ENGINEERING NEWS

Finite Element Analysis Solves Mechanical Design Problems

Finite Element Analysis Solves
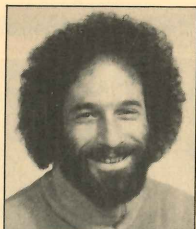
Barry Ratihn, IDS Engineering, now at Oregon State University for a masters degree in structural mechanics.

Kurt Krueger, Scientific Computer Center, ext. 5976 (Beaverton)

For more information about SAPV, the structural analysis program, type HELP,SAPV on a Tek Cyber terminal. For information beyond what the HELP command provides, call Kurt Krueger on ext. 5976.

GLOSSARY

Deflection — distance an object moves when a force is applied.

Finite element analysis — analyzing a complex mechanical structure by characterizing discrete parts (finite elements) of the structure's finite element model.

FEM 181 — finite element modeling program for the 4081 Interactive Graphics System.

Linear program — a computer program that analyzes structures made of materials that stay in the elastic range when struck.

Natural frequency — the frequency at which an object oscillates after it has been struck. A higher natural frequency means greater stiffness.

Post-processing — processing FEA results by observing a graphic display or by thumbing through printed data.

SAPV — the fifth generation of the Structural Analysis Program first written at the University of California at Berkeley. To find out more about SAPV, type the HELP,SAPV command on a Cyber terminal.

COMPETITIVE ADVANTAGE

Finite element analysis is playing a greater role in product design. Until 1975, only the largest organizations (such as Boeing Aircraft Co. and the National Aeronautics and Space Administration) could afford the time that finite element analysis required. They could afford to have designers make the structural models by hand (the most time-consuming task), analyze these models with a finite element analysis program on a large mainframe computer, and search the analysis results for possible structural failures resulting from high stress or high deflection. But these companies could not afford the extra material weight (on a spacecraft, for example) or a component failure (in a commercial airplane, for example) that might arise from incomplete analysis.

Now there are interactive graphics programs that allow a designer to create and edit models on terminals that display three-dimensional representations of the models before and after analysis. The Tektronix 4081 Interactive Graphic System provides such a finite element modeling capability. Systems like the 4081 are cost-effective tools for all but the smallest manufacturers (see figure 1). The 4081 system is cost-effective because it requires about 70% less time to model and preview a structure, and create an analysis input file, than modeling and keypunching cards by hand. Now that the most time-consuming task has been trimmed 70% with interactive graphics, the finite element analysis method is a viable design tool.

AN EXAMPLE

Modeling and analyzing the Tektronix 4663 Plotter rail exemplifies the use and benefits of automated finite element modeling and analysis.

Refer to figure 2. The rail presented several problems for finite element analysis and FEM 181 (a 4081 finite element modeling program): how much stiffer would the rail be if we (1) doubled the side thicknesses, (2) doubled the top thickness, (3) doubled both side and top thicknesses, or (4) added a .275-inch high box structure (see figure 3) to

Texas Instruments
Bechtel
Ford Motor Co.
Rockwell International
General Motors
S.E.P. (military, France)
Phillips
Euratom (nuclear, Italy)
General Electric
Chrysler
C.E.R.N. (atomic energy, Switzerland)

Figure 1. Here are 11 organizations which have purchased Tektronix 4081 Interactive Graphics Terminals for finite element modeling and analysis. One department inside Tek, LID Portables, has also purchased a system.

Mechanical Design Problems

THE COST

Finite element analysis can be a very valuable tool for mechanical engineers at Tektronix. Two factors have enhanced its value. First, with an 4081 Interactive Graphics Terminal, using an interactive graphics modeling program (such as FEM 181) can cut finite element modeling time by 70% ... modeling with hand coding was the most time consuming part of the finite element analysis process.

Second, the next step in the process (the analysis of the model) is now very inexpensive for Tektronix designers. For example, in the 4663 Plotter rail project discussed in the

article and shown in figure 2, the author used the SAPV program residing on Tek's Cyber to analyze the model he had created on a 4081. For each version of the model, his average computer cost was about $8.90 per run (using the night batch rate). If he had used an outside timeshare system, such as the Cybernet, his SAPV processing costs would have been about $210 per run.

Using finite element modeling and analysis saves turnaround time as well as labor time compared to calculating and then testing a series of hand-tooled models. With finite element modeling and analysis,

a designer can obtain ball-park results on many models within a few days, and then perform "shake-and-bake" tests of hand-tooled versions of the most promising models.

Finite element modeling and analysis allows a designer to change one characteristic of a model without having to wait weeks for a model to be built. For example (without building a new model) a designer can define a steel structure, and then change the material parameter (to aluminum, for example) by merely editing three card images in the analysis input file.
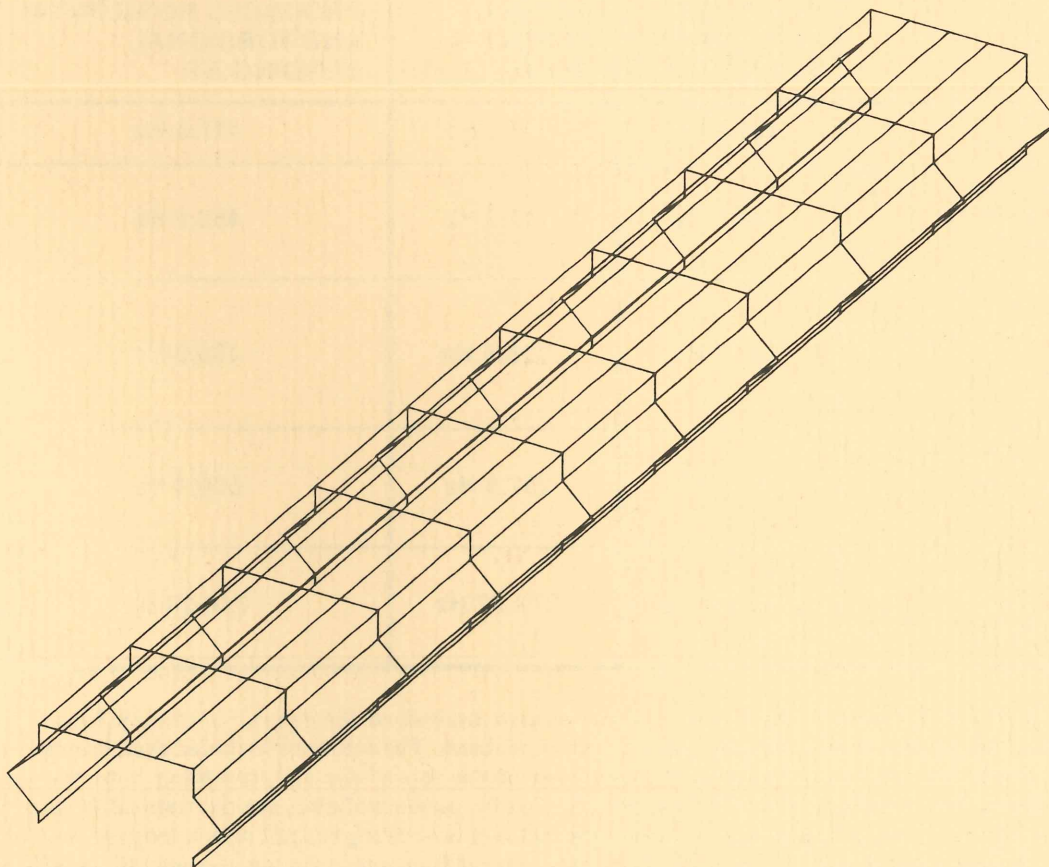

