COMPANY CONFIDENTIAL

Engineering News

VOLUME 4 / NUMBER 2 FEBRUARY 1977 JOYCE LEKAS, EDITOR EXTENSION 6601 DELIVERY STATION 50/462
ASSOCIATE EDITORS: AL CARPENTER (X5468), BURGESS LAUGHLIN (X6071)

Ion Implantation At Tektronix

Also in this Issue:

In the spring of 1973, an ion-implantation system was installed in Tek Labs. Ion implantation is an alternative technique to thermal diffusion for doping semiconductors to obtain certain characteristics. The first concern was to develop new high-performance devices, then to improve the yield of some existing devices by replacing some diffusion steps with ion implantation.

Ion Implantation vs Diffusion

Diffusion and ion implantation doping both require several masking and etching steps to define functional features. These steps are alternated with one or more doping steps.

Diffusion doping takes place in a high-temperature furnace. The depth of a diffused PN junction depends on the impurity element, temperature, and time.

With ion implantation, the junction depth can be accurately controlled; the junction location and total doping can be independently varied. This flexibility is not available with diffusion technology without considerable manipulation of the temperature and deposition cycles during the entire process. As frequency requirements increase, devices become smaller and junction depths become more shallow. Dose control in the active channel of a JFET is important in controlling V_p, the pinch-off voltage characteristic. V_p is significantly affected by very small changes in the doping of the channel.

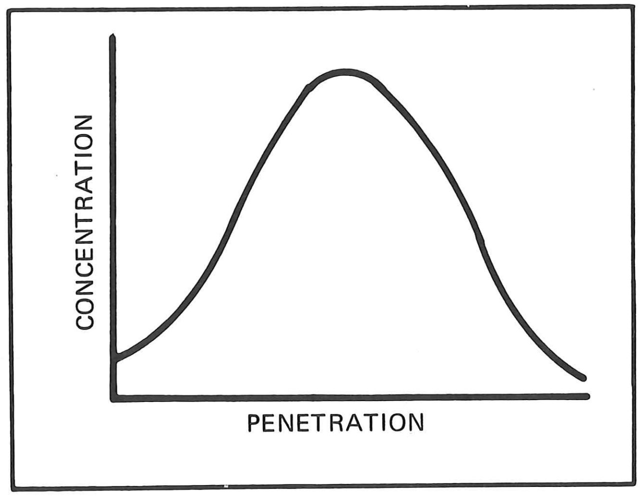


Figure 1. Depth of implanted ions at a uniform energy level.

Ion Implantation Process

The desired element, usually boron or arsenic, is introduced into an ionizer and ions are drawn into an accelerator by induction of a voltage drop. The ions are accelerated to 20-200 keV and passed through a magnetic field which bends them towards a target. The selected ions are passed through sweeping plates which raster them on the target, in this case a semiconductor wafer prepared through masking and etching for the introduction of dopant.

Depth of the implanted ions at the uniform energy level is shown in figure 1 as a Gaussian profile. Depth is controlled primarily by the energy of the ion beam, but is also affected by the mass of the ion and the density of the target.

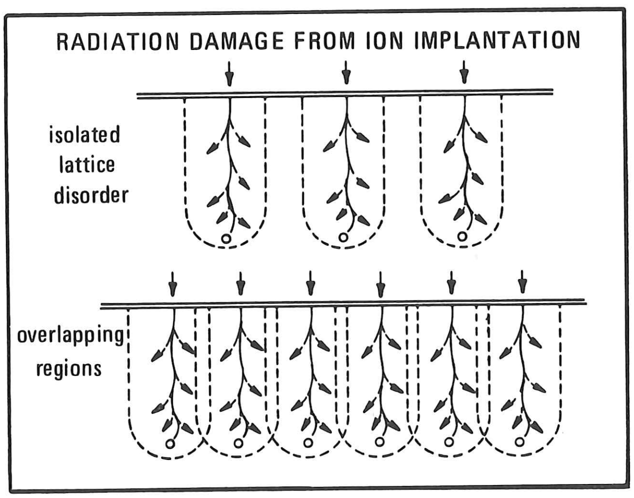


Figure 2. Lattice disorder. Heavy doses of ions may cause areas to overlap, forming amorphous regions.

