic readout supplies lobe peak to null depth ratios of antenna pattern.

ever, presents circuitry problems which can get complex.

This problem was solved by using a simple servo bridge balancing circuit with a high back-resistance silicon diode. The servo used with this diode is able to proceed in the direction of the greatest ratio of lobe peak to null depth. When the diode is properly oriented, the servo direction cannot be reversed. To regain the original 1:1 ratio, it is only necessary to short out the diode momentarily. The servo then swings back to its unity ratio.

Edwin S. Oxner, Sr. Engineer, Varian Associates, Radiation Div., Palo Alto, Calif.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 735.

Tunnel Diode Trigger Circuit Can Reset Itself 731

The tunnel diode trigger circuit, Fig. 1, resets itself without the need for a clipping line or additional reset pulses. A trigger applied as shown switches the tunnel diode from the low state (state *1*) to the high state (state *2*). The diode now presents a higher impedance than in the original state, and its current decreases to I_2, Fig. 2. The original current through the tunnel diode is

$$I_1 = \frac{V_s - V_1}{R' + R}$$

If capacitor C were sufficient to maintain the voltage across R', the current through the tunnel diode immediately after switching to state *2* would be

$$I_2 = \frac{V_s - V_2 - V_{R'}}{R}$$

Since the voltage across capacitor C changes with the time constant of C, R, and R' in parallel, the current through the tunnel diode will decrease toward

$$I' = \frac{V_s - V_2}{R' + R}$$

(continued on p 164)

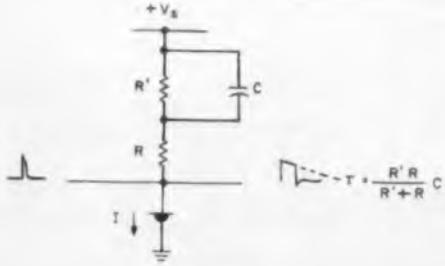


Fig. 1. Presence of voltage holding capacitor C allows tunnel diode trigger circuit to reset itself.

IDEAS FOR DESIGN

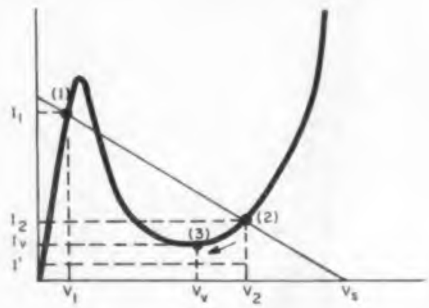


Fig. 2. After being switched to state 2 by trigger pulse, capacitor C causes current to decrease to I_v and the diode switches back to its original state.

Thus the voltage across the tunnel diode will decrease exponentially, moving from point *2* to point *3*.

When the current through the tunnel diode reaches I_v (the valley current), the diode will switch back to its original state.

The conditions for the tunnel diode to reset to state *1* are:

$$I' < I_v \text{ where } I' = \frac{V_s - V_2}{R' + R}$$

Since V_s and R are chosen by normal circuit considerations, and I_v and V_2 are obtained from the tunnel diode specifications, the value of R' is determined as:

$$R' = \frac{V_s - V_2 - I_v R}{I_v}$$

The "on-time" of the tunnel diode is determined by the time constant T where:

$$T = \frac{R'RC}{R' + R}$$

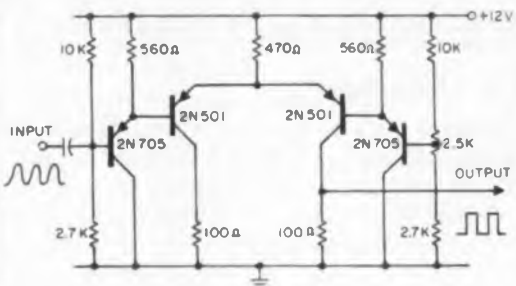
Since the values of R' and R are determined by the previous considerations, the on-time of the trigger circuit is fixed by the choice of the value of C.

Robert N. Larsen, Assist. Electrical Engineer, Argonne National Laboratory, Argonne, Ill.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 731.

Emitter-Coupled Limiter Produces HF Square Waves 732

A sine-to-square wave converter can be easily designed by using diode clippers. But



High frequency sine-to-square converter is made up of transistorized emitter-coupled lihiteds.

the rise time of the square wave then depends on the magnitude of the input sine wave. Thus, the ratio of the peak-to-peak values of the input to the output should be at least 3.

