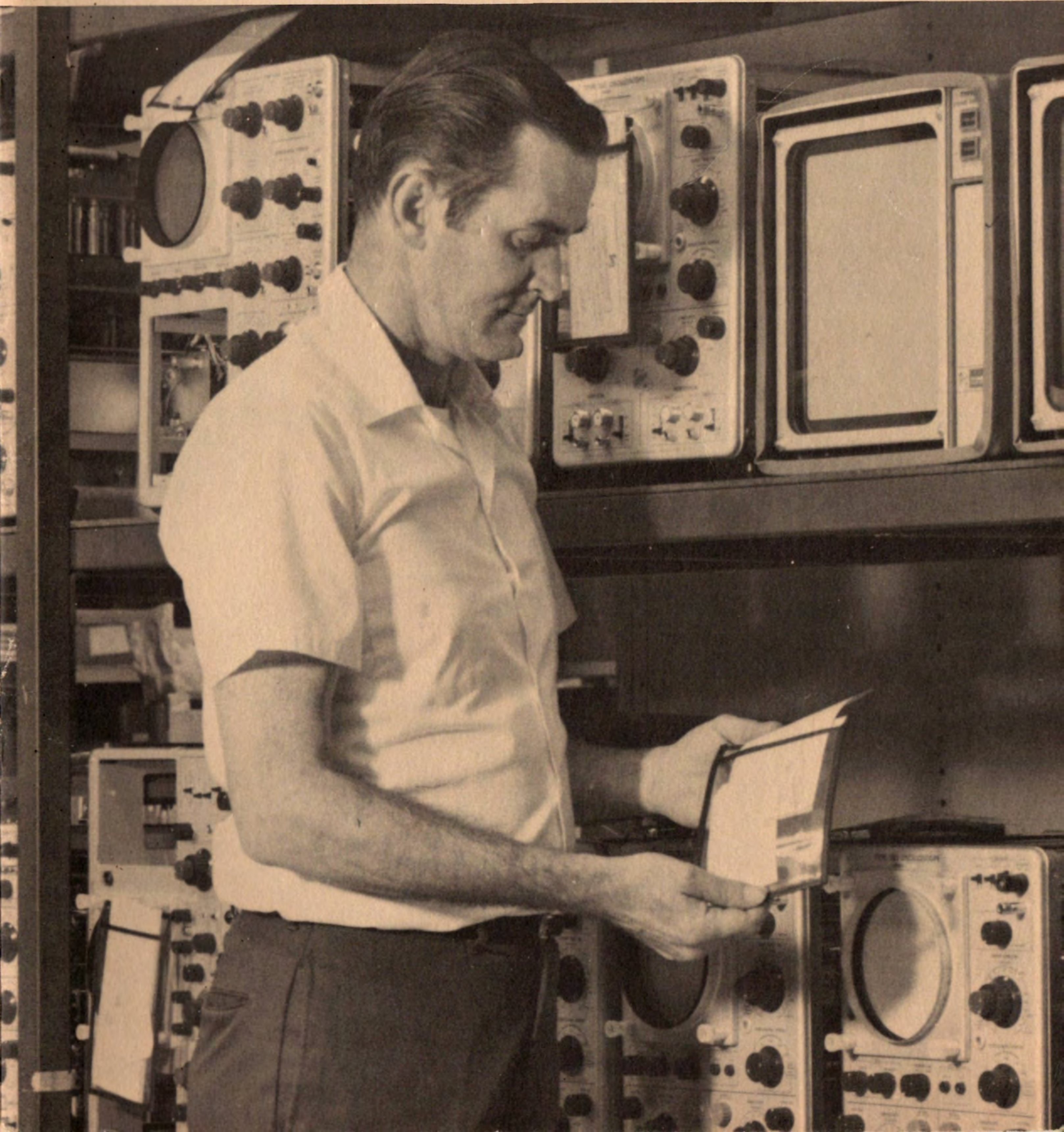
tek talk

THE TEKTRONIX EMPLOYEES MAGAZINE

SUMMER-FALL 1968

TEKTRONIX: ITS INSTRUMENTS



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TEKTRONIX: ITS INSTRUMENTS

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THE WORLD IS NOT YET WELL

The world of Tektronix is a world of exploding time . . . .

In it, a split second is a commonplace; the infinitesimal is something to divide; each of its fragments, something to measure.

The hope of man is to control his environment. This truth has always been. His leashing of dread disease gives it poignancy; his leap into space lends it dimension. Research beckons that the goal can be reached; international tensions warn that it must be reached.