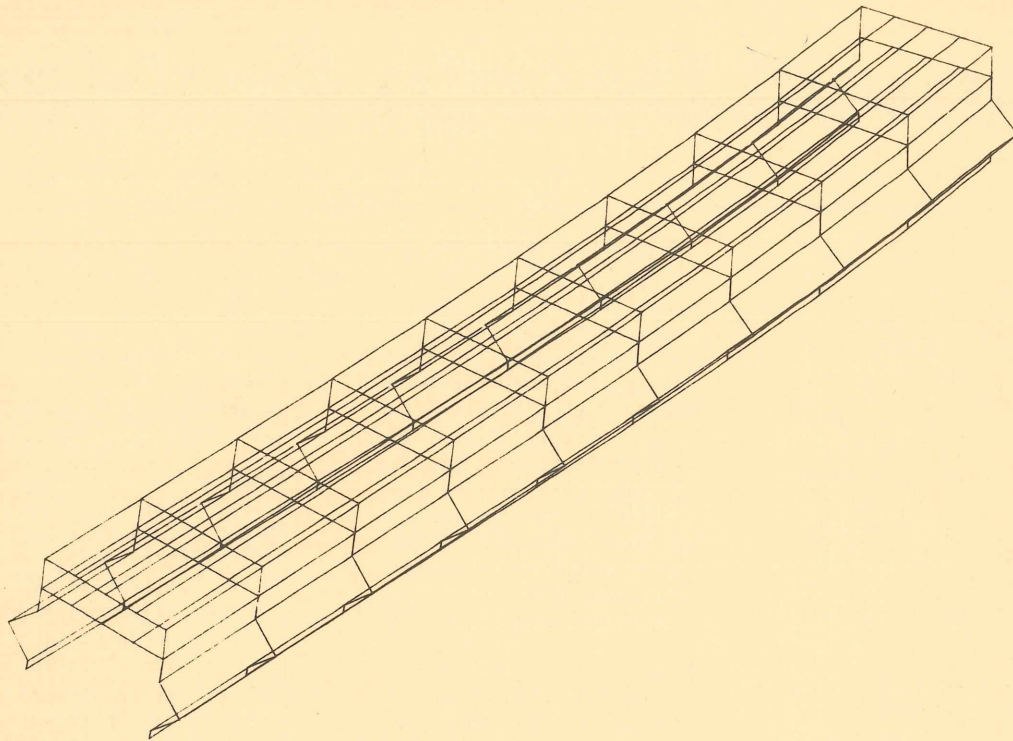**Figure 2. A finite element model of the 4663 Plotter pen rail.**

Figure 3. A finite element model of the 4663 Plotter pen rail with a box structure attached to the top of the rail for additional stiffness.

ALTERNATIVE MODELS	1st NATURAL FREQUENCY PRODUCES HORIZONTAL BENDING AT:	2nd NATURAL FREQUENCY PRODUCES TORSIONAL BENDING AT:	3rd NATURAL FREQUENCY PRODUCES HORIZONTAL AND TORSIONAL BENDING AT:
RAIL AS IS	132.9 Hz	205.5 Hz	417.8 Hz
DOUBLE THE THICKNESS OF RAIL TOP	141.7 Hz	249.8 Hz	486.9 Hz
DOUBLE THE THICKNESS OF THE RAIL SIDES	139.7 Hz	225.6 Hz	438.0 Hz
DOUBLE THICKNESS OF RAIL TOP AND SIDE	152.3 Hz	257.1 Hz	500.4 Hz
ADD A BOX STRUCTURE TO TOP OF RAIL	159.03 Hz	272.72 Hz	740.26 Hz

Figure 4. This table shows SAPV data for an example finite element analysis of the pen rail on the 4663 Plotter. The table shows the results of analysis of proposed solutions to a pen chatter problem. The solutions included doubling the thickness of sides of the rail on which the pen rides, doubling the thickness of the top of the rail, doubling both the top and side thicknesses, and adding a box structure to the top of the rail. The frequencies shown are the natural frequencies for the structural alternatives shown on the left. For example, with the rail as it is, striking the rail with a frequency of 132.9Hz will produce horizontal bending (pen chatter). The higher the rail's natural frequency, the less the rail will be affected by pen motor operation or other sources of vibration. Higher natural frequency means stiffer construction. With the box structure added to the pen rail, the rail's natural frequency is 159.03Hz (16.4% stiffer than the original rail).

FINITE ELEMENT METHOD

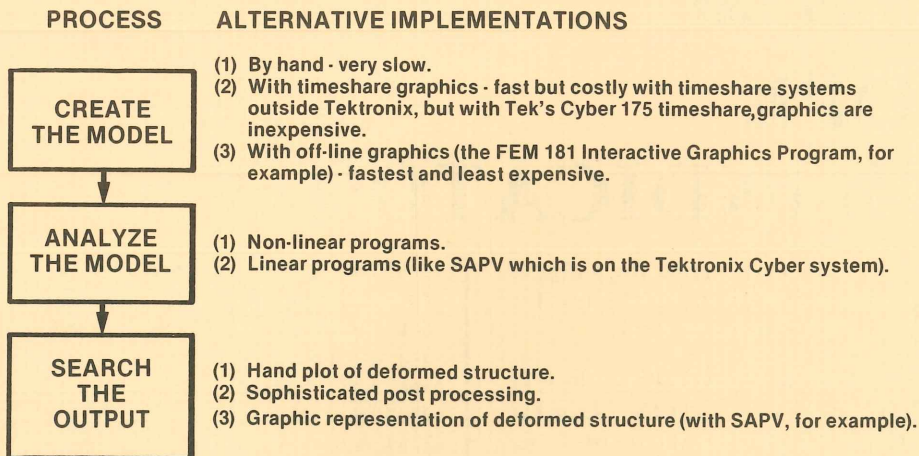| PROCESS	ALTERNATIVE IMPLEMENTATIONS
CREATE THE MODEL	(1) By hand - very slow. (2) With timeshare graphics - fast but costly with timeshare systems outside Tektronix, but with Tek's Cyber 175 timeshare, graphics are inexpensive. (3) With off-line graphics (the FEM 181 Interactive Graphics Program, for example) - fastest and least expensive.
ANALYZE THE MODEL	(1) Non-linear programs. (2) Linear programs (like SAPV which is on the Tektronix Cyber system).
SEARCH THE OUTPUT	(1) Hand plot of deformed structure. (2) Sophisticated post processing. (3) Graphic representation of deformed structure (with SAPV, for example).