Notice the occurrence of lattice disorder shown in figure 2. Lattice disorder is the displacement of crystal atoms by the colliding dopant ions as they lose speed (radiation damage). Heavy doses of ions can cause wider incidence of lattice disorder and create an amorphous area where individual damage regions overlap.

The Tektronix Accelerator

The equipment (diagrammed in figure 3) consists of an ionizer in a lead-steel shielded room, an accelerator, a separating magnet, a series of focusing points, sweeping plates, and a vacuum chamber in which the wafers are placed.

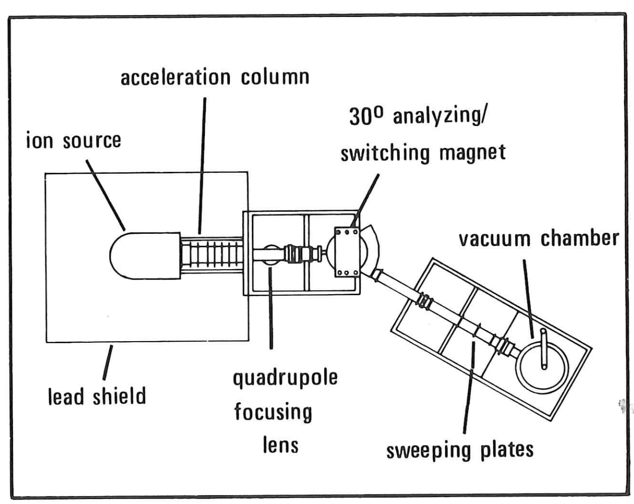


Figure 3. The accelerator equipment necessary for ion implantation.

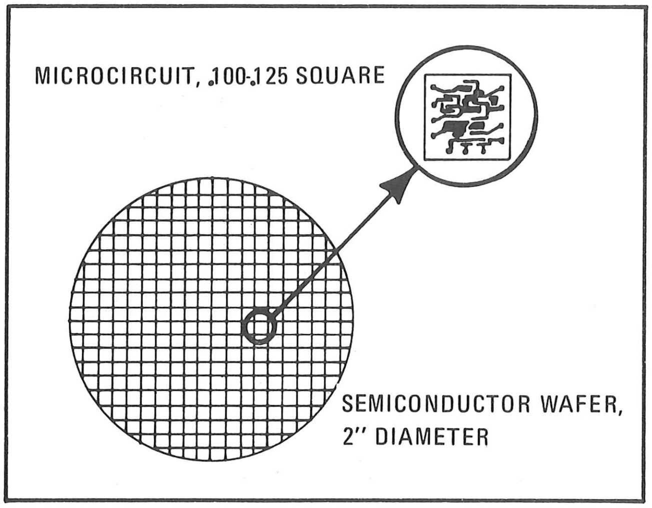


Figure 4. A semiconductor wafer containing hundreds of microcircuits.

Three types of ion sources are used. The most common is an RF discharge tube; a glass envelope with two RF clips on the tube and an electrode at each end. The RF clips generate up to 100 watts of power at 100 MHz. Phosphorous, boron, oxygen, nitrogen, helium, and hydrogen are ionized this way. A cold cathode, using an arc discharge system is also common for ionization of elements found in a gaseous state.

A third type of ionizer is used to ionize a solid, such as manganese. This type uses an electron beam to vaporize the solid. A voltage drop is induced between the two ends of the ionizer to draw the ions into the accelerator, a glass tube with twelve metal electrodes mounted evenly along its length. A voltage drop of 1.5-20 kV between each of these electrodes is controlled by the operator. These voltages relate directly to single ion keV.

After realignment through a focusing lens, the ions pass through a powerful magnet. Here the desired ion is bent towards its final target, and unwanted species are rejected by mass selection.

