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UNILAYER

A New Circuit Board Technology

EDE develops the fourth generation of circuit board technology...

UNILAYER

Douglas A. Reed, Electrochemical Development Engineering, ext. 5182 (Beaverton).

Tek's Electrochemical Development Engineering group has developed "Unilayer," a new generation of multilayer circuit boards that promises benefits for product design and for product reliability.

Comparing multilayer and Unilayer construction will clarify the Unilayer concept. Figure 1 shows cross sections of a conventional four-layer multilayer board. Using heat and pressure, a press machine laminates two thin sheets of copper-clad laminate. The laminated sheets have runs and pads etched on the inside surfaces, as shown in figure 1-A. Figure 1-B depicts the board after lamination, and figure 1-C shows the board after drilling. Drilled holes pass through the pads on the board's inside surfaces. In the drilled holes, the through-hole copper plating electrically connects these pads.

Figure 1-D shows a conventional multilayer board after copper plating.

Figure 1-E shows the board after etching removes unused copper, leaving copper pads and runs (conductors) on the outside layers.

As shown in figure 1-E, the connections between a multilayer's inside and outside layers are made through the copper cylinders in the drilled holes. Such through-hole connections are a source of multilayer reliability problems.

Two factors affect the reliability of through-hole connections. First, drilling creates **drill smear** (plastic melted by drilling friction). If hole-cleaning operations don't remove enough of this smear, then the smear may insulate all or part of the cylinder.

Second, mechanical and thermal "flexing" of the circuit board stresses the plated connection, sometimes causing an intermittent or open connection.

UNILAYER

Figure 2 shows five steps in Unilayer board manufacture. First, holes are drilled in the laminate and then the board surface and holes are plated with copper (refer to Figure 2-A),

FOUR GENERATIONS OF CIRCUIT BOARDS

In the 1930's an English manufacturer laminated copper-clad foil onto a rigid substance to make the first circuit board. Few electronic manufacturers used circuit boards to mount and interconnect electronic components until U.S. manufacturers began using the technique during World War II.

In 1956, Tektronix began building one-sided copper boards, the first generation of circuit boards. By 1960, Tektronix converted from phenolic-resin laminate to epoxy-resin laminate, and began producing two-sided, through-hole plated circuit boards, the second circuit-board generation. A year later, we began using multilayer boards in some instruments. In 1962, we first used solder-mask on Tektronix circuit boards. Moving into new facilities in 1965, Electrochem fabricated Tektronix' first production-quality multilayer boards (the third circuit board generation) and also began using numerical control equipment to control circuit board processing.

In the last 19 years, the number and complexity of circuit boards in our products increased substantially. In 1960, the Tektronix 543 Oscilloscope had one circuit board for triggering. Today, 5000-series instruments have six or seven circuit boards, 7000-series instruments contain 15 to 20 circuit boards and portables have 12 to 14. The 492 Spectrum Analyzer uses more than 70 circuit boards. Circuit board size and circuit density have also increased. In 1965, typical circuit boards were four inches wide and six inches long with about 12 drill holes per square inch. Today's boards are as large as 18 by 24 inches; densities of 28 drilled holes per square inch are common.

There have also been changes in the kinds of laminates we use. In 1965 we manufactured our first boards (an AC-DC switch) on a Teflon™-based laminate called Duroid™. In the late sixties we began using polyphenylene oxide boards in several instruments, primarily for attenuator applications.

We recently replaced polyphenylene oxide with polysulfone because polyphenylene oxide's electrical properties changed when the resin manufacturer changed the resin production process. (For more information about polysulfone, see Jerry Jacky's May 1978 "Circuit Boards from Polysulfone" **Engineering News** article; for a copy call T & M Publicity on ext. 6792.) We also use specialty substrates such as polyimide for flex circuitry.

In summary, Tektronix has had three generations of circuit boards: one-sided boards (first generation), two-sided boards with through-hole plating (second generation), and multilayer boards (third generation). We are now preparing to produce the fourth generation of boards: Unilayer circuit boards.

CONVENTIONAL MULTILAYER BOARD CONSTRUCTION

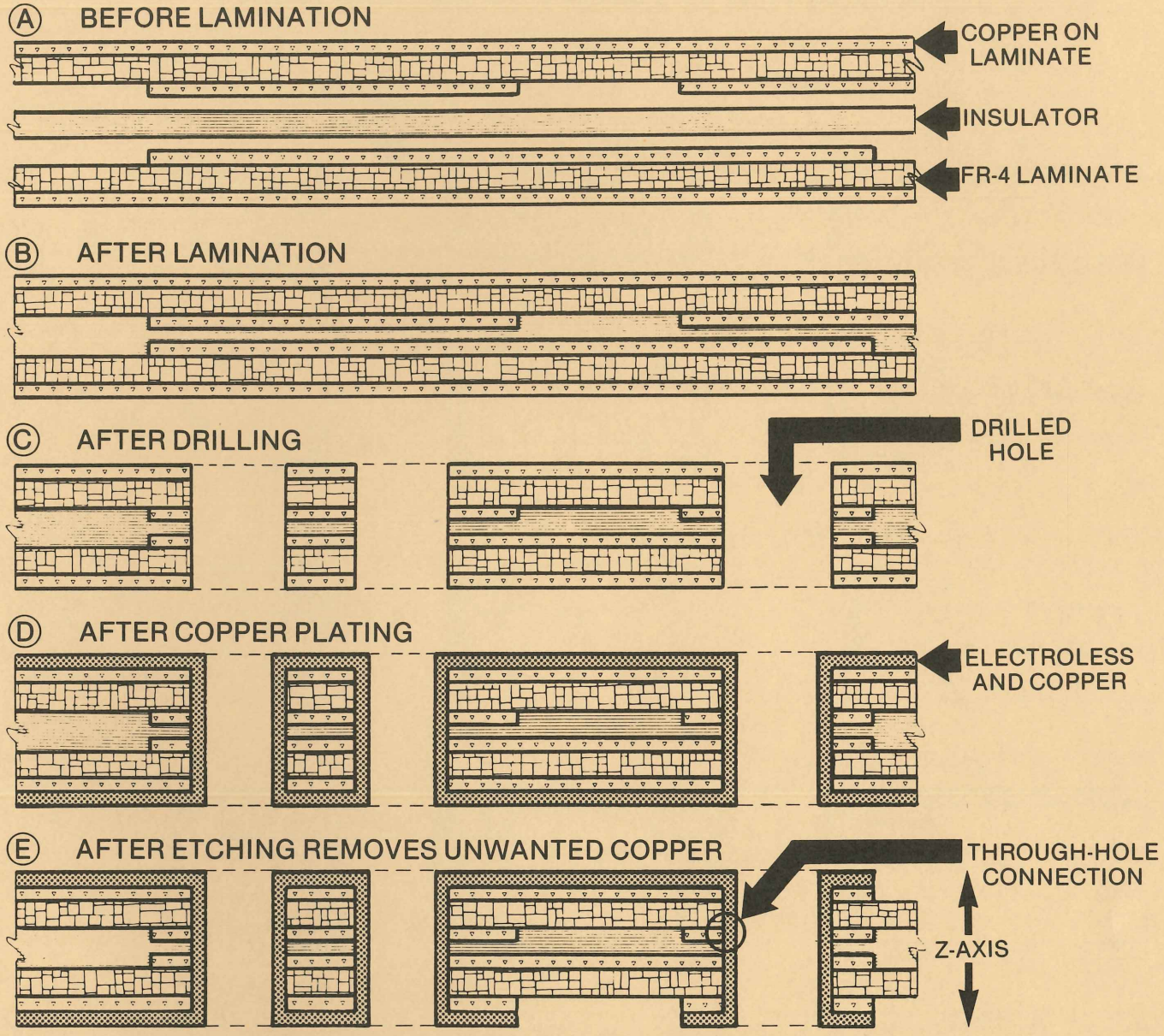

Figure 1. Conventional multilayer board construction proceeds in four stages: lamination, drilling, copper plating, and etching.

forming the two inside layers (layers 2 and 3) of the final Unilayer board. In figure 2-B, etching has removed unwanted copper, leaving pads and runs. At this point, pads, runs and through-hole platings are the same as on a conventional two-sided, all-copper plated circuit board.

In figure 2-C an insulator has been applied to the top and bottom surfaces of the board. Next, as shown in figure 2-D, copper is plated over the insulator and through the drilled holes. Finally in figure 2-E, etching unwanted copper forms pads and runs on the board surfaces.

Figure 3 is an example of a finished six-layer Unilayer board. This unilayer process (building multilayer boards from the inside out) offers several reliability and design benefits.

RELIABILITY

Compared to conventional multilayer construction, Unilayer construction produces 45 times the layer-to-layer contact area in the drilled holes. This increased contact area makes Unilayer boards more reliable. Another advantage is that drill smear can not produce an open connection in Unilayer board through-holes, since we never drill through inner-layer pads.