Figure 5. The finite element method has three stages: creating a model, analyzing the model, and examining the analysis results (a three-dimensional plot of the structure, for example).
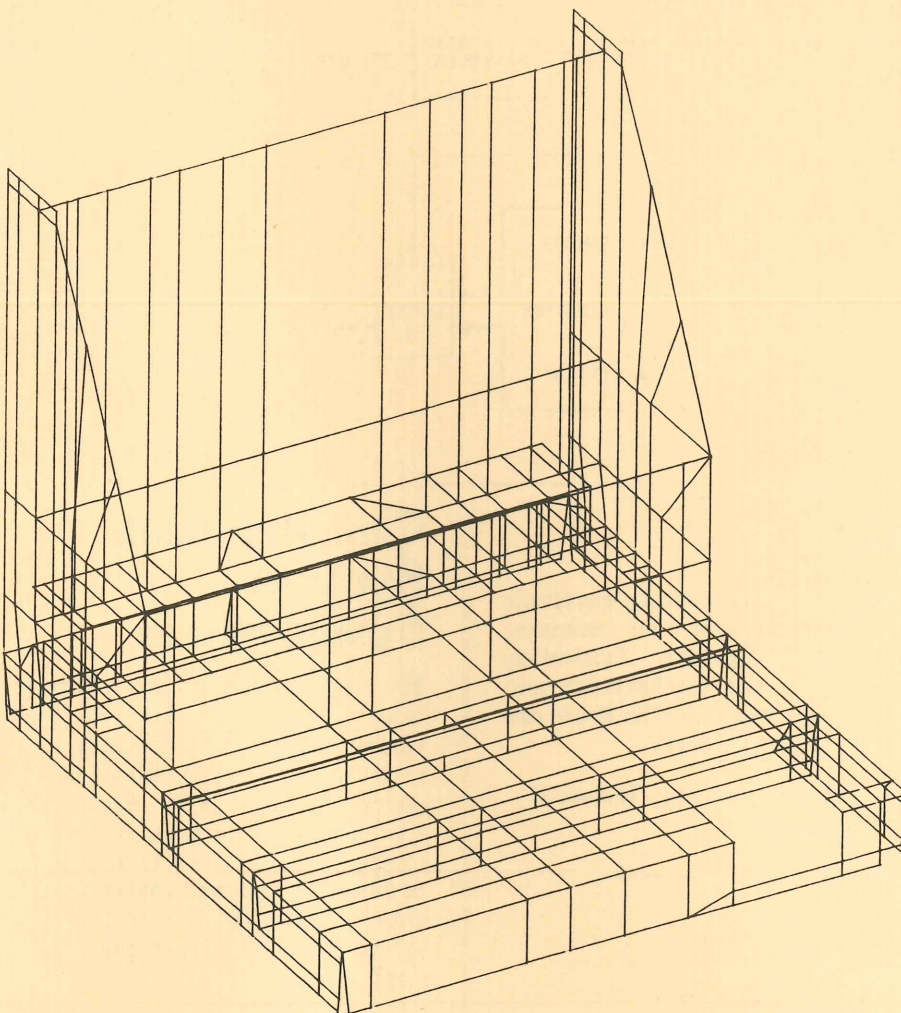

Figure 6. This 618 Monitor crt frame finite element model is another example of a dynamic analysis problem that the FEM 181 quickly modeled and SAPV quickly analyzed. The frame was too loose. The questions we had to answer were: will this modification help? how much?

the top of the rail. The rail is a simple supported beam with a 2.5 ounce mass (the pen holder) in the middle.

We modeled the rail as is and for the four design alternatives above, analyzed these on Tek's Cyber system, and answered the above structural questions in four man days.

Figure 4 shows the results of a SAPV analysis of the models depicted in figures 2 and 3. The SAPV results confirmed, with ball-park data, what mechanical engineers know intuitively: putting a box on the rail gives the rail more stiffness than other alternatives. Going beyond intuition, the SAPV results answered the question "by how much?"

The IDG Environmental Lab tested an extruded model of the rail with the box addition. The Environmental Lab tests showed the rail had a natural frequency of 160Hz which is much higher than the frequency of any vibration likely to affect the rail. If the rail's first natural frequency were 60Hz, and if the operating frequency of the motor that drives the pen along the rail were 60Hz, then the motor would cause the rail to vibrate (causing pen chatter). A designer must, then, design a rail with a natural frequency higher than any likely source of vibration and higher than required by military specification.
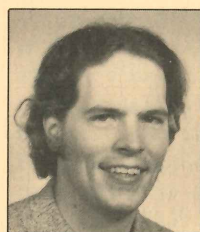
When the IDG Environmental Lab tested the original rail while mounted in the plotter, the first harmonic natural frequency was 65Hz and the second harmonic natural frequency was 122Hz. (The frequencies in table 1 are for the rail as a part separate from the plotter.)□

PATENTS RECEIVED
OSCILLOSCOPE SWEEP-RATE INDICATOR

David H. Olson, SID Engineering, ext. 7749.

**Eldon Carl Berg, formerly with TM500 Engineering, has left the company.**

This patent is for a system that determines the sweep rate of an oscilloscope time base. A sweep gate signal enables a counter to permit clock pulses having a predetermined repetition rate to be counted while a time-base generator produces a sweep-driving ramp waveform. To generate control signals that indicate the sweep rate, a decoder decodes the counter output which is proportional to the length of a time-base sweep. Other circuits use the control signal to display the time-base sweep rate or to provide autoranging for a digital voltmeter scaled in time units for time interval measurements.

The patent was a result of an effort to retrofit the DM43 Digital Multimeter to existing scopes. The DM43 had a time-interval readout mode. To properly scale the readout, the position of the TIME/DIV switch had to be known. Scopes sold with the DM43 attached included a time base printed circuit board that had the required extra positions on the CAM switch. Already available was an expensive option to upgrade existing oscilloscopes, but the option had to be installed by a service center and the installation required replacing the timing board.