The selected ions then pass through vertical and horizontal sweeping plates, similar to those found in a crt. The sweeping plates are intentionally out of synchronization to avoid forming definite trace patterns across the prepared wafer surface. The wafer is a two-inch silicon disk with devices on the order of 0.100 inch etched on the surface (figure 4). The wafers are loaded into the vacuum chamber, which is pumped to 10^{-6} torr. Up to 60 wafers can be processed at a time.

Ion implantation is substituted for diffusion in the normal process sequence for production of a semiconductor. The prepared silicon wafer is carefully cleaned and loaded into the vacuum chamber. The wafer crystal structure is deliberately misaligned with the ion beam by tilting the wafer at a seven-degree angle to avoid channeling. Once the implant cycle is run, a second cleaning is performed. The final step is annealing. The wafers are placed in a high-temperature furnace with a dry nitrogen or argon gas flow at 900-1100 degrees C. This fixes the dopant ions in their proper substitutional sites, corrects lattice disorder, and restores electrical activity to the implanted regions.

A Look at Today and the Future

So far, one circuit manufactured by ion implantation is in production—the P18, an NPN-JFET combination. Discrete devices, such as the D156 (fast NPN) will soon be in production. Other circuits are in development stages, including all the SHF 3 (6 circuits) and P- and N-channel JFETS. As devices and circuits are developed, descriptions will be published in Engineering News.

The first applications of ion implantation made extensive use of the precise dose control. Precision dose control is especially suitable for precision resistor processing and for processing MOSFET and JFET devices where it is necessary to control channel doping. Precision doping is also important in the processing of high-speed bipolar transistors. Most of the work in Tek Labs has occurred in this area. The exact profile of the implanted regions in bipolar transistors is also critical as it affects breakdown voltages and high-frequency performance. More work is being done in this area as we push for more performance at higher frequencies.

High-energy ion beams can also be used for some unique processes that make use of radiation damage. One of these processes, taper etching, allows better metal step coverage. Another process, called gettering, is used to trap unwanted metallic impurities in silicon devices.

Also, MCE expects to begin applying implantation to the manufacture of MOSFET circuits, but the extent of involvement in that area will depend on the needs of circuit designers. Finally, they will continue to put sufficient emphasis on the basics to be able to recognize and develop unique ion implantation processes. For more information, call Dean Casey at ext. 5370.

PRESSing Technical* Questions

Larry Mayhew,
Group Vice President
Information Display

Bill Walker,
Group Vice President,
Test and Measurement

From time to time, editors of the various trade publications call engineers directly with technical questions. Often the information requested does not seem to be confidential, but coupled with other information it could damage our competitive position. Knowing this, what is the proper response when the call is directed to you?

First, find out who your caller is. Editors sometimes do not identify themselves right away. When it is an editor, be courteous, but do not answer his questions immediately. List the questions he would like to have answered, and tell him you'll call him back. This gives you time to review the questions with your manager, and with someone who normally handles press information. Joyce Lekas, Technical Information manager, (ext. 6601) can help you.

When you are reviewing the information with your manager, some of the things you should consider are:

- Are you the right person to respond to these questions?
- Is the requested information in any way proprietary?
- Is there any way the publication of this information could hurt our competitive position?

By carefully considering your response to the listed questions, by jotting down your responses, and by reviewing the possible problem areas with your manager, you will be able to respond well to any editors' queries.

The same principle applies when a press person arrives at Tektronix with a microphone in hand. You need not respond to his questions on the spot.

It is important for Tektronix to continue to be an open, responsive company, and to reap the benefits that good press coverage can bring. For the protection both of the engineers and the company, I urge you to use the help available here and to use care in speaking with the press.

Larry Mayhew
Bill Walker

A small pamphlet on this subject will soon be available to all employees.

***For corporate questions call Susan Stone, Corporate Communications Manager, ext. 6526.**

NEW PUBLICATIONS

Microelectronics

A new publication, **Microelectronics Digest**, contains news items on research, technical discussions, applications, new products, literature, and other material dealing with microelectronics.