To master his world, man must understand and, where possible, measure its changing face. In the minutest sliver of time, incredibly small events occur, billions upon billions. Any one of them may change your tomorrow . . .

To measure them, and to do so exactly, demands instruments of precision never before called forth. Such an instrument is the laboratory oscilloscope.

Man can no longer afford to overlook the infinitesimal. In his quest to measure what must be measured, to understand the changes in a world that each moment is new, the men and women of Tektronix contribute their skills, their insights and their best efforts.

VILLAGE VOICE/FRED W. McDARRAH

(An essay suggested by comments at the Region 6 conference, Institute of Electrical and Electronics Engineers, Portland, Oregon, May 20-22, 1968.)

"We have proved," said Oregon's Senator Mark Hatfield to the electronics engineers, "that man can live in outer space and under the sea."

"But he is finding it increasingly difficult and unpleasant to live in between."

And the senator went on to plead for a re-ordering of priorities in our society, and to urge that, in the rampaging onrush of technology, we not lose the vital juices of humanity.

The senator spoke of food, and of famine:

It is a fact of life in this 20th century that, for each one of you who goes to bed tonight with a full stomach, someone, somewhere, is starving.

And, if current trends persist, within 10 short years the unfed will outnumber the fed—by **three** to one.

"It is a very black mark on our sense of values, and a contradiction of our search for progress," Mark Hatfield noted, "when part of the world competes for the moon, while the other part competes for a loaf of bread."

Writes Don Fabun in Kaiser Aluminum News:

"Statistics have lost their cutting edge . . . In the mind's eye one sees those thousands of bodies removed by the sanitation squads in Calcutta each morning; the night soil of hunger. One reaches for the check, flips out the plastic credit card, dismisses the real world with a flourish of a ballpoint pen . . ."

If thousands of deaths by hunger could not disturb the public conscience, one death by assassination did. Two weeks after the senator spoke, America saw still another of its leaders shot down in anger. In the shock of aftermath, many citizens asked themselves, maybe for the first time, just what kind of a world ours has become.

It depends on where you look.

RESURRECTION CITY 1968 AP

For one thing, it is a world with less food per person than during the depression 30 years ago. Famine, the grey sister, stalks at will. Nations, in abrasive coexistence, rub old sores raw. Man shows—both in the chill of social rebuff and in the heat of riot and fire—that he can be a wolf to man. The poor, no longer invisible, camp on the doorsteps of the halls of Justice. The ghetto's prisoner finds it increasingly hard to see himself as his keeper's brother.

Over a wall of years, two strangers—the parent, the child—strain to recognize one another.

Forests give way, ultimately to asphalt, Rivers glutted with sewage slither to the sea. Amber-smeared skies hover toxic over strangling cites.

It is all there to see. And, while the play goes on, the shrouded figure of Final War waits impatient in the wings.

In a hollowed-out Colorado mountain hides NORAD, an incredible bombproof sentinel that scans our entire continent, second by second, in great detail. A blip that doesn't belong may trigger the Retribution button.

In lands across the sea, similar electronic caverns may exist, for similar reasons. Engines of war—the spawn, and the price, of Nuclear Stalemate—crawl the land, prowl the waters and, maybe, encroach beyond what we know as sky.

It is easy to say Society is sick, maybe too easy. For you could have said that *any* time.

But today the sickness is harder to ignore. Assassination, once it happens virtually in your living room, becomes more than just a word. Nor is war an abstraction any longer, for we can watch it almost every night, just before Johnny Carson comes on.

Now the search begins. To find causes and reasons, to fix blame, to seek out the Devil and exorcise him.

Why is the world not yet well? Many devils suggest themselves; take your pick.

One is called Technology.

Man is the endless tinkerer, so this argument runs, and Technology a grinning demon urging him to excess. Man, the button pusher run amok, too much obsessed with what *will* happen if he crosses two wires, too little caring whether or not it *should*.

A leading US magazine has suggested that the Constitution be rewritten, to restrict technology. "What they (the scientists) most often call a search for truth," writes W. H. Ferry, "is in fact obscene curiosity . . . Technology is the villain."

Technology has been termed Galloping, Rampant, Runaway . . . blamed for the spoiled waters and the fouled air and the mushroom N-cloud and, even, somehow, for the mobs run wild. At least things were—well, *quieter*—in other days (i.e. non-technological ones.)