DESIGN

Unilayer construction also offers several advantages to the circuit board designer. First, layer-to-layer

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UNILAYER BOARD CONSTRUCTION

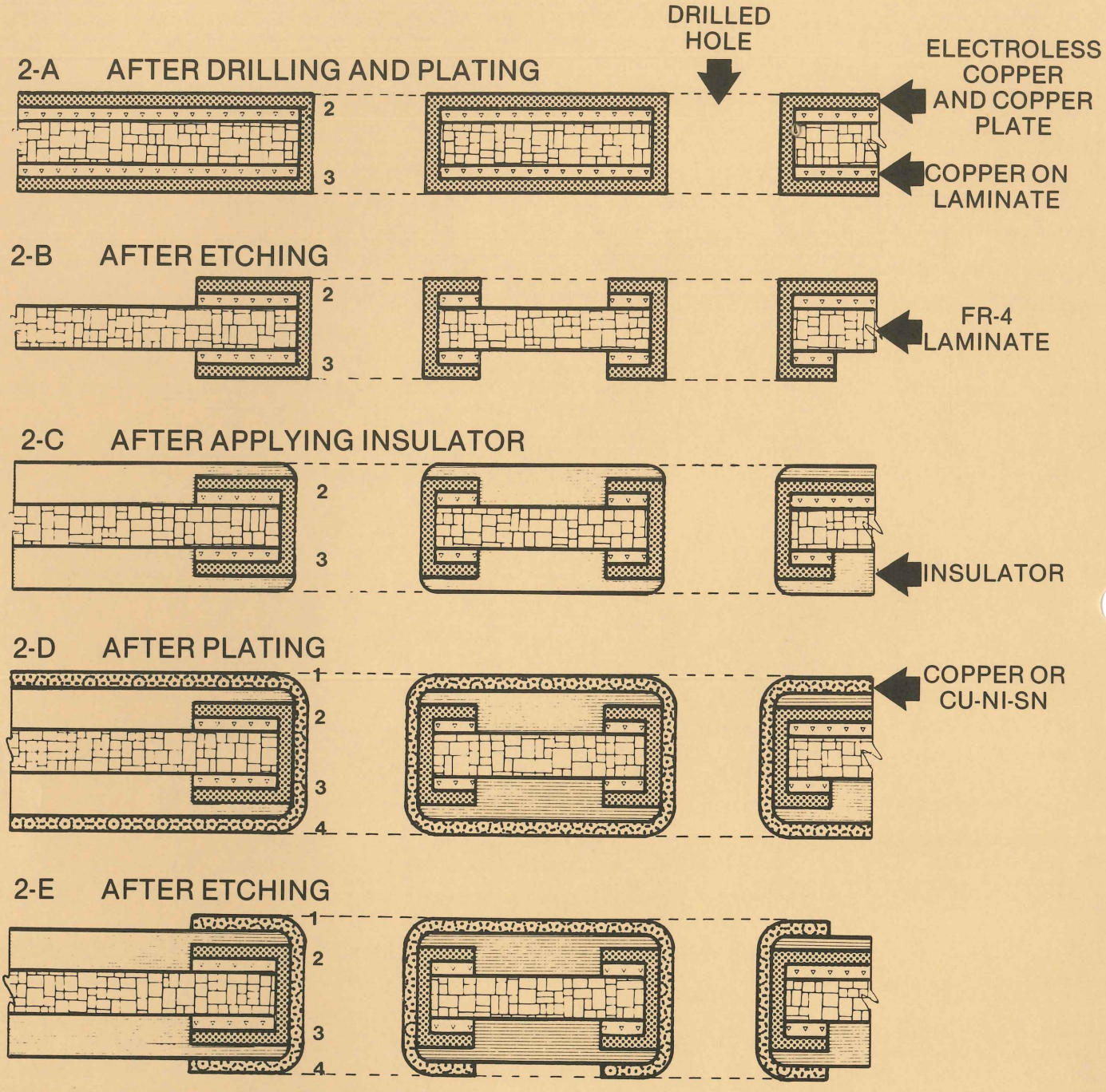


Figure 2. Unilayer board construction proceeds in five stages: drilling holes in the laminate, plating, etching layers 2 and 3, applying insulator, and etching layers 1 and 4.

EXAMPLE OF A SIX-LAYER UNILAYER

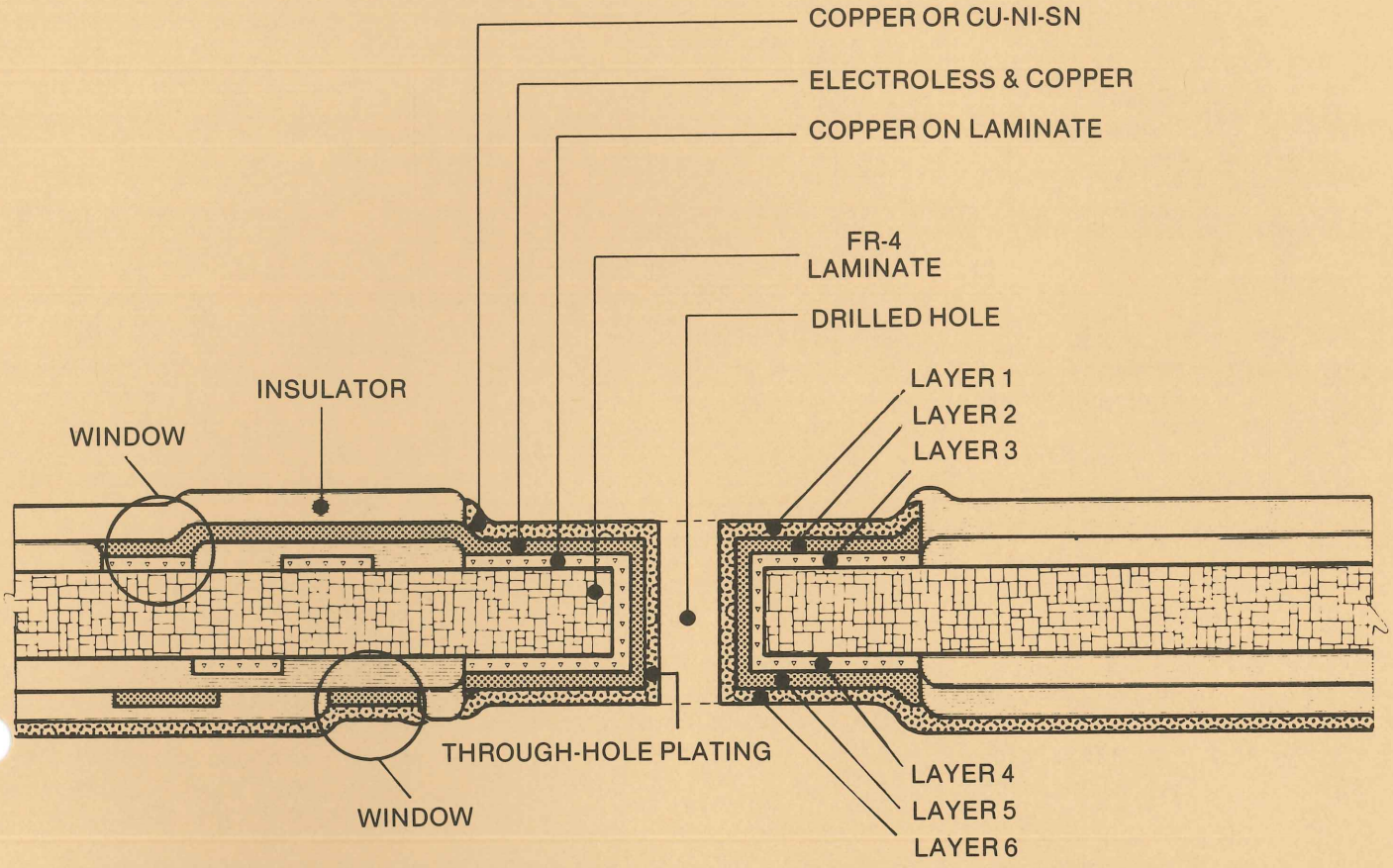


Figure 3. An example of a finished six-layer Unilayer board.

Continued from page 3

connections no longer have to be made at a drilled hole. Instead, a designer may interconnect circuits on the same board surface by leaving a "window" in the applied insulating layer (see figure 3). In this respect, Unilayers are similar to hybrid construction.

As a second benefit, technology is available that will soon allow designers to design components into a board's inner layers, thus saving surface area.

Third, Unilayer enables designers to place the same number of interconnections on fewer layers than are required for conventional multilayer construction.

PROTOTYPES

Electrochemical Development Engineering is building prototype Unilayer boards for circuit board design groups within the Information Display Group. These prototypes will help this group evaluate circuit board design alternatives.

ASSISTANCE AVAILABLE

IDG has given the Unilayer project a great deal of support and we are building Unilayer boards for engineering evaluation.

Electrochemical Development Engineering will help any design group produce Unilayer artwork and will build prototypes without charge. Orders for Unilayer boards should be placed using standard Quick Board Line procedures. Until FY000, Electrochemical Development Engineering will fabricate Unilayer boards; after FY00, the Quick Board Line will fabricate them.