The patented system shown here was a much less expensive alternative.□
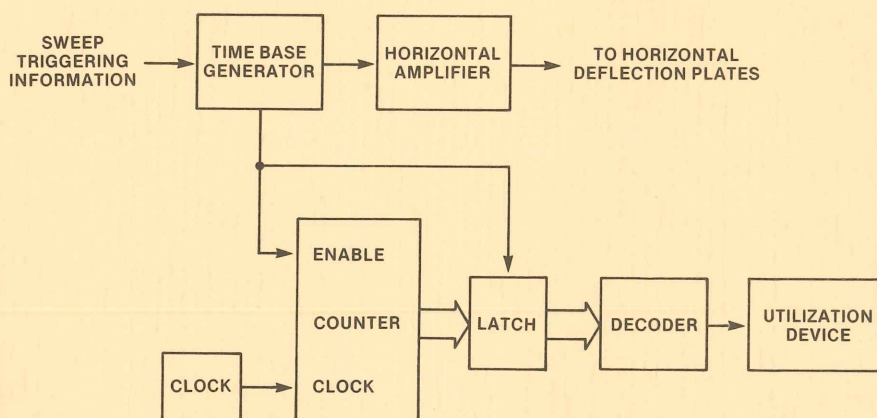
NASA TECHNICAL BRIEFS

Technical Standards maintains a file of National Aeronautics and Space Administration **Technical Briefs.** These briefs cover a wide variety of technical subjects, many that could be useful to Tektronix. The Summer 1978 issue extensively covers solar energy. The issue also addresses such subjects as electronic components and circuits, electronic systems, materials, life sciences, mechanics, machinery, fabrication technology, and mathematics and information sciences. The Briefs can be examined at 58-187.

- Chuck Sullivan, Technical Standards□

Circuits And Systems Symposium

The IEEE Circuits and Systems Society, sponsors of the 1980 IEEE International Symposium on Circuits and Systems, has called for papers for the 28-30 April 1980 symposium in Houston, Texas. The symposium is devoted to all aspects of theory, design, and applications of circuits and systems with focus on microelectronics "from physics to application."

For more information about presenting papers, summaries, abstracts, or special sessions, call Bill Furlow (T&M Publicity) on ext. 6792.

MORE INSTRUMENTS AT THE COUNTRY STORE

In their October monthly meeting, the Surplus Instrument Review Committee approved 44 additional instrument models for sale in the Country Store. Not all of the instruments work and Tektronix will not maintain some of them. Table 1 lists the instruments approved in October. The list indicates the variety of instruments that pass through the store.

Operating managers may requisition instruments by writing to Instrument Control at D.S. 58-188. Two levels of management above the requestor must approve the request. Standard asset transfer policies apply.

For more information, call Ray Barrett (Instrument Control) on ext. 5653. □

TABLE 1		
Beckman	605	Resistance Bridge
Beckman	7580	Transfer Oscilloscope
Beckman	7570	Amplifier
Cal. Stds. Corp.	VA100A	Volt Meter
Fluke	80E	Voltage Divider
FXR	V772A, S772A	Test Oscilloscopes
GenRad	874	Slotted Line
H-P	560A, 561B	Digital Recorders
Keithley	151	Null Detector
Keithley	600A	Electrometer
Remex	550, 651	Tape Readers
TEK	L-20, L-30	Spectrum Analyzers
TEK	RM504, R504, RM503 R503, RM527, R27	Scopes
TEK	T4002, 4002A, T4005	Terminal
TEK	4901, 4902, 4903	Plug-In Graphic Units
TEK	4951	Joystick
TEK	564, 564B	Oscilloscopes
TEK	3S7, 3T7, 3A5 3B5, 3C66, 3S3, 3S5, 3T6, 3T77, 3T5, 2A63, 2B67 3A10	Plug-Ins

Table 1. In October, the Surplus Instrument Review Committee approved these instruments for sale in the Country Store. The list indicates the wide variety of products available in the Country Store.

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. □

MICROMETER ELECTRODE SYSTEM WANTED

Bob Rogers (Ceramics) is looking for a piece of equipment rumored to have been used at Tektronix more than five years ago: a micrometer electrode system that measures capacitance.

With this system, an operator places a device in a holder and turns a micrometer until it contacts both plates in the system. The operator reads the capacitance and then removes the device. Next the operator reads the capacitance of the air gap, and calculates the subsequent dielectric constant. Test procedure ASTM D150-74 documents the procedure.

If you know where this system is, please call Bob Rogers on ext. 5369. □

A quick–and–dirty analysis of the trade-off between...

DESIGNED–IN SERVICEABILITY AND DEVELOPMENT COSTS
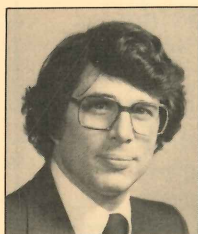
Jim Geisman, Marketing Planning and Strategies (T&M Marketing), ext. 6023.

This quick-and-dirty analysis allows a project leader or small team of engineering, marketing, manufacturing and service people to determine the financial implications of designing for serviceability. Since return-on-investment calculations are irrelevant for small returns, this analysis focuses on determining whether the returns are large enough to warrant further examination.

This analysis is offered in the belief that it is better to be roughly right than precisely wrong.

As our products become more complex, designed-in serviceability can reduce customers' ownership costs and can be a major selling point. However, designed-in service features aren't free, so we need to trade off their development costs against the benefits they bring.

Deciding which way to go with the trade-off may be a two-step process. First, a project leader or design engineer makes a ball-park estimate of the trade-off. Often, the rough estimate overwhelmingly favors designed-in service features. In which case, you're through.

Occasionally, the estimate is a fence-sitter. If it is, the second step is to analyze the trade-off in more detail and contact someone else (business unit or division management, marketing people, or financial analysts) for more information.

QUICK-AND-DIRTY ANALYSIS

A quick-and-dirty serviceability/development-cost trade-off isn't easy to make — some claim it is impossible — but the analysis shown in figure 1 can help *roughly* determine the value of designed-in service features for a given product. To obtain the proper range of numbers and to check your estimates, you can consult other engineers and people in manufacturing, marketing, and the service organization.

The analysis can be applied to both analog and digital products. Digital products may incur higher product development costs and may require field service people to invest in expensive specialized equipment to decrease mean time to repair. The cost of added parts for digital products may be negligible. On the other hand, analog products may require more mechanical parts such as test points, plugs and sockets. Designed-in service features can also affect manufacturing tests and quality control by decreasing the skills and time required to calibrate and verify a unit's operation.