However, an emitter-coupled limiter not only needs a much smaller input voltage, but its rise-time is limited only by the switching times of the transistors. These can be reduced by driving the switching transistors out of a common collector stage.

The circuit shown produces, once the potentiometer is adjusted, a fast rise time, symmetrical square wave. A 5-mc sine wave with 2 v peak-to-peak at the input gives a 2-v peak-to-peak square wave with a rise time of approximately 20 nsec. For an input voltage of 6 v peak-to-peak, the rise time reduces to less than 10 nsec with a slight overshoot.

Harald Hahn, Assist. Electrical Engineer, Brookhaven National Laboratory, Upton, L.I., N.Y.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 732.

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Choose the Ideas which suggest a solution to a problem of your own or stimulate your thinking or which you think are clever.

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So vote for the Ideas you find most valuable. And, after you've voted, why not send in an Idea of your own?

REPORT BRIEFS

Tem Diode Switching

The theory and technique for the design of a broadband (100-to-1 frequency range) TEM microwave diode switch are presented. A coaxial transmission line switch has been constructed that provides 26 db or greater isolation and insertion loss ranging from 1.6 db to less than 1 db from 40 mc to 4000 mc. An analysis is given of the switching action of one and of two or more diodes. Also discussed is the biasing of the center conductor of a TEM transmission line over broad frequency bandwidths so as not to interact with the rf signal. *Theory of TEM Diode Switching, Robert V. Garver, Diamond Ordnance Fuze Laboratories, Washington, D. C., Oct., 1960, 56 pp, Microfilm $3.60, Photocopy $9.30. Order PB 153579 from Library of Congress, Washington 25, D. C.*

RFI-Duplexer Tubes

An investigation was conducted on several types of TR duplexer tubes and a waveguide filter commonly used in systems, to determine their effectiveness in rejecting spurious microwave radiation. The devices studied were all designed for operation in the 2.8-Gc frequency band. The low power level characteristics of these devices were checked over a frequency range of 2.6 to 35 Gc. Results of the investigation showed that neither the TR tube nor the waveguide filter can provide adequate protection against unwanted signals at frequencies higher than the system frequency. *Characteristics of Microwave Duplexer Tubes Under Spurious Radiation Conditions, Irving Reingold, Army Signal Research and Development Labs., Fort Monmouth, N. J., March 31, 1959, 27 pp, Microfilm $2.70, Photocopy $4.80. Order PB 147821 from Library of Congress, Washington 25, D. C.*

Waveguide Components

Presents the design and development of components for use in a circular waveguide system employing the low-loss TE_{01} circular electric wave mode. Components were investigated with regard to direct scaling for use with 2.710-in. ID and 0.725-in. ID circular waveguide at 9.375 Gc and 35 Gc, respectively.

Several new components were developed. These include a straight waveguide section, a flexible waveguide section, couplings, transistions, bends, a mode absorber, a rotary joint, a high-power load, a low-power load, waveguide switches and windows. Proposed designs are presented for directional couplers and ferrite components. All experimental work was done in the X band. *Investigation and Development of Circular Waveguide Components, Alva C. Todd, Dick M. Joe, Demetrios P. Kanellakos, Armour Research Foundation, Columbus, Ohio, April, 1959, 136 pp, Microfilm $6.90, Photocopy $21.30. Order PB 150589 from Library of Congress, Washington 25, D. C.*

Printed Antennas

Discusses several types of printed antenna arrays and related feeds and baluns. Detailed consideration is given to the Franklin array, Chireix-Mesny array, and the capacitively coupled collinear array. Experimental techniques, such as probing the magnitude and phase distribution of the current along a printed array and measuring the impedance and phase velocity that characterize printed balanced lines are described. The antenna performance characteristics for the types of arrays that were studied are given including gain, loss, impedance, size, side-lobe levels, and half-power beamwidths. *Study of Printed Antennas, J. A. McDonough, R. G. Malech, J. Kowalsky, Airborne Instruments Lab., Inc., Mineola, N. Y., Aug., 1955, 57 pp, Microfilm $3.60, Photocopy $9.30. Order PB 150667 from Library of Congress, Washington 25, D. C.*