ACKNOWLEDGEMENT

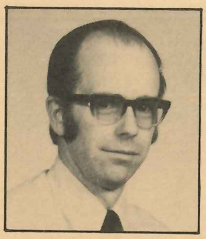
I wish to thank Suzette Noble (Manufacturing Systems) for the original drawings used in figures 1, 2, and 3, and Evelyn Cox for microphotos that the graphic designer used to produce the cover.

□

ECB Manufacturing has included Unilayer in its planning but has not established a time table for process implementation.

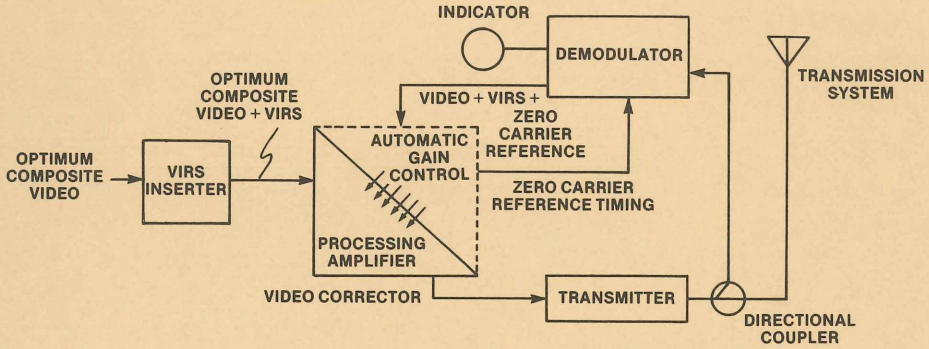
PATENTS RECEIVED

VIDEO TRANSMISSION STABILIZER



David J. Jurgensen, T.V. Products Engineering, ext. 7070 (Beaverton).

Charles W. Rhodes, T.V. Products Engineering, ext. 7068 (Beaverton).



Federal Communications Commission broadcasting standards require broadcasters to maintain signal parameters such as video gain, sync amplitude, and burst phase within specified limits. After detecting a transmitted signal, broadcasters can monitor the signal to determine signal parameters and then to maintain them.

Broadcasters use a vertical interval reference signal as a reference for the signal parameters. The broadcasters insert this reference signal into the television signal when there is no display on the receiver.

The invention shown here uses the reference signal leaving the demodulator to automatically correct the output of the transmitter. Placed in the signal path to the transmitter, this invention varies the parameters of the signal flowing into the transmitter. This invention also uses the zero carrier reference signal from the demodulator to compensate for variations in demodulator gain, thereby correcting transmitter output. □

NEW BOOKS AVAILABLE

The Institute of Electrical and Electronic Engineers Press recently published three new books.

Robert G. Meyer (University of California, Berkeley) edited **Integrated-Circuit Operational Amplifiers,** a collection of 38 article reprints that fall into eight categories: Monolithic Op Amp Design Techniques, High-Speed Op Amps, Instrumentation Op Amps, Precision Op Amps, High-Power/Voltage Op Amps, FET-Input Op Amps, Special Op Amps, and Modeling Op Amps. This 320-page book is $11.95 in the paperbound IEEE-member edition, $17.95 in the clothbound member edition, and $23.95 in the clothbound non-member edition.

Alan B. Grebene (Exar Integrated Circuits) edited **Analog Integrated Circuits,** a collection of 57 reprinted articles that discuss circuit design and application rather than fabrication. The articles fall into these eight categories: Fundamentals of IC Analog Design, Operational Amplifiers, Voltage Regulators and References, Wideband Amplifiers, Multipliers and Modulators, Data Conversion Circuits, Communication Circuits, and Precision Linear Circuits: Trimming Techniques. This 448-page book is $14.95 in the IEEE-member paperbound edition, $21.70 in the clothbound IEEE-member edition, and $28.95 in the non-member clothbound edition.

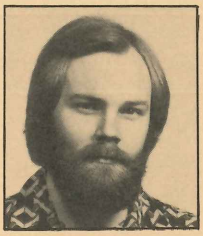
Donald G. Childers (University of Florida) edited **Modern Spectrum Analysis,** a collection of papers reprinted from many journals. The collection includes tutorial, historical, state-of-the-art, and applications papers. Several papers describe algorithms for **maximum entropy** (a new, spectral-estimation procedure). The 39 reprinted articles fall into five categories: Historical; Spectral Estimation by Maximum Entropy, Autoregression, Linear Prediction, and Maximum Likelihood; Statistics, Extensions, and Adaptive Techniques; Algorithms and Model Order Selection; and Applications. This 340-page book is $14.95 in the IEEE-member paperbound edition, $22.95 in the IEEE-member clothbound edition, and $29.95 in the non-member clothbound edition.

TO ORDER

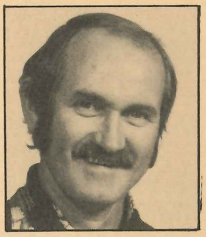
To order any of these books or for more information, call the Tektronix library, ext. 5388. □

PATENTS RECEIVED

KNOCKDOWN STAND



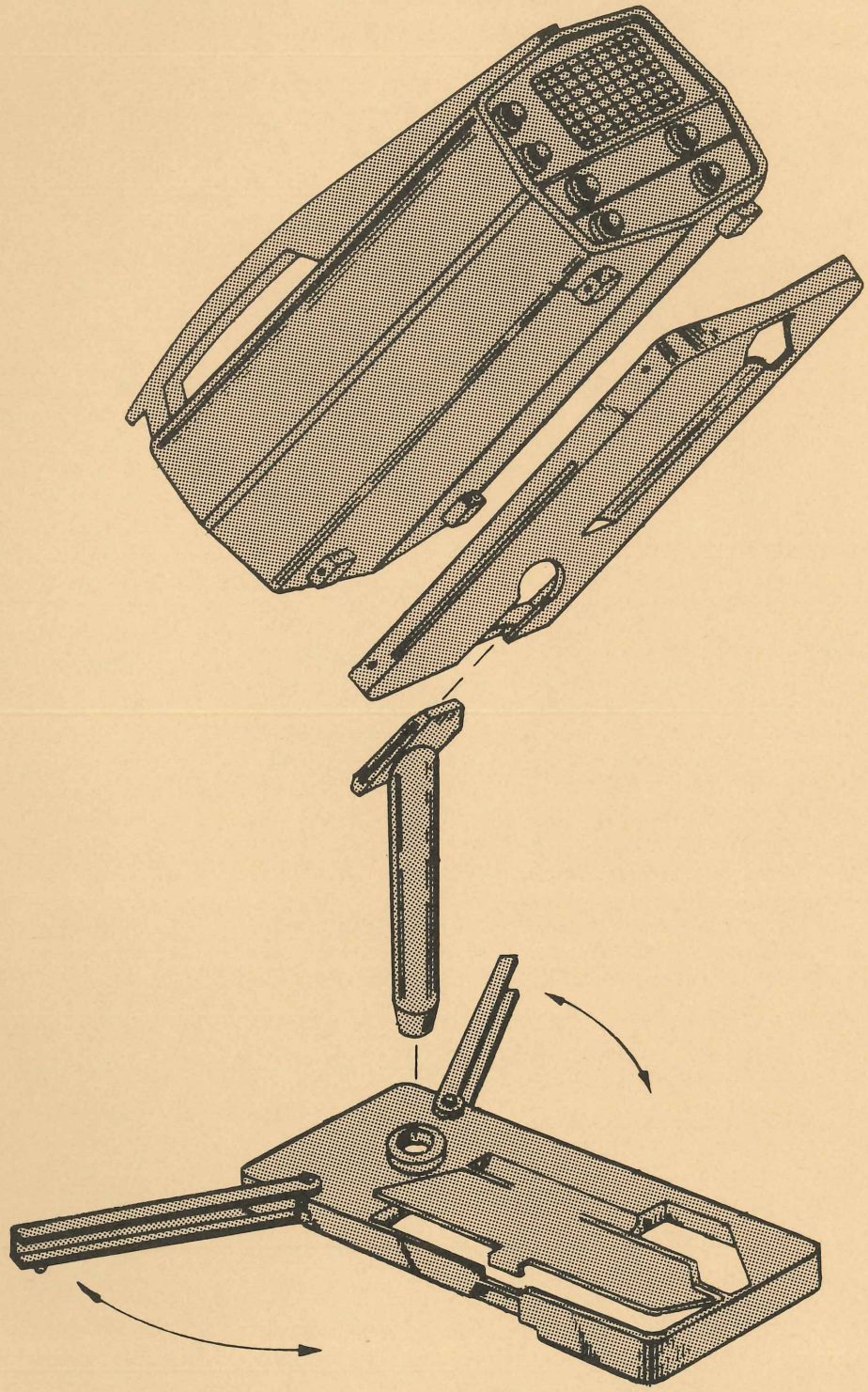
David R. Hargis, Service Instruments Division Mechanical Engineering, ext. 7365 (Beaverton).



James (Al) A. Hill, Service Instruments Division Industrial Design, ext. 7794 (Beaverton).

Most oscilloscopes and other test and measurement equipment (even portables) are designed primarily for benchtop use. However, in situations such as computer servicing, convenient work spaces are not always available. Stands and carts now on the market are bulky and not very portable.