So the argument goes, but it is wishful thinking. We all have read about the Good Old Days: History says they were often days of blind superstition, vast ignorance, stunted lives, crippling labor, brutish subsistence and racial viciousness far exceeding today's. And—if you go back far enough—you find Man at the cave's mouth, clubbing his fellows to death in a rather non-technological way.

But this is beside the point. The pockmarks of the past do not make any less appalling the diseases of the present. And the humanist's concern over unbridled technology is a valid one. Nuclear megatonnage may indeed level the land; cybernation may reduce men to numbers or other processable units; the stains of passion could easily be lost in the gleam of chrome; and "the castration of spirit by technique" may yet occur, in spite of us all.

"I am concerned," confided Tektronix' Lang Hedrick to the same engineers, "that our profession's response (to crucial problems of today) will be delayed and minimal . . ."

Man has much to learn, about brotherhood, about community, and a dwindling span of days in which to learn it; to decide what is really important, before time, and hunger, and the fevers of emotion make that decision merely academic.

There can only be one answer, and it has been suggested so often as to become a cliche: True personal dedication to a more humane world. But it doesn't help to fight false devils; and that is what Technology is.

Humanity and Technology are opposites only if we elect to *make* them opposites, So, to the question, "Which will Man choose?" the answer must be, "Both."

Technology—from the first pointed-stick plow to the latest satellite in space—has always served man's "human" needs, as he sees them to be.

"However different the holy causes people die for," writes Eric Hoffer, "they perhaps die basically for the same thing." He is pointing out that almost all human endeavors are undertaken to help attain a better world.

The only problem has been: Define "better."

"Stop the World— I want to Get Off," sings Broadway's Anthony Newley, putting to words an music the queasiness of many. But the magazine that suggested legislating technology was saying something else: Let's leash science and the technician, at least until we can get our footing: Stop the world—we want to get *on!*

To insure man's humanity by halting his technology is another one of those simple-sounding solutions to complex problems. But man in his environment is truly the naked ape unless he makes wise use of the best tools that environment can provide, And the alternative to the scientific search is to *stop* searching. There are too many answers still missing to do that.

Besides, as history proves, the record of pre-technological Man was nothing to brag about. In fact, if you accept as measures of human-ness such things as health, intellectual growth, absence of superstition, emotional depth, cultural awareness and compassion for the less fortunate, the most "human" time of all times may be *today*—in the same world, and at the same moment, in which men starve and hate.

A world, in short, of great contradictions.

The Innovation Gap is shrinking, the engineers were told. Guil Hollingsworth of Seattle's Boeing Co. pointed out that the span between an idea's inception and its first application is decreasing by about a half year each year, and that the gap in the fairly near future will cease to exist. That, he figured, will be about 1984.

"Then, we'll have to use things even *before* we think of them," he observed, possibly joking.

So, the world won't stop at all, or even slow down, but will spin ever faster beneath its tenants' feet. The exponential curve that graphs the accelerating growth of technology shoots upward ever more steeply; so do the curves that depict growth of population, or of information, or of available energy. It is a world in the grip of massive revolution. (Significantly, one curve that *doesn't* bend up that fast is the speed at which man learns.) Change occurs faster and faster, and there are mornings when a fellow gets to feeling pretty obsolescent.

As the Innovation Gap closes,

LARRY HUDETZ

simmering time vanishes—time in which to sit back, and rock a bit, and just think about things. It would be tough if one had to look *while* one leaped . . .

The challenge to the engineer, said Mr. Hollingsworth, is great: First, to keep himself abreast of the fast-rising floodtide of innovation; second, to interpret its significance to others.

"The engineering environment," Lang once pointed out, "must by no means be restricted to the laboratory. The second responsible role of the engineer is to *tell* the world the probable impacts of technology on all of society."

Thus the engineer becomes something of a teacher, something of a prophet—and, for the moment, also something of a fire-fighter.

Dr. Otto Schmitt of the University of Minnesota, speaking to the same group, said electronic engineering today is a "holding operation," seeking to keep society running while the Life Sciences come of age.

Today, and not only in electronics, the "holding operations" are many:

Until the world's explosive population surge is controlled, the hungry billions must be fed. Until real justice is instilled, first in institutions and then in the hearts of man, political stability must be insured, and both real and emotional fires subdued. Until crime's roots are dissolved, it must be denied its fruits; until war is a forgotten option, the nation must be unassailable.

Today, more effort is being spent in "human" activities than at any time in history. This is not to say it is enough, for the challenge is gigantic: To provide more food so the world will not writhe in hunger. To educate, not only in the techniques of existence but also in the attitudes of life. To make skies blue again, water clear once more, and men's minds and bodies whole.