Transistors

A hybrid parameter equivalent circuit for the common emitter connection is developed. The basic circuit is modified for high-frequency use in such a way that the parameters of the equivalent circuit are independent of frequencies. Methods of measuring these various parameters are discussed in detail and circuit diagrams are provided for each such measurement. The proposed transistor equivalent circuit is then used in the analytical development of circuit design equations and criteria for low-pass, high-pass, and band-pass amplifiers. *Transistor Equivalent Circuit Criteria, Thomas L. Martin Jr., David J. Sakrison, et al, Arizona University, Tucson, Ariz., Aug. 30, 1956, 83 pp. Microfilm $4.80, Photocopy $13.80. Order P B 147539 from Library of Congress, Washington 25, D. C.*

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CIRCLE 185 ON READER-SERVICE CARD

REPORT BRIEFS

Radiation Damage in Semiconductors

A diode resistant to nuclear radiation damage was constructed as a result of extensive studies of nuclear irradiation effects on semiconducting materials. The diode uses p-type germanium with resistivity of about 0.20 ohm-cm as the base material. Principal object of the study was to determine the mechanisms by which radiation degrades semiconductor devices. The researchers state that one of the most significant accomplishments of the program was the development of the instrumentation and techniques of measurement used with the General Atomic electron linear accelerator. *Research in Radiation Damage in Semiconductors, J. W. Harrity and others, General Dynamics Corp. for U. S. Air Force, Feb. 1960, 157 pp, $3.00. Order PB 161673 from OTS, Washington 25, D. C.*

Ground Support Functions

This study was conducted to determine the relations between automation and personnel requirements for guided missile ground support functions. Three systems—Snark, Bomarc, Mace—were investigated in regard to organization-level maintenance of electronic equipment. The study shows that automatic equipment, itself, is not the cause of increased personnel requirements, but rather the use to which automation is put within the over-all support organization. *Automation and Personnel Requirements for Guided Missile Ground Support Functions, General Electric Co. for Wright Air Development Center, May 1959, pp 49, $1.25. Order PB 151978 from U. S. Department of Commerce Field Office, 1031 S. Broadway, Los Angeles 15, Calif.*

Ceramic Tubes

This Air Force "phasing-in" study reports on the results of a survey to facilitate the prompt use of newly developed high-temperature ceramic tubes and components in aviation electronic equipment. Many of the supporting components investigated were still in the research and development stages. Various materials and construction methods were tested in a search for simple, efficient, and economical means of installation and servicing. *Adaptation of Ceramic Tube Types,* *Aerovox Corp. for Wright Air Development Center, June 1959, 166 pp, $3.00. Order PB 151922 from U. S. Department of Commerce Field Office, 1031 S. Broadway, Los Angeles 15, Calif.*

Sampled-Data Systems

Theory of the operational analysis of the finite, pulse-width system is developed. The closed-form expression of the response of such a system is described by several well-known operators such as the z-transform, the modified z-transform and the simple form of the p-transform. Finding the incremental responses and their superposition is the basic principle of the theory. It is applied to two-sampler systems as well as multirate sampling systems. *Operational Analysis of Finite Pulsed Sampled-Data Systems, T. Nishimura, Electronics Research Laboratory, University of California, Berkeley, Calif., May 1960, 39 pp, Microfilm $3.00, Photocopy $6.30. Order PB 149092 from Library of Congress, Washington 25, D. C.*

Reliability

A specific mathematical model is formulated for improving system reliability with a minimum of effort. Also shown is how to determine the allocation of effort among subsystems which yields the desired system reliability at minimum total expenditure of effort. *Increased Reliability With Minimum Effort, Arthur Albert, Frank Proschan, Applied Mathematics and Statistics Labs., Stanford University, Calif., Oct. 9, 1959, 29 pp, Microfilm $2.70, Photocopy $4.80. Order PB 149943 from Library of Congress, Washington 25, D. C.*

Speech Statistics

At a symposium co-sponsored by the Leningrad State University and the Speech Section of the Commission on Acoustics, USSR Academy of Sciences, papers were presented by Soviet scientists on the investigation of speech, linguistics, telephonic acoustics, physiology, mathematics, and related subjects. Fourteen of these research reports on statistical methods have been translated and compiled in this publication. *Problems of Speech Statistics, translated from a Russian-language publication of the Leningrad State University, 1958, 137 pp, $2.75. Order 6111792 from OTS, Washington 25, D. C.*

YOUR CAREER

Over 8,000 Requests For "Self-Tests"

The do-it-yourself tests put out by the General Electric Company's Light Military Electronics Department, Utica, N. Y., have proved surprisingly successful. LMED says 8,695 "self-tests" have been sent out in answer to requests.