PROCEDURE		
Add unit cost savings for: · field repairs (over product life); hrs x $rate/hr = · manufacturing cal, test and QC; hrs x $rate/hr = TOTAL SAVINGS PER UNIT =	(1)_____ savings per unit	10 · 20 hrs @ $30/hr 1/2 · 1 hr @ $20/hr
Deduct unit cost increases for: · parts · labor hrs x $rate/hr = TOTAL COSTS PER UNIT	(2)_____ cost per unit	Some LSI, but no extr 1/2 · 1 hr. @ $20/h
Total net unit savings (worst and best case) = (1) minus (2)	(3)_____ net savings per unit	Lowest savings – high cost = worst case $280 – 80 = $200 Highest savings – low cost = best case $590 – 40 = $550
Expected production = (lowest and highest product volume)	(4)_____ units	–
Product lifetime savings (worst and best) = (worst-case savings x lowest volume = worst) (best-case savings x highest volume = best)	(5)_____ lifetime savings	Lowest savings x lowe volume = $200 x 2000 units = $ Highest savings x high volume = $550 x 5000 units = $
Cost of time developing designed-in service features =	(6)_____ development costs	2 · 4 person/months @ $36,000/year

Figure 1. A quick-and-dirty analysis of

OBJECTIVES

The quick-and-dirty analysis shown in figure 1 was developed to help engineers and marketing people determine whether additional development expenses are warranted on a given project. Adding service features increases product complexity and usually increases development costs. The analysis should help answer the question "Is the added serviceability worth the time, money and effort it requires?"

The analysis is a rough-cut attempt to define a range of costs. Since it is a rough-cut analysis, it won't produce perfect results, but can provide more help than what is now available.

EXAMPLE

Figure 1 includes an example of using the analysis. With the worst-case condition in figure 1, the savings ($400,000) might net *at least* 34 times the development cost investment ($12,000). However, this still may not be enough to justify building special test equipment, writing service documentation and investing in special parts.

The example illustrates the leverage an engineering decision can exert over the cost to Tektronix: a modest engineering effort can greatly reduce costs. Often, some of the costs are passed onto the customer. In the example, most of the $300-$600 per-unit product-lifetime savings in field repairs *are* passed on.

Incidentally, in this example we assumed a product having a typical production life, about 5 to 7 years. However, product support continues nine years after Tektronix discontinues production. Our example also assumes this hypothetical product, having "average" complexity, required only a few additional parts to implement the serviceability features. Here, the development cost indicates pretty straight-forward documentation and firmware for the limited serviceability objectives indicated by the repair savings.

This quick-and-dirty analysis ignores investments in equipment because such investments require careful analysis. If your analysis shows substantial savings, have a financial analyst determine what level of investment is required.

EVALUATING THE RESULTS

If a trade-off is a fence-sitter, field service people may be able to sway the analysis by providing information such as training costs, service equipment costs, and the time saved by using the designed-in service features.

Even if the trade-off shows there are no cost savings, marketing people may believe customers are willing to pay a higher price to offset increased development costs. The trade-off could then favor designed-in features, providing a higher price will be charged.

OTHER CONSIDERATIONS

There are other factors to consider but they are difficult to quantify: product-introduction timing, product complexity, and special customer needs.

If service features are included as an afterthought, the product may be late getting to market. Profits from additional sales may be lost, which, in turn, may offset savings realized by designed-in serviceability features. (If service features are designed into the product at the beginning of product development, the product may not be delayed much, if at all.)

More complex products are more likely to need designed-in service features. Also, products used in isolated locations and products used by customers who can't tolerate long downtime require more designed-in service features. As an added benefit, these features sometimes allow customers' service people to service our products without advanced training, or allow customers to hire less skilled people (who are easier to find in today's tight market for service technicians). □

XAMPLE		COMMENTS
	$300 · $600 $ 10 · $ 20 $280 · $590 savings per unit	How much field service time will be saved? How much will MTTR be reduced? Designed-in diagnostic features often save manufacturing time too. So be sure to estimate cal, test, and QC savings. Include any other savings too.
M	$ 30 · $ 60 10 · 20 $ 40 · $ 80 cost per unit	Include anything that affects manufacturing cost of sales. Sometimes memory and board space are already available (free); at other times a 4KROM board may be needed. Other parts, like plugs, mechanicals? Labor should be separate because labor costs increase, semi-conductor prices decrease.
	$200 · $550 net savings per unit	Subtract (2) from (1). If (2) nearly equals or is less than (1), the designed-in features may still be justified by manufacturing and field needs.
	2,000 · 5,000 units	Number of units produced over product life? (ask marketing people for estimated range).
000 0,000	$400,000 · $2,750,000 lifetime savings	Even if (5) is small, the designed-in service features may still be justified by manufacturing and field needs.
	$6,000 · $12,000 development costs	This time includes project engineering, prototype support, evaluation, service manuals, and perhaps other factors. No. (6) should be much less than (5).

development-cost/ serviceability tradeoff.

PROFILE
THE QUICK BOARD LINE
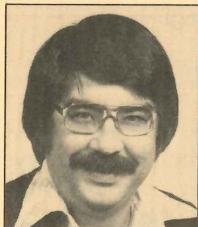
Tino Ornelas, Operations manager for Electrochemical Support, ext. 5666.

This article is another in a series of profiles of departments that support Tektronix engineering and scientific activities. The editor interviewed Tino Ornelas, Operations manager for Electrochemical Support.

Could you briefly describe your job?

I'm the Operations manager for Electrochemical Support. I manage several areas: scheduling, subcontract, quality assurance, a communications section, and a new section: data processing/systems.

What is Electrochemical Support's charter?

Basically, our charter is to fabricate engineering circuit boards, that is, printed circuit boards used in pre-production instruments. In addition, our charter now includes fabricating other boards directly related to engineering. (We are still defining who is "directly related to engineering.")

We also process boards for the Cables, CRT and Custom Mod departments which are not engineering, but are related to it.

How is Electrochemical Support organized?

Wally Doeling manages Electrochemical Support. As you can see in the organization chart (figure 1), there are five sections with the Fabrication section as the focal point. Since the other four groups support Fabrication, all five groups are functionally interrelated and are very important to each other.

What functions does operations perform?

Operations performs a variety of functions. For us, the most important is communication with the business units. The goal of our communications is informing people associated with printed circuit boards of new developments in Electrochemical Support and of changes in standards. The communications section uses memos, bulletins, telephone calls, one-on-one meetings, group meetings and group presentations. Also, we've started a monthly newsletter to which anyone associated with engineering printed circuit boards can contribute.

What is the Quick-Board line?

"Q.B.", for short, is the old "Fab Lab." We changed the name to "Q.B.", but most people still call it "Fab Lab." Anyway, the Q.B. Line produces engineering circuit boards.

Do you process some orders for production instruments?

Yes, we do fabricate boards for the Custom Mods department. Some of those boards are for production instruments.

How much has the demand for the Quick-Board line grown in the last few years?

The demand has grown directly with company size. The company added 5,000 people last year and many of them were engineers.

Adding to the demand was a change in our charter from fabricating pre-design-completion and two-board orders, to A-phase, B-phase, and all other engineering boards.