The invention shown here provides a compact, lightweight, portable stand for T900 instruments. The user can assemble the stand as a support for T900 instruments or reassemble the stand and attach it to an instrument for easy transport. The stand also has storage space for instrument accessories.□



An interview with Earl Wantland
ORGANIZING FOR HIGH TECHNOLOGY

This interview with Earl Wantland, president of Tektronix, is reprinted from the January, 1979 issue of ***Industrial R/D****. Cliff Mosbacher, IR/D executive editor, conducted the interview in October, 1978.*

What is your view of R&D budgets for the next year?

There won't be any changes from Tektronix' point of view. Funding R&D is absolutely essential to any company like ours, and I believe it is essential to any industry where technologies are the bases for the products. That's where the vitality for the future comes from. There have been major problems with some industries as they've been squeezed for profitability and have succumbed to the temptation of cutting back on R&D budgets. Over a period of time, there is just no renewal process taking place. Any specific technology has only a certain time frame of effectiveness.

Like the steel industry.

Like the steel industry. In a way, the same thing happened in the textile industry. People quit developing new machinery and new approaches to making it more effective. We don't dare let that happen. I feel our level of commitment to funding R&D is very high. You may remember back in '69-'70 when we really got ourselves into difficulty as a company from the growth point of view — right at the time the recession hit. We chose the strategy of heavy R&D funding and lower profitability rather than to ride with the financial community and optimize profits at that time. The financial community reminded us for five or six years after that of what we had done. But I believe it was the right thing to do.

Funding R&D is absolutely essential to any company like ours...

It turned out that way. Are you holding to shorter-term R&D these days, or still going to long-term projects?

We try to have a portfolio balanced between some directly product-related activities and a fair amount allocated to longer-term technologies. Longer-term technologies are those that are not likely to be used in products for five, seven, or even ten years, but instead have a potential for being important and have the possibility of usefulness. Of course, we have to be working on a longer time scale, for those kinds of things.

Also, we must have a very good surveillance activity in these areas and contacts with the important work that is going on so that we know about it early. No organization can do everything, but you can stay current with things that you think are most important.

How do you choose which projects you fund and which you don't?

It's hard to describe a process like that, but we do have some formal planning processes that systematically prioritize technology. This is in addition to prioritizing business and business units. During the course of the year, there is a process that is quite well structured where R&D personnel meet periodically with the business units and systematically go through the technology directions and their importance for that business unit. Then our planning people in Tek Labs pull that all together, and it's reviewed by the top technical people in the company.

In other words, you keep close liaison between Marketing and R&D.

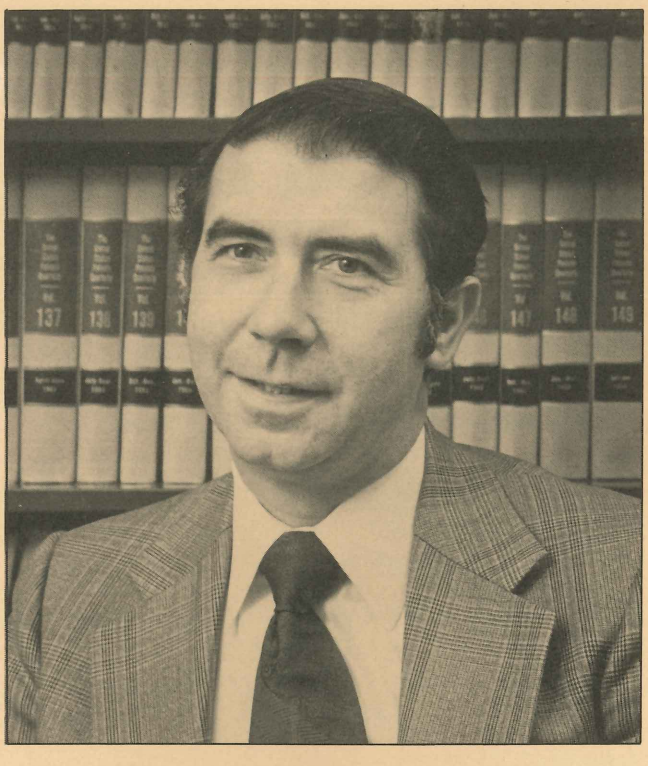
You make sure it's tied together. You don't want R&D to go off completely by itself, but you still need to have some work being done that isn't fully committed to your business units. Sometimes you're working so far out in the future that it's outside of their time horizon for their operating results.

Do you reserve a certain amount of the R&D budget for "blue-sky" projects?

Well, we've not formalized the percentage, but Bill Walker (executive vice-president) and I have an informal agreement about how much. He then has the job of finessing that as we move through time, depending upon our overall set of priorities. There are always periods of time in a technology's development when it is not clear what category a project is in. As a project moves closer to real use, and even when it is first being used, a lot of work remains to be done for other applications, for advancing the technology, or for improving the performance of the technology. So, a project often really falls into more than one category. There are no good clean criteria; it takes quite a bit of judgment.

You have different value scales that you apply simultaneously?

Right. It's a complex world we live in. It doesn't fall into nice, neat channels, or nice neat boxes.



Are there any specific techniques you use to measure projects? Do you use return-on-investment?

Not for R&D projects. We are looking for technologies that offer an inherent performance advantage for one aspect or another of future products. If they offer that inherent advantage, and if we can develop the skills to take advantage of them, then we have a good corporate position.

At Tektronix, we have a very fine group of people to work out the integration of such technology with all the other aspects of product development. But at the R&D level, you're really working with science coupled with intuition about which developments will emerge as the more important. You need a certain amount of scientific intuition in your corporation.

How many people do you have in R&D?

Roughly 10% of our people.

Do you augment that with outside people — with consultants from the academic world, for example?

To a limited degree we do. We have some outside work being done for us. Sometimes they come in for a short period of time and work with us. It's not a large portion of what we do, though.

Do you have an exchange program of getting people back into the academic field?

We have had very few examples of that, but we have had a few.

Another point that has intrigued me about Tektronix is that it's a local company as opposed to some others in the industry that have spread out geographically. What's your philosophy on that?

Well, we first started here, and this was the home of the founder, so that's the natural part of it. We found very early that we could be successful, even though we were not in the center of most scientific work that was going on. Good people and a healthy approach to the work and scientific achievement generally brought success, so being here was not a disadvantage. At least, the advantages and disadvantages balanced out reasonably well. So, there was not much stimulus to go some place else.

The other thing, the style of the company, I think, made it important for personal interaction of a lot of different skills and individuals to better integrate — synthesize — all the different elements. All product development is an assortment of compromises — conflicting desires in the design phase — so you really have to optimize what you are doing. That takes something other than a serial and arm's-length kind of approach.

I notice you have an open office.

That's correct. I think this has a lot of advantages when you are trying to work out very complex sets of interactive and sometimes conflicting requirements. You need the possibility of interaction on a continuing basis, because you don't think of everything the first time. You have to come back to people and retest your ideas and assumptions, and come back time after time. From a scientific point of view, or from a stimulation-of-innovation point of view, I think that mode has proved to be effective for us.

We believe that it is virtually impossible to interact when you have people who are really remote from each other. The amount of effort, the coordination it takes to bring people together then is very costly, too. So, our orientation is to stay close here.

As you can see, we have developed a very large site. We have another one at Wilsonville, which is only 17 miles away, and the new site that was recently announced is less than 25 miles away — easy traveling because it is freeway the whole distance.

If the world continues to be kind to us, we will eventually have to travel farther for some of our operations. But, for as long as we can, I think there is tremendous advantage in having R&D functions close together.

I find it fascinating that the Japanese have planned a whole scientific community and are moving government-supported research institutes into it. They purposely are doing that to structure interdisciplinary sessions...because it is important to integrate the "disciplined" society.

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That poses a problem for us in this country.

The real power in what the Japanese do is that they have both the inclination and determination to set priorities as a country, and they have a participative process of setting priorities. Of course, it is sometimes difficult to see who is more equal than others in that process, but when the priorities are set, the Japanese work in a way that is consistent with those priorities. That has a tremendous amount of power. I read some place where they have only around 10,000 lawyers in their whole country. They don't operate from a basis of law; they operate from a basis of what is appropriate. They don't have all this loss of energy in trying to find a way through the laws and confronting people from a legal point of view.

We have had a number of people draw the parallel between the Tektronix style and the Japanese style.

They don't have the adversary situation we have so many times in this country. You have done much the same here, though, haven't you, in avoiding adversary situations?

We have had a number of people draw the parallel between the Tektronix style and the Japanese style. There is some similarity between the ways we approach things.

I think you were awfully close to it in that we've never been autocratic in our approach to things. We've been very participative in our approach. Of course, I think there's a pretty good understanding of who has responsibility when push comes to shove. But on any specific issue, the most capable person, or the most knowledgeable person in the company, may be several levels down in the organization, and we are far more inclined to function so that **that** person is the most influential person for that particular aspect of what we are doing.

We don't stick very close to the authority hierarchy... We do seek a kind of consensus in many, many things.