These tests were originated by LMED as a recruiting "gimmick." They have been publicized in LMED's employment ads during the past year. The result, according to GE recruiter Ron Bach is that about 10 times as many names have come into LMED as might otherwise have been expected. The number and quality of the "hires" resulting from this greater number of "contacts" has been encouraging, Mr. Bach said.

The self-tests are made up of multiple-choice questions and each test averages about six pages in length. They cover the technical specialties of interest to LMED, ranging from electronic packaging to radar and digital computer design. Sample questions from two of the most recent of these tests, the one on digital computers and the sole nontechnical test of the series, are included here to show the nature of the questions. Using the answers given at the back of each test, an engineer can score himself and then, by comparing his score with the norms developed by LMED through testing its own engineers, he can see how he "stacks up" with engineers presently at LMED.

GE Doesn't Use Test Results in Its Own Recruiting

GE recruiters themselves do not pay any particular attention to what a man says his score was on one of these self-tests. GE does hope of course that the tests create the right "image" of attitudes and opportunities at LMED and that the tests serve to help applicants voluntarily pre-screen themselves. But the recruiters at LMED still believe that their personal interviews "in depth" are best for determining which men to make offers to.

Mr. Bach says he has found one particular line of questioning the most productive in separating out the better engineers. He first asks the engineer he is interviewing to describe the engineering organizations he has been with. Then, most important, he asks the man to describe in detail his functional relationship with those organizations. What were his individual responsibilities? A man

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- All forms are delivered unopened to one reliable specialist at ELECTRONIC DESIGN.
- Your form is kept confidential and is processed only by this specialist.
- The "circle number" portion of the form is detached before the application is sent to an employer, so that no company will know how many numbers you have circled.
- All original applications are placed in confidential files at ELECTRONIC DESIGN, and after a reasonable lapse of time, they are destroyed.

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Date of Birth ____________ *Place of Birth* ____________ *Citizenship* ____________

Position Desired ____________

Educational History

College	Dates	Degree	Major	Honors

Recent Special Training ____________

Employment History

Company	City and State	Dates	Title	Engineering Specialty

Outstanding Engineering and Administrative Experience ____________

Professional Societies ____________

Published Articles ____________

Minimum Salary Requirements (Optional) ____________

Use section below instead of Reader Service Card. Do not write personal data below this line. This section will be detached before processing.

Circle Career Inquiry numbers of companies that interest you

900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924

925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949

YOUR CAREER

who can't describe his responsibilities on past engineering jobs (and a great many can not, apparently) would probably not receive an offer through Mr. Bach.

Nontechnical Test Has Uncovered Good Administrators

An example of the self-screening potential of these tests has been the number of good men for nonengineering, administrative posts within LMED which the one nontechnical test in the group has helped uncover, Mr. Bach said. Nonengineers also read the ads for engineers, he said, and when they see that a nontechnical test is also available, they are encouraged to write to what they would have otherwise considered a hopelessly technical organization like LMED to inquire about the test and employment. Some of these nonengineering applicants have been employed in businesses as far removed from engineering as advertising agencies.

What Do the Tests Mean?

Since most of the tests are technical, engineers will have little trouble in understanding the right or wrongness of the answers. They may however question the relative meaning of their scores as compared to the norms given for the GE engineers. For example, one ELECTRONIC DESIGN editor who did not think himself a match for a LMED computer designer was surprised to find that he self-scored in the second to highest (there were five) group which according to GE indicated he "shows probability of excellent performance in intermediate to high-level computer research, design and development." It was this editor's conclusion that multiple-choice questions favor the widely read person but possibly disfavor the working designer who must concentrate in a certain area.

Nevertheless the tests make for a pleasant evening's exercise and with intelligent self-interpretation can be a quasi-quantitative indication of one's strengths and weaknesses.