Does Electrochemical Support have space problems?

Very much so. Let's use my own group, Operations, as an example. There are many segments in Operations, but Quality Control is the largest. In 350 square feet of office space, we have Quality Control, Scheduling, a technical aide and myself (a total of seven people), work tables, and furniture for visiting circuit board designers.

Presently, the Quick-Board Line is too far from the supporting process areas (such as Tooling and Quality Control). When Q.B. was in building 50, two-sided quick-boards traveled about a thousand feet during processing.

As the process is now set up in building 38, a quick-board order must travel 6118 feet during processing. That's a problem because travel time adds greatly to turnaround time.

In November 1977, Underwriter's Laboratories certified printed circuit board line widths as narrow as 6 mils. How has that affected the Q.B. line's operations? What does the future hold?

We discourage line widths less than 12 mils because we cannot process 6-mil lines without using special procedures. Anyway, very few boards use 6-mil lines now.
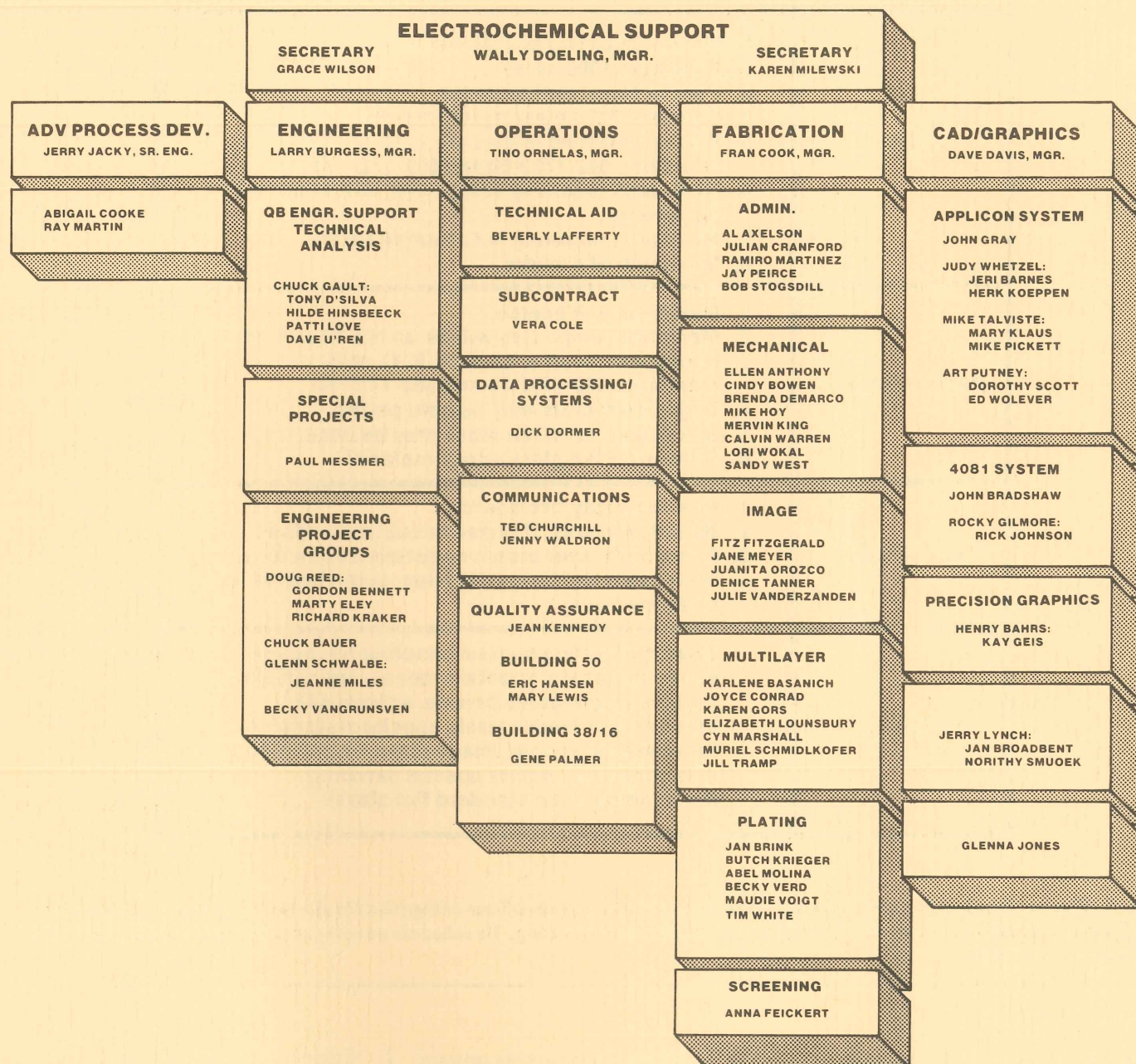
ELECTROCHEMICAL SUPPORT

SECRETARY
GRACE WILSON

WALLY DOELING, MGR.

SECRETARY
KAREN MILEWSKI

ADV PROCESS DEV.
JERRY JACKY, SR. ENG.

ABIGAIL COOKE
RAY MARTIN

ENGINEERING
LARRY BURGESS, MGR.

QB ENGR. SUPPORT
TECHNICAL
ANALYSIS

CHUCK GAULT:
TONY D'SILVA
HILDE HINSBEECK
PATTI LOVE
DAVE U'REN

SPECIAL
PROJECTS

PAUL MESSMER

ENGINEERING
PROJECT
GROUPS

DOUG REED:
GORDON BENNETT
MARTY ELEY
RICHARD KRAKER

CHUCK BAUER

GLENN SCHWALBE:
JEANNE MILES

BECKY VANGRUNSVEN

OPERATIONS
TINO ORNELAS, MGR.

TECHNICAL AID
BEVERLY LAFFERTY

SUBCONTRACT
VERA COLE

DATA PROCESSING/
SYSTEMS
DICK DORMER

COMMUNICATIONS
TED CHURCHILL
JENNY WALDRON

QUALITY ASSURANCE
JEAN KENNEDY

BUILDING 50
ERIC HANSEN
MARY LEWIS

BUILDING 38/16
GENE PALMER

FABRICATION
FRAN COOK, MGR.

ADMIN.
AL AXELSON
JULIAN CRANFORD
RAMIRO MARTINEZ
JAY PEIRCE
BOB STOGSDILL

MECHANICAL
ELLEN ANTHONY
CINDY BOWEN
BRENDA DEMARCO
MIKE HOY
MERVIN KING
CALVIN WARREN
LORI WOKAL
SANDY WEST

IMAGE
FITZ FITZGERALD
JANE MEYER
JUANITA OROZCO
DENICE TANNER
JULIE VANDERZANDEN

MULTILAYER
KARLENE BASANICH
JOYCE CONRAD
KAREN GORS
ELIZABETH LOUNSBURY
CYN MARSHALL
MURIEL SCHMIDLKOFER
JILL TRAMP

PLATING
JAN BRINK
BUTCH KRIEGER
ABEL MOLINA
BECKY VERD
MAUDIE VOIGT
TIM WHITE

SCREENING
ANNA FEICKERT

CAD/GRAPHICS
DAVE DAVIS, MGR.