We don't stick very close to the authority hierarchy for everything we do. We do seek a consensus in many, many things. It's more than just consensus; it is a mode that brings the insight of a lot of people working together to bear upon any particular issue before we come to a conclusion. In that process, a consensus emerges very often as a result.

I don't know as you'd call it a consensus-seeking process. I think it's an approach to working that recognizes that every person has a very limited sphere of understanding and experience, and that each person has a different one. If you have reasonable balance, and you can bring that balance together in a helpful, interactive, respectful way, then what comes out is a far superior conclusion. To an extent, we have done that pretty well. And, I think that oftentimes describes what the Japanese do. They do it more effectively, and they surely do it on a larger scale. On a national scale, they represent the highest order of achievement in that arena.

The latest governmental study is examining what would enhance innovation in this country. At a conference in Washington recently, everybody threw up their hands and said, "we don't really know what creates a successful new product or a successful innovation."

It's a complex, living kind of a process. It is virtually impossible to describe because it happens in so many different subtle ways.

I wouldn't have any confidence that you would get much insight from a study of that kind. It's important that you have a set of attitudes that are tolerant of new ideas, at least for a long enough period of time that they can be thoroughly examined and judged rather than to discard those that don't seem to conform with convention. I think one of the difficulties comes out of a strong need for fair treatment of everybody in all circumstances. That gets translated into sameness, which means tight administrative control and very little latitude for deviation.

As opposed to the creative.

Yes, the creative people either get so frustrated that they go someplace else, or they are suppressed to the point where they are not effective. Then, if you add to that a tendency not to fund those kinds of activities, it shouldn't be a surprise that vitality isn't renewed. It keeps diminishing.

Sweden is a good example of that on a national scale. For a long time, in addition to being the leaders in a social direction, they were very innovative from a technical point of view. But, gradually, this other phenomenon that I tried to describe a minute ago, suppressed the innovative element and they virtually lost their vitality as a nation. Now Sweden has severe problems. I meet Swedish executives at least once a year. The last time I talked to them, they were not very optimistic about getting some resurgence to the level of the old Swedish innovation.

Latitude for the innovator is really a key idea...you really need it in all functions of the organization.

Latitude for the innovator is really a key idea. It's something management needs to watch continually, because there are so many other pressures toward conformity and administrative purity of one kind or another. It's not easy, but I think it's awfully important that management remember that if you're going to continue to regenerate your vitality, innovative ideas

must be generated. I feel that it's not just required in R&D; you really need it in all functions of the organization.

Innovation is a very important element in success over the long term, although it's viewed as a nuisance or a disruption on a current basis. That's because it runs in the face of other things that are going on, or else it runs in the face of other things that have been the norm for a long time. Still it is important everywhere in the organization. I encourage — I try to encourage — innovation everywhere.

Organizationally, you keep moving people around, too.

It's important for people to have broader experiences. In my own small set of experiences, I can reflect on the number of times that I have had to completely change my position on an issue. That's a very important thing to learn — that you really don't know very much and that as you gain a broader perspective and understanding of a broader environment, you understand more the context of validity of any idea. You can't do that if you have a narrow set of experiences. If you look at any particular discipline for too long, your effective understanding is highly skewed by it.

...it takes a generalist to manage an organization of any scope, but... it's also important to have been a specialist first.

There's another idea that I think is important — that it takes a generalist to manage an organization of any scope, but that it's also important to have been a specialist first. In fact, what's even better is to have been a specialist in two different disciplines, maybe even more. When you put together your general understanding out of some specialized understandings, the interrelationships contribute very important subtleties and a lot of detail and complexity. But, if you come strictly through the liberal arts approach to life and stay in that mode, you end up working with intellectual generalities rather than having any real understanding of what's important.

At the same time, some people are happy as specialists, keeping up with one specific field.

It's important to have specialists who know their speciality as well as anyone possibly can. There again, you need to bring all of them together in a healthy, respectful way.

In other words, it's management's job to be sure everybody is in the right place at the right time.

And that they are linked together. That interdependence must really be understood and respected — rather than thinking in terms of autonomy. I'm not very fond of the word "autonomy." I think it became obsolete when the kings of England had some of their authority removed.

Let's turn to something else. Over the years, out of your R&D here, you've come up with a number of products that have been the basis for new companies rather than being part of Tektronix. Have you had such specific goals or has R&D come up with something that doesn't fit into what you consider Tektronix' bailiwick?

Sometimes R&D work is aimed at a specific product idea. Sometimes it is aimed at a specific physical function that manifests itself in a performance characteristic at the component level and is not aimed specifically at a product or a market. Then ideas begin to formulate for uses and new applications. From time to time, one of these ideas is a good one, and you begin to shape a direction for it.

You know, these things evolve. When you first are working on new technologies, you don't know for sure where they're going to lead. You have only a very fuzzy idea. For example, storage technology, which has been very important to us, was initially for low-speed or low-repetition rate phenomena in oscilloscopes so that you could store an image and it didn't decay. Really that was the first idea about the application, and it was an important idea. But, as the technology advanced, the idea began to be used with completely different combinations of elements. The performance levels were enhanced and ideas for other applications developed. It was quite late in that proceeding that the idea of using storage technology for a computer output or a computer terminal developed. You can see from the large Wilsonville complex how well that developed.

You don't see that in the beginning. Go back to the beginning of the transistor. At that time people were talking about audio applications, and there was a lot of skepticism about its being useful for anything beyond that. Look at what we're doing now with semiconductors. The important thing is that these new technologies keep emerging and that we really encourage other people in industry, besides ourselves, to continue funding R&D and keep the vitality coming.

When you come up with something that isn't applicable to Tektronix, do you license it?

We haven't done very much of that. We have used inventions in some cases as a cross-licensing vehicle, but we don't have much active licensing. If an invention is not likely to have an application here, oftentimes we just give all the rights to the inventor.

And the inventor goes off and starts a new company.

If the inventor wants to.

"...no organization can be all things."

One or two companies in this area came right out of Tektronix.

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That's true. I think that's a very healthy thing. You know, no organization can be all things. You always have a limited set of resources and you're forced to prioritize. One of the important things about our industry is that it still has new entrepreneurs coming along, and they represent a very important part of the vitality of the industry.

The problem they have today is finding funds.

There seems to be an answer to that problem, too. Venture capital, as nearly as I can tell, is coming back into the market. They got so badly hit by the recession in '69-'70, followed by a change in the tax law, that venture capital almost disappeared. We seem to be getting a reversal of the tax law now, and the money seems to be re-emerging. That's a very positive sign.

You still need the management, the financial people, the business people to work with the innovative people. It's rare to find an entrepreneur with all those assets.

That's right. The true entrepreneur doesn't usually go to Harvard Business School, but does have an intuition about how money should be used and what you get back for it, in addition to the technical ideas, the product ideas. Those people are rare. Oftentimes, you do need a team that is fairly balanced. The good venture capitalist provides the innovator with business experience; the venture capitalist understands that element of it quite well and can really help the innovator a lot. I'm encouraged by the trend towards more venture capital.

Is Tektronix participating in any way?

As far as being venture capitalists? That's an idea that we've talked about informally, but frankly, these last few years we've been so busy with the things that we're already doing, there really wasn't much time to think about something like that. It's not something that should be excluded, and, if the right idea came along, I think we would consider it. □

27 Authors Wrote For EN In 1978

*In the nine **Engineering News** issues published in 1978, 27 Tektronix authors contributed major technical articles. In order of appearance, the authors were:* Chris Curtin, Karen Seaward, Richard Nute, Al Schamel, Chong Lee, Stan Davis, Steve Heitman, Jerry Sherrill, Laudie Doubrava, Tom Woody, Dale Hartman, Roger Lind, Gale Morris, Jerry Jacky, Bill DeVey, David Bell, Dale Aufrecht, Casey Veenendaal, Joe Morabito, Novia Weiman, David Bennett, Chet Heyberger, Chuck Haymond, Dave Levadie, Bob Cram, Al Caravone, and Gary Nelson.

Contributing information about patents they received were: Richard E. Hansen, David R. Smith, Jerry Turnbaugh, Patricia McLaughlin, Bruce Rayner, Gerald Taylor, Fendall Winston, Larry Nelson, Phil Crosby, Casey Veenendaal, George Hull, Phillip Sheeley, Howard Meehan, Barrie Gilbert, Bo Janko, and Roland Crop.

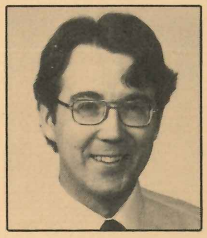
Also providing technical information for articles were: Jack Scribner, Bob Roberts, Bob Ross, Linda Mattson, John LaRue, John Winkelman, Marilyn Bernert, Chuck Sullivan, Ray Barrett, Joyce Lekas, Mike Taylor, Will Gallant, Chuck Frost, Howard Duffy, Dennis Feucht, Carolyn Schloetel, Jacquie Calame, Deanne Kidd, Cliff Morgan, Pete Perkins, Ken Hawkin, Steve Blazo, Don Boldea, Bill Berg, Ed Strande, Bob White, Nancy Andrews, Henry Bahrs, Bill Wilke, Carol Schober, Susan Stone, Bob Metzler, Micki May, Bruce Campbell, Bill Walker, Cathy Hendel, John McCoy, Om Gupta, Mike Rieger, Gene Cowan, Jere Marrs, Trent Cave, Douglas Smith, Al Zimmerman, Eric Geislinger, Marion Peterson, Gene Hanson, Jon Birck, Bill Drummond, Doug Reed, and Karen Hall.