A race is going on, between Man's power for what we call good and his power for what must certainly be evil. He is probably closer than he has ever been to extinction. But: He is also nearer than ever to self-ennoblement. And his future for years ahead must be to walk a teetery plank between the alternatives.

You can't unborn a baby, as Corporate Counsel Jim Castles is fond of saying, or put toothpaste back in a tube. Nor, he might have added, can you destroy knowledge once it's known. There is certainly a risk in the scientific search, in that you're not sure you'll like what you find. Any box may be Pandora's.

Communications are a case in point. The medium *is* the message, as Marshall McLuhan says, and instant global communications—an activity in which Tektronix is deeply involved—is one hopeful sign, if not always comforting.

Thousands objected recently when television showed them, with graphic harshness, that 10 million Americans are hungry. But TV didn't invent hunger; nor did it cause riots; nor did it create the other festering sores on the social body that it pictures.

Two years ago, Lang said in Tek Talk that live color TV from the battlefield might well result in the abolition of war—an idealistic sort of statement. But America *has* turned far less hawkish. Was it for economic reasons? A coldly practical decision? Flagging interest? Or might it have been, in part, that we took one too many after-dinner looks at war and one day found it intolerable?

Well, perhaps not. And maybe our decisions will be no different in any case, But we *will* know more about what we're deciding.

It has been said: What is necessary is possible. See poverty first hand; watch war; look into the face of the hopeless; *then* set your priorities . . .

Improved communications, then, is one hopeful sign. Awareness doesn't *guarantee* wisdom; but it is a necessary first step.

The world is not yet well. To say so implies that the sickness may be curable.

Scientist/author C.P. Snow spoke of the "Two Societies," the scientists and the humanists, and he worried that the two would never understand one another. His feeling was that the least likely thing would be for the scientist to turn humanist—but there are signs this may be happening.

The theme of the engineers' meeting, "Electronics Serving Mankind," reflects their growing concern with human problems. Technological man may be developing a strong social conscience in part because he knows first-hand the mighty forces that are involved. As a case in point: Among the strongest pleaders for nuclear disarmament are physicists who worked on the bomb. Scientific institutions—Cal Tech, for example—are adding humanities majors. The computer is now bringing to bear—on problems of mental health, crime, medicine and sociology—if not brain power, at least impressive intellectual brawn and speed.

It may be that the big change in technology will not be a diminishing of activity but something just as radical—the channeling of technological effort into new, "human" uses—some probably undreamed of. Its ability to do so is a survival skill, and an option no longer.

How does the human mind work, and what makes it sometimes snap and twist? Playing our *hunches* as to how man ticks is no longer an adequate solution. Can racial stereotypes yield to Life Science? Can mass behavior be analyzed with superior technology and, at long last, understood? Or will we continue to relive, while we last, our riotously volatile society?

Some humanists have objected to Life Sciences as a concept. For instance, they say, the computer can't analyze social behavior, because it is a counting machine, dealing only in units and bits, and can't allow for the endless variables that make man the enigma he is.

However, it's not known that man *can't* develop ways to adapt these machines; only that it hasn't seemed important to him to do so, until now. And, if he can't use them for these purposes (for, after all, they were designed for something else), he may well develop a new technology that *will* do the job.

The computer only *seems* like the ultimate machine; but then, so, probably, did the steam engine.

The shift of technology into unexpected uses is something we at Tektronix know first-hand. The oscilloscope was designed as a tool for the electronics industry. Today its uses encompass all economic and scientific endeavors: Biochemistry, clinical psychology, physical therapy, entomology, diagnostic medicine, food technology, pollution control, mechanical engineering—and how many other uses?

You never know, until you try . . . .