A sample of **Microelectronics Digest** is available in the Technical Information office, 50-462.

Computer Graphics

The Laboratory for Computer Graphics and Spatial Analysis within the Graduate School of Design at Harvard University announced a new edition of **LAB-LOG**. This publication is primarily a catalog of computer programs, data bases, and publications concerned with analysis and graphic display of geographic data for planning purposes. Also included is a brief description of the Laboratory's history, research directions, and operating policies. A sample copy of **LAB-LOG** is available in the Technical Information office, 50-462.

Medical Instrumentation

The **MICSUS Newsletter**, a bimonthly publication of the Tektronix TM 500 Marketing group, is addressed to persons engaged in the use of, or service of, medical instrumentation. (MICSUS—Medical Instrumentation & Calibration Users Society.) The newsletter covers medical measurement problems and solutions, techniques, and application notes.

The **MICSUS Newsletter**, edited by Dick Brown, was first published in January 1976. For more information, call Dick at ext. 7442.

ADL Impact Services

"Outlook for the CATV Industry Through 1985" is the title of a summary of the **ADL Impact Services Report** for December 1976. The summary covers projected market figures, regulatory trends, and technological advances in cable television. For more information, call Mike Connell at ext. 7945.

3rd ENGINEERING FORUM

The topic of the third Engineering Forum, scheduled for March 4, is video display techniques. The purpose of every forum is to give Tektronix engineers a chance to communicate their ideas to managers and to other engineers. If you would like to contribute to the March forum, Phil Crosby (ext. 7079) and Steve Joy (ext. 2295) invite you to submit a one-page description of your idea to them before February 10.

NPN-JFET Combinations

Monolithic Circuits Engineering has now perfected ion-implantation doping for manufacturing P-channel JFETs and NPN bipolar devices in the same IC.

The NPN-JFET combination is possible with diffusion doping, but the yield is low due to the complex process and because light doping is difficult to control. In addition, the JFET top gate and the NPN emitter are done with the same diffusion (see figure 1). This means that the characteristics of the two devices cannot be independently controlled, because diffusion depth inversely affects the β of the NPN device and V_P (pinch-off voltage) of the JFET. That is, a deeper diffusion increases β but decreases V_P.

With ion implantation, the wafers are doped after the base diffusion. First, the top gate is doped with arsenic, then the P channel is doped with boron (see figure 2). The NPN and JFET device characteristics can be independently controlled. This process can produce devices with dc characteristics as good as any matched discrete devices.

IC's with this combination have been successfully used in test devices for six months now. The first production IC to use the new process should be designed within a couple of months. These devices, with an f_T of up to 100 MHz, have application in input circuits, sweep circuits, and amplifiers.

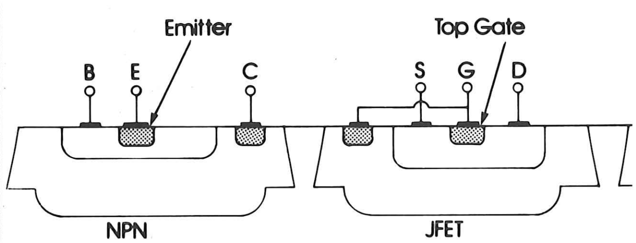


Figure 1. Cross-section of diffused NPN-JFET devices.

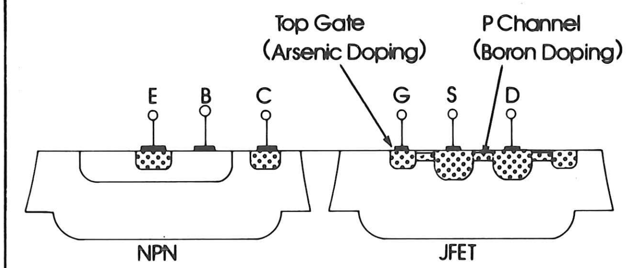


Figure 2. Cross-section of implanted NPN-JFET devices.