CONTRIBUTING TO EN

If *you* have an article or paper to contribute or an announcement to make, contact the editor on ext. 6792 or write to 19-313.

The most important step for the contributor is to put the message on paper so that the editor will have something to work with. Don't worry about organization, spelling and grammar. The editor will take care of those when he puts the article into shape for you. □

PATENTS RECEIVED
A MASTER-SLAVE, CLOCK-DRIVEN VOLTAGE COMPARATOR



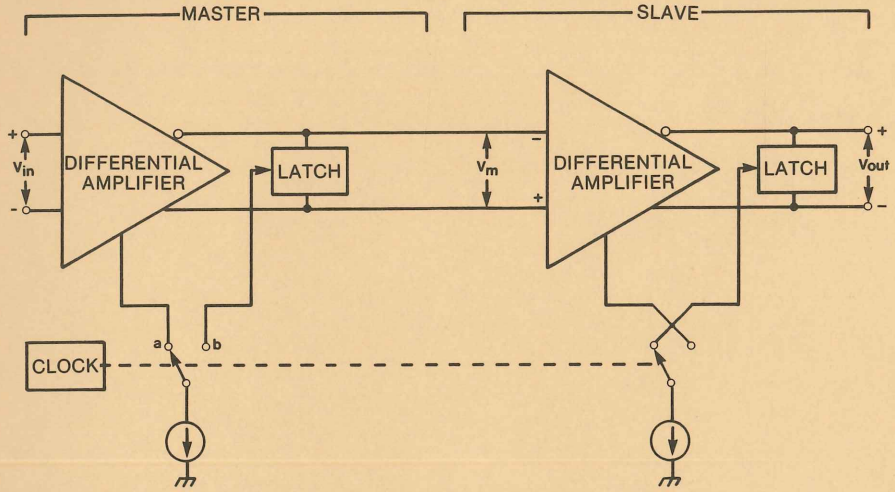
Steven E. Wetterling, Component Development, ext. 5674 (Beaverton).

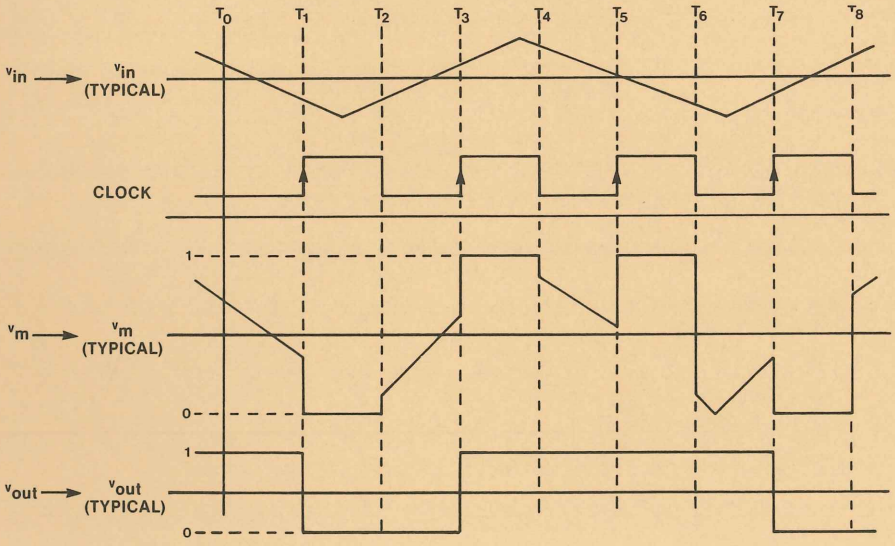
Previous clock-driven (strobed) comparators had to perform both amplication and latching. With such circuits, comparison data is available at the comparator output only during the latch-portion of the clock period (the latch-portion is typically less than 50% of the clock period). At very high clock rates, the output data-valid period is too short to allow accurate data transmission to other circuits.

The patented circuit shown here uses a master-slave configuration for a clock-driven comparator whose output is valid during the whole clock period. When the clock input is low, the master acts as a differential amplifier while the slave is latched to the master's prior decision state. When the clock signal moves from low to high, the master latches to the decision state determined by the master's differential input voltage just prior to the transition. While the clock input is high, the slave is an amplifier, transmitting the master's decision state to the system outputs.

When the clock signal turns low, the slave latches the system output in the current decision state until the next clock low-to-high transition. Thus, the decision state is a valid data output for a whole clock period. This gives transmission and processing circuits more time to handle the data.

The M175 SHF3 integrated circuit, which will be used in an upcoming Measurement Systems Division product, uses this circuit. □





PART NUMBERS FOR WIRES

In March, Wire Prep (part of Electrical Component Manufacturing) will assign a part number to each wire configuration that it makes. Part numbering will enable Wire Prep to use computer-assisted methods to control wire production. Wire Prep builds over 24,000 wire configurations for Tektronix instruments.

BILL OF MATERIALS

Figure 1 shows the structure that all Bills of Materials for new wire kits must follow.

FOR MORE INFORMATION

If you have questions about part-numbered wires, call Mike Waggoner (project manager) on ext. 5796 (Beaverton), Dick O'Brien (scheduling manager) on ext. 7345 (Vancouver), or Bud Siegle (Wire Prep Pilot) on ext. 7314 (Vancouver).

(INSTRUMENT) 7603		
(VERTICAL AMPLIFIER KIT)	670-1442-00	1 ea.
(WIRE KIT)	198-3144-00	1 ea.
(PELTOLA CABLE)	175-0108-00	1 ea.
	177-1121-00	1 ft.
	220-0774-00	2 ea.
	210-0775-00	2 ea.
(PELTOLA CABLE)	175-9109-00	1 ea.
	177-1120-00	1 ft.
	210-0774-00	2 ea.
	210-0775-00	2 ea.
(RIBBON CABLE)	178-1900-00	1 ea.
	131-0707-00	2 ea.
	352-xxxx-00	2 ea.
	175-xxxx-00	1 ft.
(SINGLE CONDUCTOR WIRE)	195-9000-00	1 ea.
	177-0200-00	1 ft.
	131-0707-00	2 ea.
	352-xxxx-00	2 ea.

Figure 1. Bills of Materials for wire kits must follow the structure shown above. The example uses real prefixes but dummy numbers.

1. Each striped wire configuration must have a part number. Most configurations are already numbered.

2. Each new wire configuration must have a part number. The wire material determines the number. Any "wire, electrical" will have a 195, 196, or 197 part number prefix and will be named "lead, electrical." Each cable configuration made from "cable, rf" or "cable, special purpose electrical" will have a 175 or 178 prefix and will be called "cable assembly, rf" or "cable assembly, special purpose electrical."

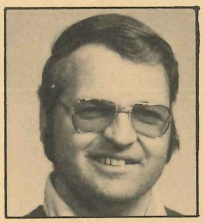
Figure 2. Beginning in March, all new wire items must be part-numbered and all new kits must meet the above requirements. □

PUBLISHING OR PRESENTING A PAPER OUTSIDE OF TEK?

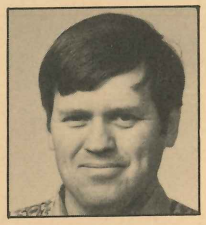
All papers and articles to be published or presented outside Tektronix must pass through Test and Measurement Publicity for confidentiality review. The Publicity department helps Tektronix employees write, edit and present technical papers. Further, the department interfaces with Patents and Licensing to make sure that patent/copyright applications have been filed for all patentable/copyrightable material discussed in the paper or article.