APPLICON SYSTEM
JOHN GRAY

JUDY WHETZEL:
JERI BARNES
HERK KOEPPEN

MIKE TALVISTE:
MARY KLAUS
MIKE PICKETT

ART PUTNEY:
DOROTHY SCOTT
ED WOLEVER

4081 SYSTEM
JOHN BRADSHAW

ROCKY GILMORE:
RICK JOHNSON

PRECISION GRAPHICS
HENRY BAHRS:
KAY GEIS

JERRY LYNCH:
JAN BROADBENT
NORITHY SMUOEK

GLENNA JONES

Figure 1. Electrochemical Support organization chart.

Widespread use of 6-mil lines definitely is in the future, but we haven't had enough experience with them to know what problems we will encounter. We are collecting data as we go along.

What kind of problems lengthen the Q.B. line's turnaround time?

Our biggest problem is having too few people. That's a problem for the other four sections of Electrochemical Support as well. Another problem is that we spend a lot of time telling engineers exactly where their boards are in the fabrication process. We have four telephone lines and most of the time they are all busy. We keep a close watch on all orders passing through the Q.B. Line. If there is a manufacturing problem or if we have to reschedule the order, we immediately call the person whose name is on the order.

What can engineers and board designers do to make the system function more efficiently?

BOARD TYPE	CHARACTERISTICS
QUICK	1. Maximum of two boards per order. 2. Less than 1000 holes. 3. Four or fewer drill changes. 4. Standard FR-4 glass epoxy material. 5. Plating confined to class A, B, C, or H in Tek standards 062-1723-00 and 062-1727-00. 6. No boards requiring silk screen, solder mask or tip plating. 7. No boards requiring N.C. tooling tapes. 8. Maximum of 4 layers.
PROTOTYPE	1. Maximum of 4 boards. 2. Maximum image size will be on the 12 x 18 flat. 3. Plating confined to class A, B, C, or H standards 062-1723-00 and 062-1727-00. 4. Edge connectors may be gold plated. 5. Silk screen or solder mask may be used. 6. Standard FR-4 glass epoxy material.
MULTIPLE	1. Five to twenty five boards. 2. Usually A phase, B phase or customer mods. 3. Some multilayer orders negotiated upon receipt. 4. With users written permission, some boards will be farmed out.
SPECIAL	Boards requiring special handling because of: exotic materials, special process, special plating thickness, pin-guide boards, special silk screening or solder mask, special material for multilayer's, special image sizes, unusual drilling specifications, and/or special handling (for example, non-standard flat sizes).

Table 1. Electrochemical Support's Fabrication section has developed four categories for the boards the section processes. Fabrication's workload determines the turnaround time for processing. To schedule or reserve time for an order, call Jenny Waldron on ext. 5666.

Each circuit board design group could designate one person to check artwork packages (work order, drawing, and mockup) before sending it to us. This would help us enormously because we know that circuit board design groups that have checkers produce mock-ups with fewer errors. Such boards require less time to pass through Quality Control. If circuit board design groups schedule their projects with us before completing their mock-ups, we could smooth out our work flow. Now, on some days we process 10 orders, but on other days we process 180 orders.

Has the complexity of boards handled by Q.B. also grown?

Very much so. Circuit boards have evolved from simple, two-sided boards to boards as complex as 18-by-24-inch, eight-layer boards. The number of holes drilled in a typical circuit board has also increased. Only two years ago, the holes/area ratio was about 22/square inch. Now it is about 28/square inch.

Engineers and customers rightly expect more and more of the technology that supports our products, but to meet those expectations our facilities have to grow too. This expansion has stressed our facilities.

What is Electrochemical Support doing to meet the demand for greater complexity?

Electrochemical Development Engineering includes a very productive group of chemical

engineers and technicians who monitor technical advances in the industry and who advance printed circuit board technology here as well. For example, unilayer (a semi-additive, highly-reliable multilayer) is a Tekronix concept developed by Electrochemical Support Engineering.

If I need a board from Q.B., what kind of turnaround can I expect?

We used to operate with a set of turnaround times, each one associated with a type of board to be processed. Today, we schedule orders by the daily load of boards coming into the Quick-Board line. We also have a classification system for boards. (See table 1).

When I bring a project to Q.B., what are my responsibilities?

When we receive a hand-taped mock-up, we check three things. First, we examine the Work Order to make sure it has been filled out correctly. Second, we check the accuracy of the mechanical drawing (there should be 3 copies of each). Finally, we check the mock-up for adherence to Tektronix standards.

What is the projected number of boards going through the Q.B. line next year?

We're asking the business units for a new forecast, but at the start of FY900 we had a total forecast of over 56,000 boards. Since the Q.B. can produce about 30,000 boards in a year, the picture isn't rosy.

What steps has Electrochemical Support taken to help meet the rising demand?

We have purchased more equipment (such as our new Tru Drils (which performs drilling and profiling), but they are not enough. We don't have duplicates of any of our processing equipment. So, if one fails, most processing stops until we can fix it. For example, we are having a lot of trouble with our etcher. When it goes down, Q.B. Line operation stops unless we're able to borrow Manufacturing's equipment.

Also to meet the rising demand we have developed a very successful subcontract ("farmout") program.

How does the subcontract program work? Which boards are sent out?

We subcontract some boards to outside manufacturers.

We started the subcontract program in May 1977 because we knew the Q.B. Line could not meet the demand. Today, most business units are reluctant to use the subcontract program because the production costs weren't budgeted but are transfered back to them. For now, the business unit must give us written permission to use subcontract for their orders.

This situation will probably change in FY000. We are designing a system to account for all of our our internal costs, so we can transfer them to the business units. Now may be the time for the business units to start thinking about budgeting for that event. When we finish designing the accounting system, then we will begin handing out receipts with the finished boards. The receipts should give managers some idea of how much to budget for engineering board fabrication.

If I need more information about what we've talked about, whom should I call?

For scheduling, call Jenny Waldron between 9 and 11 a.m. on ext. 5666. For other questions, call me on the same extension. If I can't answer your question, I'll find someone who can. □

IN PRINT

MP-Based Design Using Real-Time Analysis

Bob Francis (LDP Engineering) presented "Microprocessor-Based Product Design and Development Using Real-Time Analysis" at MIDCON in December, 1978. For a copy of the paper, call Bob Francis on ext. 6758 (Beaverton). □

EDN Human Factors Article

Gale Morris (LDP Human Factors) authored "Make Your Next Instrument Design Emphasize User Needs and Wants," an article for the 20 October 1978 issue of **EDN**.