HOW TO PREVENT EPI INVERSION

Jim Dunkley and Walt Ainsworth have written an IOC defining the rules for preventing epi inversion. The major topics covered in the open letter are:

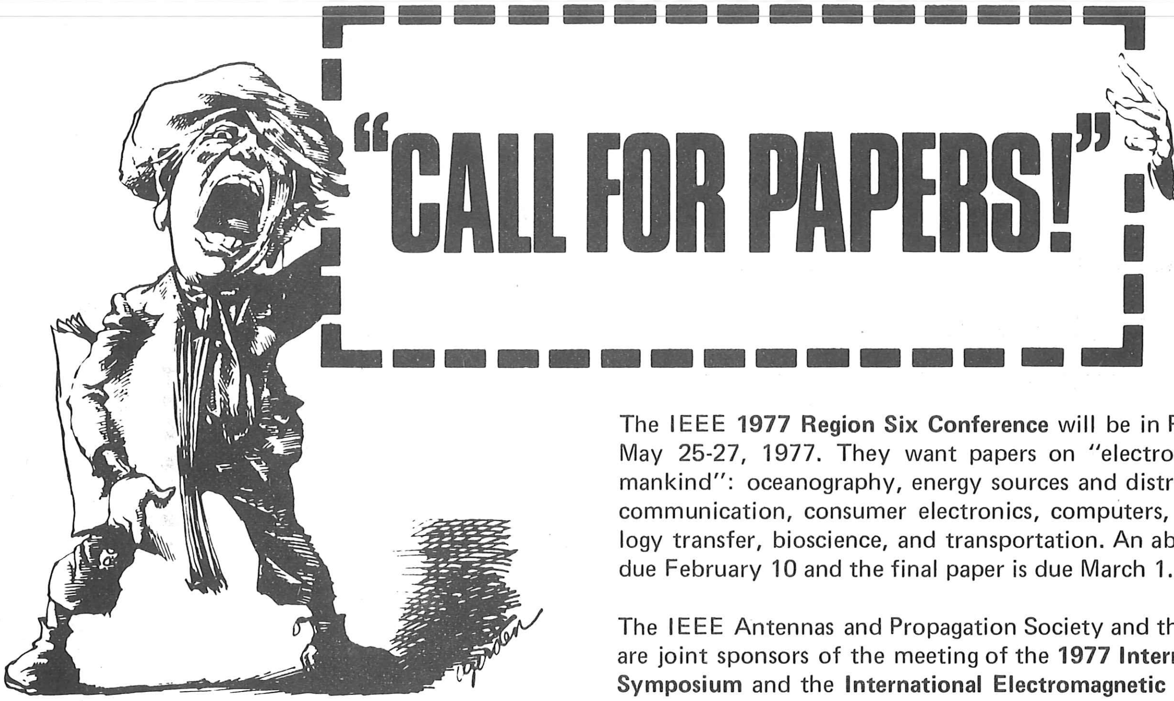
- —layout rules for preventing MOS-related inversion problems.
- —summary of n-epi channel prevention methods.
- —determination of epi threshold voltages.
- —calculation of epi threshold voltage.
- —selection of oxide thickness.
- —general layout spacings and overlaps.

If you would like a copy of the IOC, call extension 6071.

HAVE YOU BEEN GETTING IT REGULARLY

You can receive every issue of **ENGINEERING NEWS** by calling ext. 5674 and giving your name and delivery station.

If any of these calls for papers interest you, give us a call (ext. 5468 or 6071). We will give you all the details you need (length and format of the paper, and where to send it). We can also help you with the writing, illustrations, typing, and mailing.



Purdue University and the Laboratory for Applications of Remote Sensing will sponsor the **Purdue Symposium on Machine Processing of Remotely Sensed Data.** The symposium will be held June 21-23, 1977 in West Lafayette, Indiana. The two groups are asking for short papers on recent results in all areas of theory, implementation, and applications of machine processing of remotely sensed data. The one-page abstract is due March 18. The date for the paper will come later.