Management Aptitude Test More Subtle

At first sight the answers to the questions in the "Human Relations Quiz" look obvious. "This is what any company would expect you to say." Obviously a manager-type should "want to play cards with a neighbor and his wife" rather than "build some new furniture in the workshop" (question 5). Obviously he should "tend to identify more with his company than with a profession" (question 29).

Less obvious is question 27 which says that a good manager should not want his subordinates to run to him whenever they had a question but to work out their problems for themselves. Also less obvious is question 12 which says that a good manager ought to be able to readily allay other people's suspicions.

The weighing values given for the answers to the questions help to understand the logic behind the test (actually as GE explains, the tests were developed by the empirical procedure of relating responses of GE managers and individual worker types. A top weight of six points is given the answer to question 38 which indicates that a good manager type should not respect people who seem uncertain about things. But only two points are given for the answer to question 23 which indicates that a good manager thinks that people should try to behave ethically even when it means personal sacrifice.

Interested Engineers Should Obtain Complete Tests

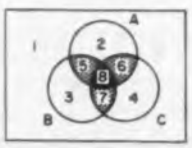
These sample questions and answers will give some idea of the tests. However, engineers who are seriously interested should obtain the complete tests by writing: Technical Recruiting, Light Military Electronics Dept., French Road, Utica, N. Y.

Sample Questions From GE Self-Test

Logic Circuits and Digital Computers

1. In a junction transistor the base-to-collector current amplification factor is in the range of:
   - *a.* 10^{-8} *to* 10^{-6}
   - *b. 0.9 to 1.0*
   - *c. 20 to 100*
   - *d. 700 to 900*

7. In the Venn diagram below, areas correspond to Boolean functions of the variables A, B, and C. How many of these represent MINTERMS?

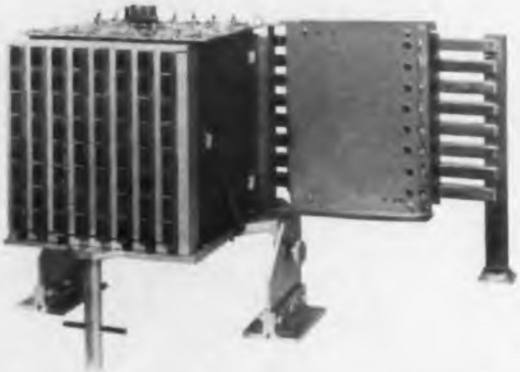


   - *a. 1*
   - *b. 2*
   - *c. 3*
   - *d. 7*
   - *e. 8*

8. With reference to the schematic circuit diagram below (if A = positive voltage and $\overline{A}$ = no voltage) the Boolean func-

Opportunities in Basic Research or Development in the fields of

ELECTROMAGNETIC THEORY & ANTENNAS



■ Requirements of new and continuing projects concerned with space vehicle communications, navigation, and radar have created new openings for electromagnetic theory specialists as well as antenna engineers. The scientists and engineers of the Research and Development Division of the Hughes Aircraft Company Aerospace Group in Culver City are providing broad scientific and technical leadership to government and company funded programs on advanced airborne and space electronic systems, air to air missiles, ballistic missiles, and satellite and interplanetary communication systems. As part of this team, the Antenna Department is responsible for a diversified program of antenna research and development in the following specific areas:

1. Advanced techniques for space communication and navigation.
2. Information theory and data processing applied to antenna systems.
3. Statistical analysis of scattering propagation.
4. Pattern synthesis from sources on arbitrarily curved surfaces.
5. Aperture control by application of solid state devices.
6. Multi-function aperture and feed capabilities.

Immediate assignments exist for scientists and engineers of superior ability who meet the qualifications in one of the following categories:

RESEARCH ■ Advanced degrees and experience in electromagnetic theory ■ Interest in fundamental research in antennas, wave propagation, scattering theory, plasma effects on electromagnetic radiation, and solid state antennas.

DEVELOPMENT ■ Graduates in E. E. or Physics or extensive experience in lieu of degree. ■ Minimum of three years of professional experience in monopulse and conical lobing antennas in reflector and array configurations, electronically scanned arrays, inflatable and erectable antennas, shaped beam arrays from curved surfaces and signal processing antenna systems.