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All papers and articles to be published outside Tektronix *must* pass through the T&M Publicity department for confidentiality review. T&M Publicity helps Tektronix employees write, edit, and present technical papers and articles. Further, the department interfaces with Patents and Licensing to make sure patent applications have been filed for all patentable designs discussed in the paper or article.

For more information or for assistance, call T&M Publicity on ext. 6792. Authors working in IDG can first contact the IDG Publicity department for assistance (ext. 2343). □

SNUBBER DESIGN LETS 492 CRT WITHSTAND 150G'S

Under heavy shock loading, the 492 Spectrum Analyzer crt image would not stay centered. In addition, the crt gun moved enough to damage the gun's deflection plates and glass rods. To solve these problems, Casey Veenendaal (Advanced Electro-Mechanical Design, Tek Labs) designed a new snubber system for the 492 crt. The new system helped the 492 Spectrum Analyzer meet the rigid military specification MIL-T-28800B which requires an instrument to operate properly even after 12-inch drops on all sides and corners.

Figure 1 compares the new and old snubbers. When shock compresses an old-style snubber, the snubber slides along the glass envelope of the crt. Since the sliding motion absorbs energy, the spring doesn't return to its original position and the trace moves off center.

Under shock, the new snubber collapses (with the snubber-to-glass contact point rolling along the glass) until the snubber knee contacts the glass envelope. At this time, the snubber's spring rate changes because the spring part of the snubber is shorter, extending from the knee to the gun assembly.

Calculated electron gun weight and expected G-forces indicated that heavier snubbers were needed to prevent the gun's glass rods from striking the envelope. The first test crt to use the new-style snubbers had 16 front snubbers and eight rear snubbers. The crt passed shock tests, but to simplify construction, eight wider and heavier snubbers replaced the front 16, and four wider and heavier snubbers replaced the rear eight.

Mounted in the new modular packaging crt mount, a 492 crt with the new snubber system passed 150G shock tests. Bill Verhoef (Environmental Labs) performed the tests.
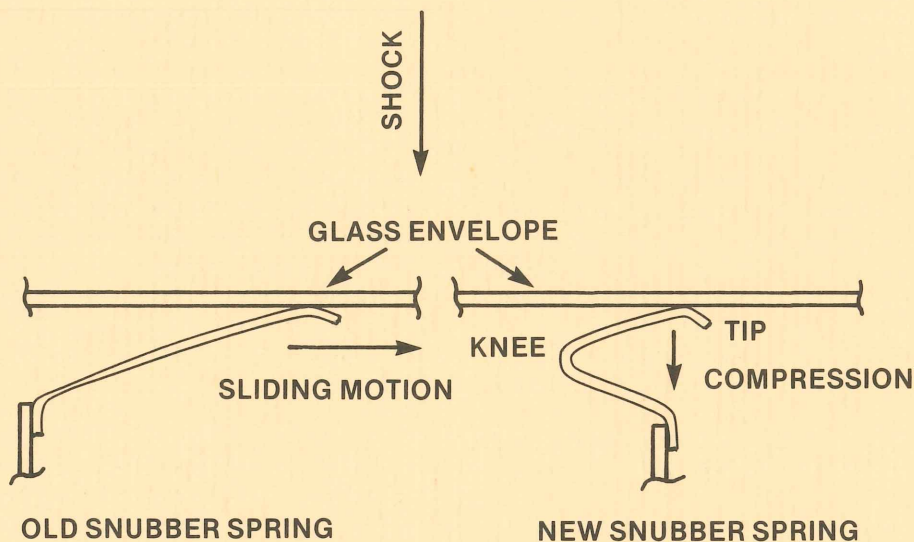
Figure 1. Under heavy shock conditions, the old-style snubber spring slides along the glass envelope without returning to its original position, thus making the trace go off-center. Under heavy shock conditions, the new-style snubber spring rolls on the glass until the knee contacts the glass envelope. Because the spring is shorter, the spring rate increases allowing the spring to accommodate higher shock loads without the gun structure touching the glass envelope.

Left, Casey Veenendaal (Advanced Electro-Mechanical Design, Tek Labs) designed the new snubber system for the 492 Spectrum Analyzer. Right, Gary Nelson (Real-Time CRT Design, Tek Labs) supervised the building of the test model snubber systems.

Gary Nelson (Real-Time Crt Design, Tek Labs) purchased materials and ordered building and testing the 492 crt. Don Mercer (Model Shop, Industrial Design) made the parts.

FOR MORE INFORMATION

For more information about shock protection for the 492 crt, call Casey Veenendaal on ext. 7045. □

THERMAL ANALYSIS ON THE CYBER

The Scientific Computer Center has added seven thermal analysis programs to the Cyber system (refer to table 1). A manual for VENTBOX is available (for a copy call the Scientific Computer Center on ext. 5714), and manuals for the other programs will be available in a few months.

For the latest list of thermal analysis programs, type HELP, THERMAL on any Cyber terminal.

If you know of other thermal analysis programs at Tektronix that should be on the Cyber system, call Imants Golts (Scientific Applications Support) on ext. 5976. □

PROGRAM	DESCRIPTION
NETFA	General-purpose, steady-state network analyzer (Gordon Ellison).
TAMS	Thermal analysis for up to four-layer slabs; multiple sources and sinks. (Gordon Ellison).
SST1	Models a one-layer rectangular slab with sources and sinks. (Jack Hurt).
SST2	Models a two-layer rectangular slab with sources and sinks. (Jack Hurt).
TDSR	Models a rectangular source with finite thickness buried in a halfspace; gives step input transient response. (Jack Hurt).
VENTBOX	Predicts thermal characteristics of simple enclosed and ventilated cabinets. (Gordon Ellison).
HOTSINK	Predicts temperature rise of vertically-oriented finned heat sink. (Charles Logan).

Table 1. Seven thermal analysis programs are now available on the Tektronix Cyber system. The programs were written by Gordon Ellison (Environmental Labs), Jack Hurt (Hybrid Circuits Engineering), and Charles Logan (Medical Products).

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PROGRAMMABLE INSTRUMENT SEMINAR RECORDINGS

In October 1978, the Digital Product Coordination group presented "Development Resources," the seventh Programmable Instrument Seminar. The seminar sponsors recorded the seminar on audio cassettes. To borrow a set of cassettes, call Ann Baynton (Digital Product Coordination group) on ext. 7095.

To suggest a topic for a future seminar, call John David on ext. 5285 or write to D.S. 58-526. □

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 his 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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