For more information and for assistance in producing your paper, call Test and Measurement Publicity, ext. 6792. IDG employees can also take their papers to IDG Public Relations (D.S. 60-631, ext. 2343). They will provide writing support and handle the appropriate interface with T&M Publicity. □

PATENTS RECEIVED
Pulse Peak Detector



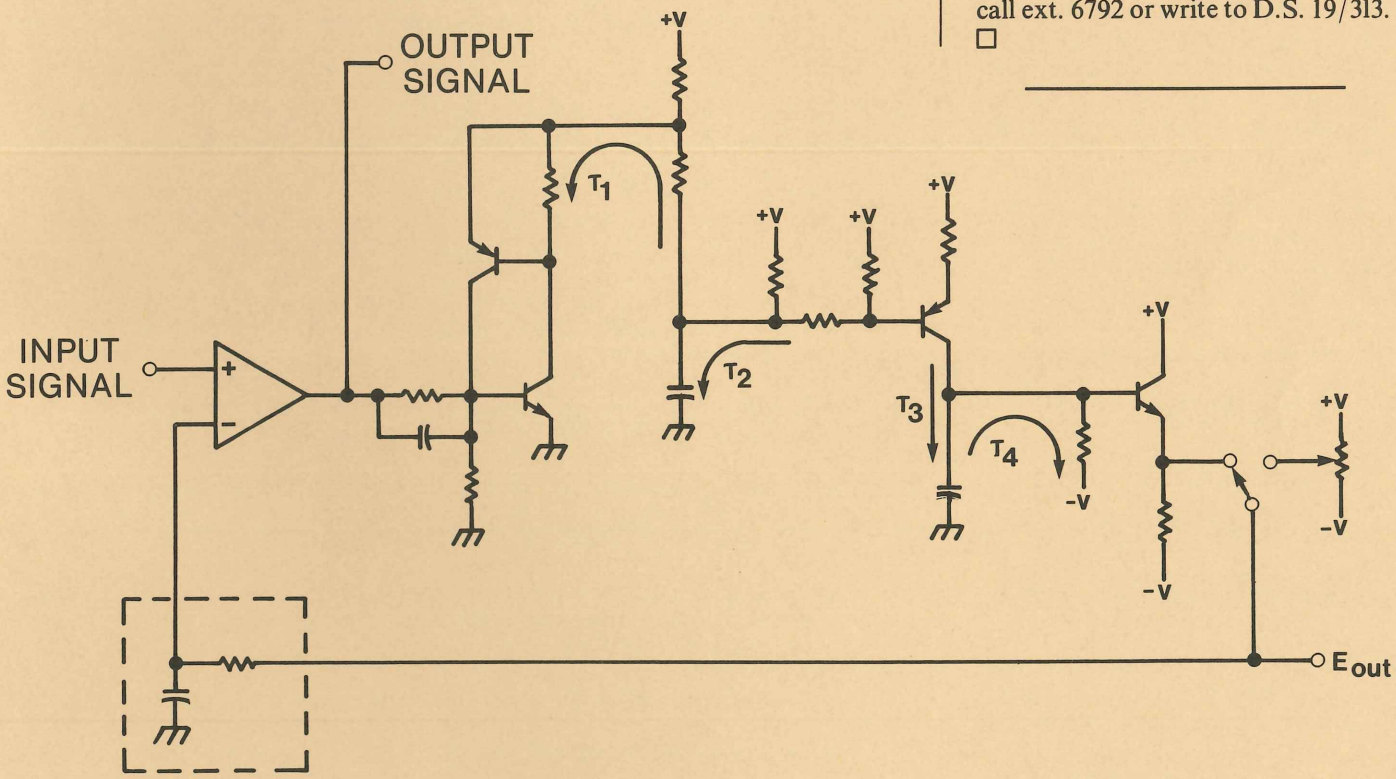
Gordon Wallace Meigs, 5000 Series Engineering, ext. 5840 (Beaverton).



Wayne Donald Thomas, Measurement Display Production, ext. 5806 (Beaverton).

This invention is a pulse peak detector that produces a dc voltage level corresponding to an input signal's peak amplitude. A differential comparator compares the input signal to the output level and activates a control circuit when the input signal's peak amplitude exceeds the output voltage.

The control circuit includes a current source which works for a minimum period of time to provide a charging current path for a storage capacitor. An emitter follower between the storage capacitor and the system output isolates the capacitor from output loading. A latch circuit insures activation of the timing circuit for all valid input pulses, down to the specified eight-nanosecond pulse duration.□



REVIEWERS NEEDED

Engineering News articles are becoming more technical and more detailed and that trend will continue. Although most articles are written and edited for a general engineering audience, only technical specialists can effectively review the content of very complex articles.

Engineering News publishes articles written by engineers and scientists in all the disciplines found at Tektronix. Examples include electrical engineering, mechanical engineering, chemistry, chemical engineering, materials research, human factors, and aspects of marketing and manufacturing of direct interest to the Tektronix engineering and scientific community.

If you are interested in reviewing a rough draft article in your specialty, call ext. 6792 or write to D.S. 19/313. □

HOBBY FAIR AWARD PRESENTED

Mike Cranford (Electron Technology Applications, part of Tektronix Laboratories) won the best-of-show award for the 1978 Microprocessor Hobby Fair. Mike's entry was a maze-solving mouse he originally designed for IEEE Spectrum Magazine's May 1978 Micro-Mouse contest.

Bill Walker, executive vice president, presented the award (several Test and Measurement instrument components, including two TM500 oscilloscope boards) at the January Engineering Activities Council meeting. The Council sponsors engineering forums to enable Tektronix engineers to present directly, to multiple levels of management, what engineers themselves consider important in technology. The Hobby Fair was Forum 11 and was presented in building 60 in Wilsonville in August 1978. Hobby Fair participants displayed microprocessor-based projects which they had developed either on their own time and for their own use or as "G-jobs" for their groups at Tektronix.

Forum Report 11 describes the projects displayed at the Hobby Fair. For a copy, call T&M Publicity on ext. 6792.□

At the January 1979 Engineering Activities Council meeting, Bill Walker (executive vice president), awarded Test and Measurement instrument components to Mike Cranford (Electron Technology Applications) for his entry, a maze-solving mouse, in the 1978 Microproccessor Hobby Fair.

In the background, from left to right, are council members Steve Joy (Engineering Activities Council chairperson), Hock Leow, Bob Oswald, Cal Diller, Bruce Ableidinger, Burgess Laughlin, Dave Armstrong, and Lynn Saunders.

TECHNICAL STANDARDS LOANS REFERENCES

Technical Standards can now loan most of the standards and other documents listed in the computer index of reference documents. There is a copy of the index in the Beaverton, Walker Road, Wilsonville, and Vancouver plants. Call ext. 7976 for more information. □

NEW DISPLAY JOURNAL

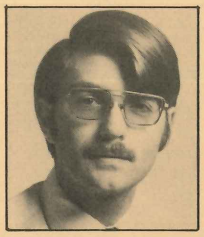
IPC Science & Technology Press Limited of England has announced the publication of **Displays**, a new international journal to be published four times a year from April 1979. The journal will cover the following areas:

- Digital and alphanumeric displays — led's, gas discharge, electroluminescent, fluorescent, CRT, IC, electrochemical, and electromechanical.
- Graphic and pictorial displays — storage tube displays, low-cost refreshed graphics, high performance graphics.
- Picture processing — image intensifiers, image converters, scan converters, image enhancement, projection systems, laser and holographic displays, and display electronics.
- Systems design — computer networks, network configurations, communication lines and services, communication interface, and information flow control.
- Commercial evaluation of display technologies.
- New and developing applications.
- Human factors in display design and use — color considerations, visibility, and operator fatigue.

Kevin Considine, Applied Research, has accepted an invitation to be a member of the International Advisory Board.

If you are interested in obtaining more information about **Displays** or in submitting papers or letters, please contact Kevin at ext. 5212.□

PATENTS RECEIVED
AUTOMATIC TRIGGER CIRCUIT

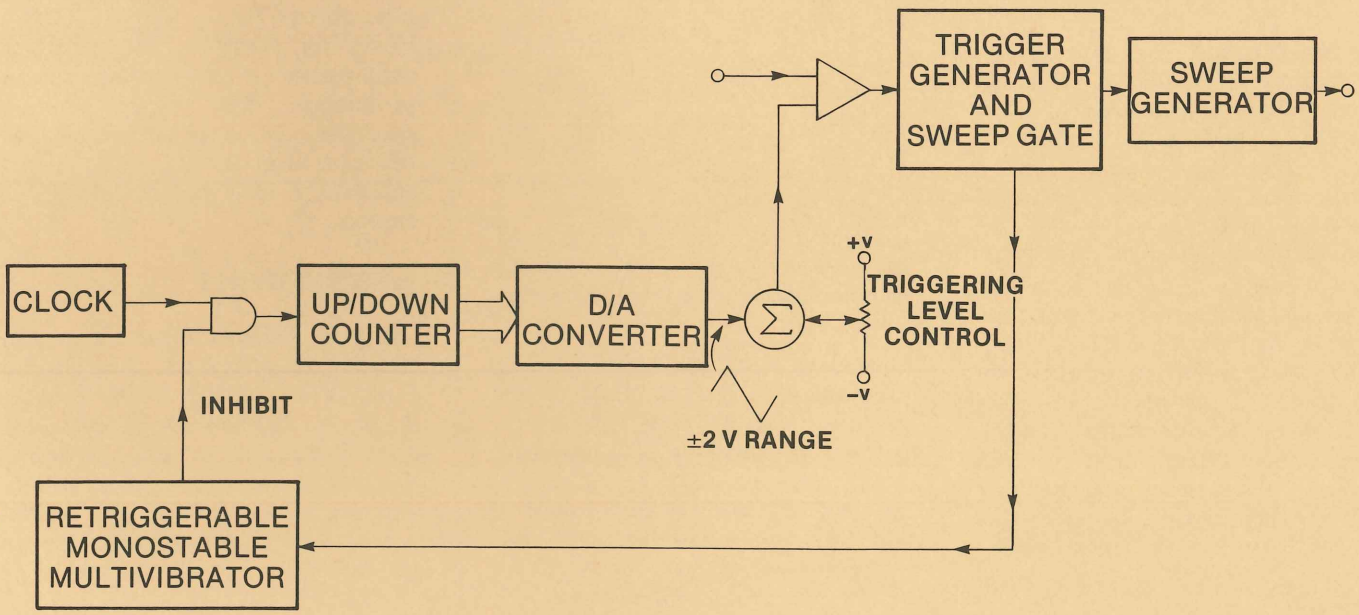


Dennis Feucht, Applied Research, ext. 5630 (Beaverton).