The IEEE **1977 Region Six Conference** will be in Portland May 25-27, 1977. They want papers on "electronics for mankind": oceanography, energy sources and distribution, communication, consumer electronics, computers, technology transfer, bioscience, and transportation. An abstract is due February 10 and the final paper is due March 1.

The IEEE Antennas and Propagation Society and the URSI are joint sponsors of the meeting of the **1977 International Symposium** and the **International Electromagnetic Symposium** (June 20-24) in Stanford, California. They are calling for papers on a wide range of subjects . . . from antenna technology (including computer-aided design of antennas) to waves in plasma. An abstract and a summary are due March 1, 1977.

The Canadian Region of the IEEE is sponsoring the **1977 International Electrical, Electronics Conference and Exposition** (in Toronto) for September 26-28, 1977. They are asking for papers on biomedical electronics, components (active and passive), telecommunications, media electronics (word processing, reproduction), safety, and standards. A 50-word abstract and a one-page summary are due on March 1.

TEK GPIB SCHEMATICS

Want to speed up your project? Don't reinvent the wheel. If you plan to use the GPIB in your interface, someone may have already designed it for you and checked it out, too.

A number of GPIB interface schematics are now available from the interface engineer. These schematics are from TEK instruments that are already operational.

But, maybe you have invented a better wheel. You can help others avoid reinventing your design by sharing it with them. If you have a working GPIB interface that you have built, please send in a copy of your schematic (and a few words of explanation if necessary) to:

Maris Graube (ext. 6234, mail station 58-188)

He will also send schematics to you if you need them.

IN PRINT...

An Engineer's notebook article, "Designing with the 6820 peripheral interface adapter," by Jack Gilmore and Ron Huntington, appears in the December 23, 1976 issue of **Electronics** magazine. This article provides a few time-saving design tips when using a 6820 PIA, a standard adjunct to the 6800 microprocessor.

If you want a copy of this article, call the library on ext. 5388. The article is in Vol. 49, No. 26, pages 85-86.

Engineer's notebook is a regular feature in **Electronics** magazine for design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. **Electronics** will pay $50 for each item they publish.

J. Phil Schierer, Jr. is co-author of an article in the November issue of **Applied Optics**. The title of the article is "Silicon Vidicon Spectrometry and Its Infrared Capabilities for Solor Research." The article describes the use of the Tektronix 7J20 rapid-scanning silicon vidicon spectrometer in observations of the 1973 total solar eclipse.

If you would like a copy of the article, call the library on extension 5388. The article is in Vol. 15, page 2884 (November, 1976) issue of **Applied Optics**.

Edward F. Ritz, Jr. is the author of an article in the December 1976 issue of **Electron Devices**. The title of the article is "A Theory of Static Deflection in Magnetically Immersed Conical Deflections." Deflectrons may be used in applications such as vidicons and scan converters.

If you would like a copy of the article, call the library on extension 5388. The article is in Vol. ED-23, No. 12 (December 1976), on pages 1325-1333.

Metric Drawings

Since metric applications at Tektronix are increasing, it appears that metric usage will simply evolve into the TEK system. Some care should be taken to avoid going off in seven different wrong directions during this gradual change.

Regarding metric **conversion**, there should never be any conversion from metric units to decimal inch. Any drawing made with metric dimensions and tolerances should be manufactured and inspected with metric equipment. If such equipment is not available, what is the justification for making metric drawings?

Designers should ascertain TEK's capability for metric production and measurement **prior** to making a metric drawing. As reference information only, a tabulated list of equivalents in decimal inch should appear on the drawing, rather than dual dimensioning. Essentially, dual dimensioning should not be used.