If you meet the above qualifications and are interested in joining other superior scientists and engineers at Hughes, please airmail your resume to **MR. ROBERT A. MARTIN,** Supervisor Scientific Employment, Hughes Aerospace Engineering Division, 11940 West Jefferson Blvd., Culver City 50, California.

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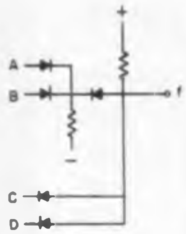
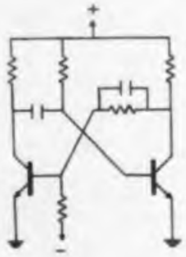


tion f is:

a. $AB + CD$
b. $(A + B)\ CD$
c. $(AB + C)\ D$
d. $(A + B)\ (C + D)$
e. $ABCD$

9. The monostable multivibrator below



a. Is used in counters.
b. Generates a gating pulse.
c. Is free running.
d. Will not work as drawn.

9. Circuits employing NOR logic

a. Are found in superspeed computers.
b. Were first used in the NORC computer.
c. Are based upon negative resistances.
d. Contain blocks which execute the negative -OR operation.
e. Contain transistors and resistors.

Professional Inventory on Human Relations

1. If you had to choose an occupation other than the one you now have, which would you rather be:
a. Physician *b. Explorer*

5. How would you rather spend an evening:
a. Building some new furniture in the workshop
b. Playing cards with a neighbor and his wife

7. Which would you *least* like to do:
a. Add several columns of figures
b. Be interviewed for a new job

9. You are usually able to "put yourself in someone else's shoes" in order to understand his point of view:
a. True *b. Not true*

10. Are you a keen judge of other people's motives:
a. Yes *b. No*

11. Opportunity to contribute to basic scien-

tific knowledge is highly important to me:

a. Agree *b. Disagree*

12. Can you readily allay other people's suspicions:

a. Yes *b. No*

14. It's more important that a man we hire can do his work well than that he makes friends rapidly among his work associates:

a. Agree *b. Disagree*

23. People should try to behave ethically, even when it means some personal sacrifice:

a. Agree *b. Disagree*

24. When internal tensions occur, do you give full attention to their resolution:

a. Yes *b. No*

27. I would rather that a man who works under my supervision:

a. Consults me whenever he had a doubt
b. Tries to work out problems for himself

29. I tend to identify more with my profession and work than with any one company:

a. True *b. Not true*

38. Do people who seem unsure and uncertain about things lose your respect:

a. Yes *b. No*

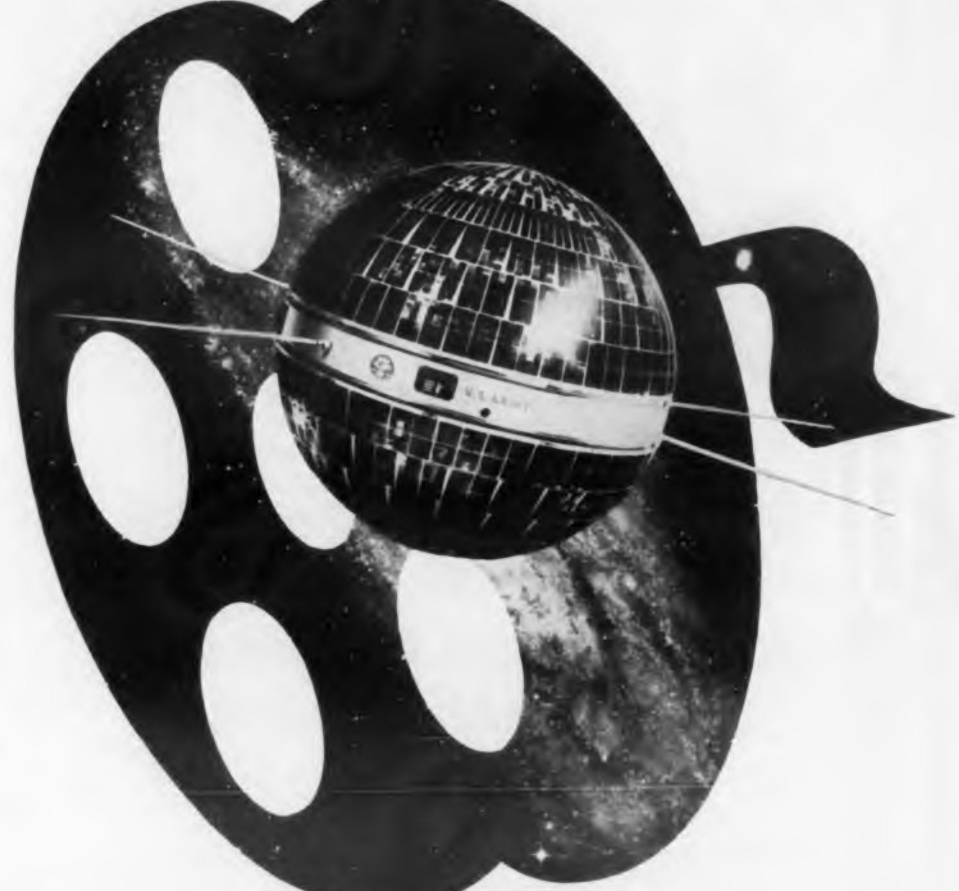
Answers to Sample Questions

Computer Quiz:

1.	*c*
7.	*e*
8.	*b*
9.	*b*
39.	*d*

Human Relations Quiz:

		Weighing Factor
1.	*a*	4
5.	*b*	6
7.	*a*	4
9.	*a*	2
10.	*a*	4
11.	*b*	6
12.	*a*	4
14.	*a*	4
23.	*a*	2
24.	*b*	4
27.	*b*	4
29.	*b*	4
38.	*a*	6



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2N575	DA3F3		
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301	311	321	331	341	351	361	371	381	391	401	411	421	431	441	451	461	471	481	491	501	511	521	531	541	551	561	571	581	591
302	312	322	332	342	352	362	372	382	392	402	412	422	432	442	452	462	472	482	492	502	512	522	532	542	552	562	572	582	592
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602	612	622	632	642	652	662	672	682	692	702	712	722	732	742	752	762	772	782	792	802	812	822	832	842	852	862	872	882	892
603	613	623	633	643	653	663	673	683	693	703	713	723	733	743	753	763	773	783	793	803	813	823	833	843	853	863	873	883	893
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609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899

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1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232	242	252	262	272	282	292
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233	243	253	263	273	283	293
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234	244	254	264	274	284	294
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1 mw INPUT!

OR MEET YOUR REQUIREMENTS WITH ONE OF THESE BENCH-PROVEN hp TWT AMPLIFIERS

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hp 490B TWT Amplifier, 2 to 4 GC, provides at least 10 mw output, 30 db gain with noise figure of less than 25 db, excellent pulse modulation characteristics and helix modulation.

hp 491A TWT Amplifier, 2 to 4 GC, has a full range output of 1 watt, with minimum gain of 30 db. Combined with a 1 mw S-Band signal generator such as hp 616A it provides a versatile full watt source for high power testing.

hp 492A, 4 to 8 GC, and hp 494A, 7 to 12.4 GC, are 30 db gain TWT amplifiers providing 20 mw output. Offering amplitude, pulse, phase or FM modulation, they are ideal for use as broadband amplifiers or isolating buffer stages.

	hp 490B	hp 491A	hp 492A	hp 494A
Frequency Range:	2 to 4 GC	2 to 4 GC	4 to 8 GC	7 to 12.4 GC
Gain:	30 db min.	30 db min.	30 db min.	30 db min.
Output Power:	10 mw min. into 50 ohm load	1 watt min. into 50 ohm load	20 mw min. into 50 ohm load	20 mw min. into 50 ohm load
Noise Figure:	Less than 25 db	Less than 30 db	Less than 30 db	Less than 30 db
Pulse Rise & Decay Time:	Approx. 0.015 μsec.	Mod. not provided	Approx. 0.015 μsec	Approx. 0.015 μsec.
Input Impedance:	50 ohms, SWR less than 2	50 ohms, SWR less than 2	50 ohms, SWR less than 2	50 ohms, SWR less than 2
Output Internal Impedance:	50 ohms, SWR less than 3	50 ohms, SWR less than 3	50 ohms, SWR less than 3	50 ohms, SWR less than 3
Price (including tube):	$1,400.00	$1,400.00	$1,500.00	$1,800.00

Data subject to change without notice. Prices f. o. b. factory.