For several years, laboratory oscilloscopes have used automatic triggering circuits such as **peak-to-peak auto.** The patented circuit concept shown here is for especially cost-sensitive applications (such as portable oscilloscopes) where low parts-cost, low parts-count, and non-critical calibration-free circuitry are important. This circuit provides **signal-seeking auto-triggering.** Table 1 compares peak-to-peak auto to signal-seeking auto.

If no trigger occurs, a digitally-generated triangle wave signal automatically varies the triggering level by monitoring the trigger generator gate output. When the triangle-wave signal crosses the trigger threshold, triggering occurs and the triggering level is held constant. □

PEAK-TO-PEAK AUTO	SIGNAL-SEEKING AUTO
Noticeable trigger-level settling time.	Practically instantaneous triggering.
Calibration adjustments required.	Lower cost; no calibration needed.
Trigger control range adjusts to range of signal.	Range fixed around variable automatic level.
Triggers over 10%-80% of signal.	Triggers like NORMAL mode.
Trigger point is always at same signal phase.	Trigger point is random along selected slope of signal.
Performance affected by signal frequency and duty cycle.	Performance independent of signal.



Designed-In Diagnostic Features....
DOWNLOADING VS. ROM-RESIDENCE

Chuck Haymond, LID Production Test Engineering, ext. 5638 (Beaverton).

Dave Levadie, LID Production Test Engineering, ext. 5638 (Beaverton).

This is the third part of a three-part article. The first part described kernel diagnostics for processor-based products. The second part discussed diagnostics for the instrument circuits in processor-based products. For a copy of either article, call T&M Publicity on ext. 6792 or write to 19/313.

DOWNLOADED DIAGNOSTICS:

Advantages

Instrument diagnostics can be resident in ROM or downloaded (through an input/output port) into RAM.

Downloading has several advantages. First, downloaded diagnostics are easy to modify if the source code and compiler are maintained on a computer.

Second, if an intelligent terminal or a computer system downloads the diagnostics, such tools as high-level languages, graphics, and string handling can be available. Third, the diagnostic programmer can segment the diagnostics to accommodate the memory available in the product being serviced.

Disadvantages

Downloading has disadvantages too. To supply diagnostic routines, downloading may require a device external to the serviced product. If the product itself includes mass storage and a suitable operator interface, there is no problem. Otherwise, there must be some external device which can interface the product to the servicer (probably through a keyboard and display) and to the source of the diagnostics to be downloaded (a mass-storage device or telephone line, for example). With down-loaded diagnostics, if the product is powered down, the servicer may have to reload the diagnostics. At low baud rates, downloading can be very time consuming.

IMPLEMENTATION

To run downloaded diagnostics, a product must have enough RAM to contain the largest diagnostic program or program segment. Also, the designer must provide some way for the instrument's processor to control the I/O port connected to the source of the downloaded code. This control requires a ROM-resident bootstrap loader program.

Most processor-based products have a standard I/O port (such as RS232 or GPIB) which the servicer can use to download diagnostics. Where a standard I/O port is not available, some designers make the instrument's bus accessible at an external connector. Of course, downloading onto the bus requires an external hardware interface.

WITH A 4051

Where downloading requires an external controller, one obvious choice is the Tektronix 4051 Computer Terminal. The 4051 provides the required interfacing, a high-level-language programming capability, and graphics. A diagnostic programmer can use the 4051 to write the routines, and the servicer can use it to download them.

However, there are drawbacks to using the 4051. Because the 4051 isn't portable, it is difficult to use on-site. It's also expensive (a 4051 may cost more than the serviced product). Another drawback is that a 4051 is not upward compatible with any computer system.

WITH A COMPUTER SYSTEM

Tektronix could install time-share computer systems in manufacturing and service centers. Each bench could have RS-232 or GPIB connections or both. Dial-up facilities could be provided for on-site servicing. This remote servicing approach requires either that the serviced product have modem-control and downloading capabilities or that the servicer have a portable, semi-intelligent terminal that can control a modem and pass data to the product's input/output port.

A company-wide computerized diagnostic system for manufacturing and servicing would offer several ancillary advantages: centralized data-base management, automated failure-data collection, and easy updating of software, for example.

For several years, the 4010-Series Computer Terminal manufacturing department has used a computerized production line system which performs cycle-rack monitoring in addition to providing access to test software at each manufacturing test station.

ROM RESIDENT

Using a ROM-resident diagnostic strategy has several advantages. First, products with ROM-resident diagnostic routines can offer resident diagnostics as a selling point. Second, using ROM-resident diagnostic routines requires a less complex diagnostic strategy because no external controller is required.

A LIBRARY

The Reprographics department (part of T & M Operations), archives firmware and software, including ROM-resident diagnostic routines. Their retrieval system provides copies of part-numbered software and firmware. Their archives include program reproduction instructions, source code, object code interpreters and compilers, and descriptions of the development system hardware. Diagnostic routine programmers should be careful to provide documentation that will help other designers easily update the routines.

Unfortunately, the archives provide no way to correlate firmware part numbers (that is, revision levels) with levels of product modification. Therefore, programmers should cross-reference source programs with ROM revisions, hardware changes, and diagnostic procedure changes (this cross-referencing applies to downloaded diagnostic routines as well).

Third, a servicer can use ROM-resident diagnostics for on-site service without external hardware. On the other hand, updating ROM-resident diagnostic routines is usually much more expensive than updating downloaded routines because PROMs must be reprogrammed or new ROMs fabricated. The servicer can not easily modify ROM-resident diagnostics to fix a software bug.

ANOTHER DISADVANTAGE

Another disadvantage of ROM-resident diagnostics is that they do require memory space in the product. In any case, kernel diagnostics must reside in the product, preferably on the processor board. If there isn't enough memory space available for the remaining diagnostics, a designer can provide diagnostics in pluggable ROM or a ROM board.

However, following the principle that no circuit should be used in diagnosis unless it has already been verified, ROMs containing diagnostic routines must be checked before they are used.

Also, a diagnostic procedure should not require the servicer to unplug and replug IC's unless (1) they are installed in carriers and (2) the board contains Zero Insertion Force sockets. Otherwise, unplugging and replugging may cover up socket problems or create other problems by damaging either the IC or the socket.

ECONOMIC EVALUATION NEEDED

So far as we know, no one has thoroughly examined the economic tradeoffs of ROM-resident vs. downloaded diagnostic routines. That examination has to be made before designers can make informed choices.

ACKNOWLEDGEMENT

Thanks to Chris Jones (Service Support) for typing the original 30-page, *very* rough draft of our three-part article. □

EAC SEEKS IDEAS FOR STIMULATING INNOVATION

The Engineering Activities Council is seeking implemented or proposed programs for encouraging engineering innovation at Tektronix. As part of its charter to "present to management what engineers, themselves, consider important in technology," the Council will propose to Tektronix upper management suggestions for enhancing engineering innovation at Tektronix.

If your engineering group has implemented or proposed an incentive or reward system that might work for the rest of the corporation, please contact Dave Armstrong (Digital Accessories Design) by calling ext. 5244 or writing to D.S. 19-092. □

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HOBBY FAIR III ANNOUNCED FOR JULY

The Engineering Activities Council recently announced that it will sponsor Hobby Fair III in July, 1979. Hobby Fairs are exhibits of engineering and G-job projects. Hobby Fair I (1977) and Hobby Fair II (1978) included only microprocessor projects, but Hobby Fair III is open to engineering projects in all disciplines.

Because exhibit space is limited, the Engineering Activities Council will select participants from among applicants.

If you would like to exhibit a project at Hobby Fair III, call Dave Armstrong (Digital Accessories Design) on ext. 5244 or write to 19-092. Applications must be in by June 1, 1979.

T&M Publicity has published reports describing Hobby Fair I and II. For copies, call ext. 6792 and ask for Forum Report 6 and Forum Report 11. □

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Why EN?

Engineering News serves two purposes. Long-range, it promotes the flow of technical information among the diverse segments of the Tektronix engineering and scientific community. Short-range, it publicizes current events (new services available and notice of achievements by members of the technical community).

Contributing to EN

Do you have an article or paper to contribute or an announcement to make? Contact the editor on ext. 6792 or write to 19-313.

How long does it take to see an article appear in print? That is a function of many things (the completeness of the input, the review cycle and the timeliness of the content). But the *minimum* is six weeks for simple announcements and about ten weeks for major articles.

The most important step for the contributor is to put the message on paper so that the editor will have something to work with. Don't worry about organization, spelling and grammar. The editor will take care of those when he puts the article into shape for you.

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