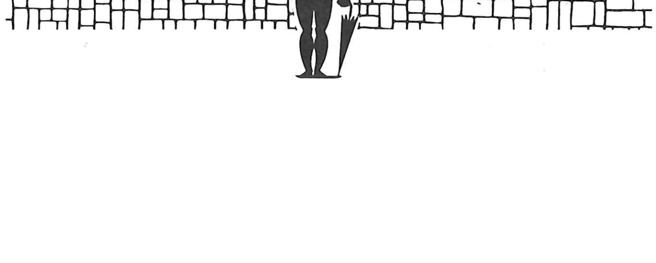
In no case should the user be required to convert metric dimensions into decimal inch. There is great potential here for different users to come up with different answers—and unusable products. It is the designer's responsibility to provide complete information to the user.

All dimensions are to be given in millimeters (mm). Where necessary, U.S. customary units can be used (such as for material thickness, pipe diameters, stock sizes, threads, and commercial parts). When so given on a metric drawing, they must be clearly identified.

Title blocks for Tektronix drawings provide identification of drawing unit. Line out the non-applicable unit. Clearly apply the word "METRIC" to the drawing so that it is visible on the folded document.

A Tektronix standard will be forthcomming shortly and information and assistance may be secured from Technical Standards.

Chuck Sullivan
Technical Standards
58-187



TEK'S MODEM IS LAST LINK

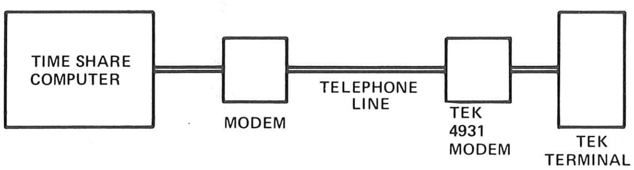


Figure 1. A Modem in operation.

Tektronix is now selling its own modem.

A modem (Modular Demodulator) is an interface between data processing equipment and data transmission equipment. For example, a modem can convert the data output of a timeshare terminal to a form that can be transmitted over a telephone line to the timeshare computer. See Figure 1.

The model number for the Tek modem is 4931. Three baud-rates are available:

—300 baud per second (bps) for full duplex systems.
—1200 bps.
—1200 bps with 5 bps reverse channel for half duplex systems.

For more information, call Will Gallant (ext. 2785).

THE STANDARDS ENGINEERING SOCIETY

The Standards Engineers Society was founded in 1947 with the objective (among others) of furthering standardization as a means of enhancing the general welfare of the technical communities and the public, and of promoting commerce, communications, and understanding.

Members may be standards engineers, people directly involved with standards, people engaged in quality control, materials, reliability, manufacturing or evaluation engineering, drafting, etc., who are seriously interested in good standards.

If you would like more information, please contact Chuck Sullivan, ext. 7976. Plans are underway to form a northwest chapter of the society.

ENGINEER'S SURVIVAL GUIDE

"Who, What, When, Where, How—an Engineering Sourcebook for Tektronix" has been affectionately referred to as the "engineer's survival guide" (or survivor's guide for those who needed this book a year or so ago). The survival guide is basically a directory of support services for engineers. Available resources, and whom to see or call for help, are described. For example, do you know that the Patents and Licensing department issues engineering notebooks for documenting that great invention you have been working on, or what programs are in the Cyber scientific computer? You can find answers to these and other questions in the survival guide. (An engineering manager mentioned that the guide is also a great recruiting aid.)

Survival guides were given to those persons who attended the New Engineers Orientation Session in the Building 50 Auditorium on November 9, 1976 (and to a few other lucky people). Since this initial distribution, the Engineering Support Services section (brown-ink pages) has been added to and updated. The first-edition pages were dated October 1976; the second edition is dated December 1976.

Why am I telling you all of this? Because I would like to send a new section to the people that received the first books, and no one knows who these people are. (Yes, I've heard about 20/20 hindsight several times recently.)

If you have a survival guide with October 1976, brown-print pages, fill out the coupon below for "Updates Only." Not only will we send you the December updates, but also any future ones. If you have survived so far, but would like to have a guide, fill out the coupon for a complete book. You, too, will receive any future updates. If you do not feel like filling out the coupon, call Al Carpenter on ext. 5468.

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