Call your hp representative today for full information on these versatile TWT Amplifiers.

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- Beta of 15 to 50 at $I_C = 5$ amp.
- Min. beta of 7.5 @ $I_C = 10$ amp.
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- JEDEC TO-36 package.
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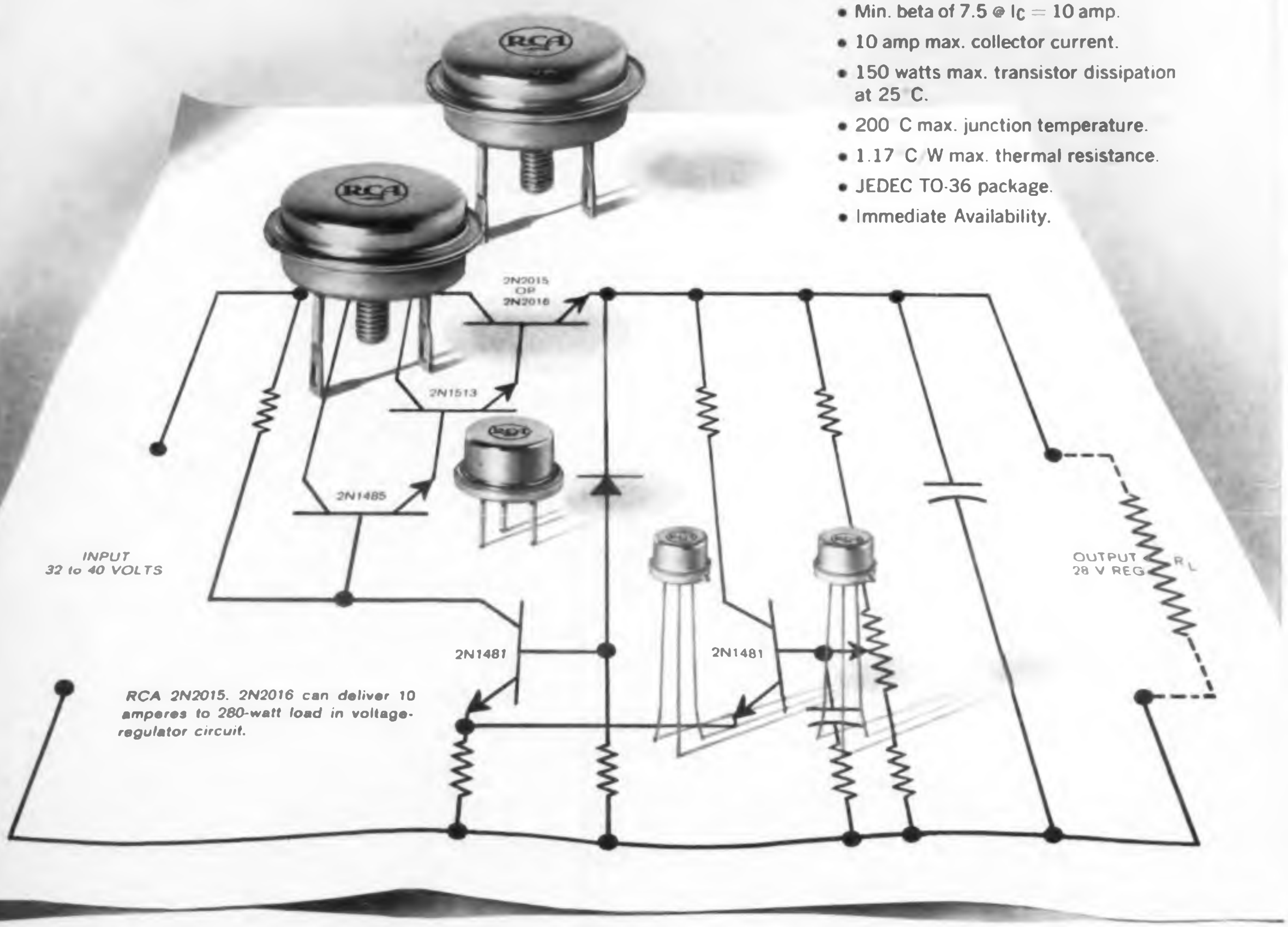

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