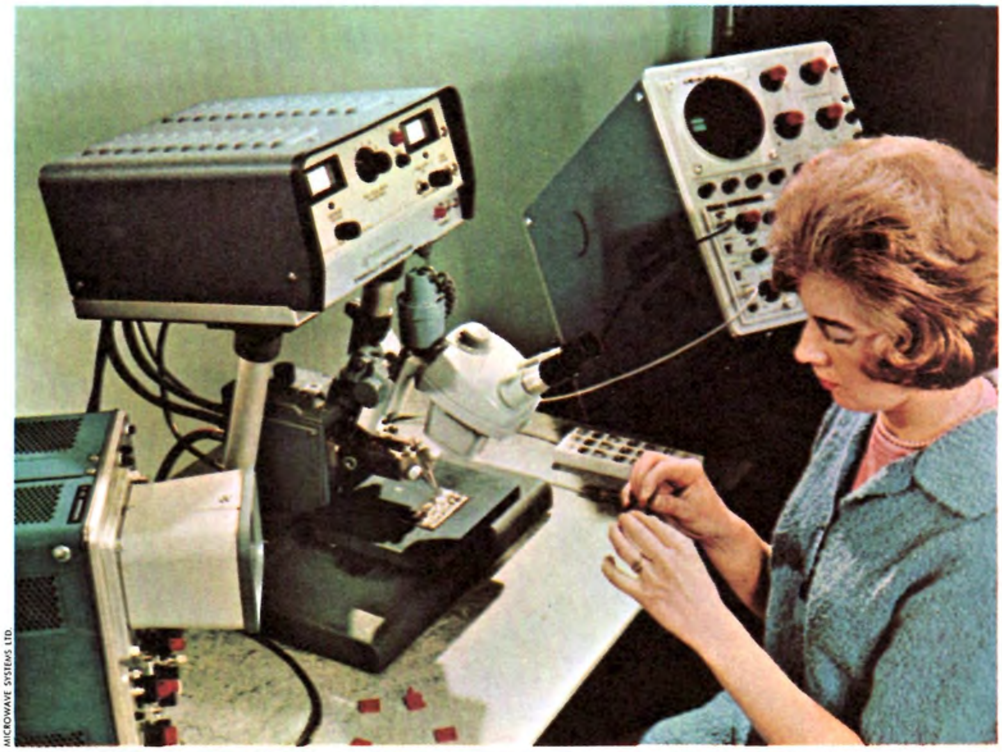
The rise of the scientist/humanist is paralleled by new statements of intent from some technological industries. Comments Joseph Wilson, chairman of Xerox Corporation:

"No corporation can wait for technology to reveal at leisure its own impact and meaning. We cannot leave the development of new social and economic systems, the collaboration of men in a unifying world culture, entirely to chance.

"For a corporation to 'live forward' (in the words of Kierkegaard), its leadership must

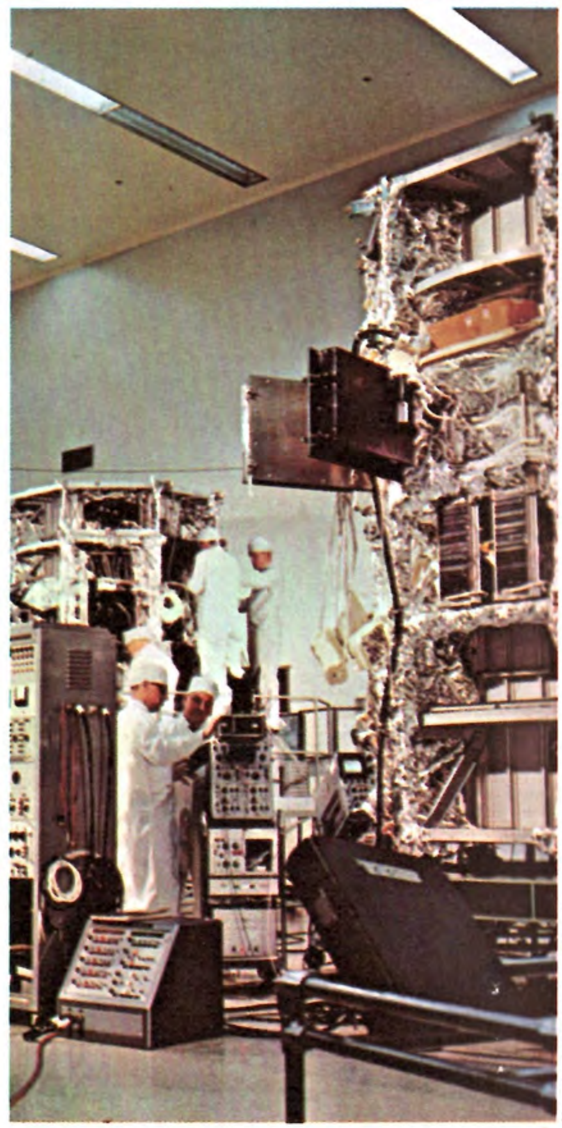
COMPUTER ELEMENTS for US Air Force's C5A jet transport are checked out at Northrup Corporation. Tektronix oscilloscopes are among the test instruments.

NORTHRUP CORPORATION



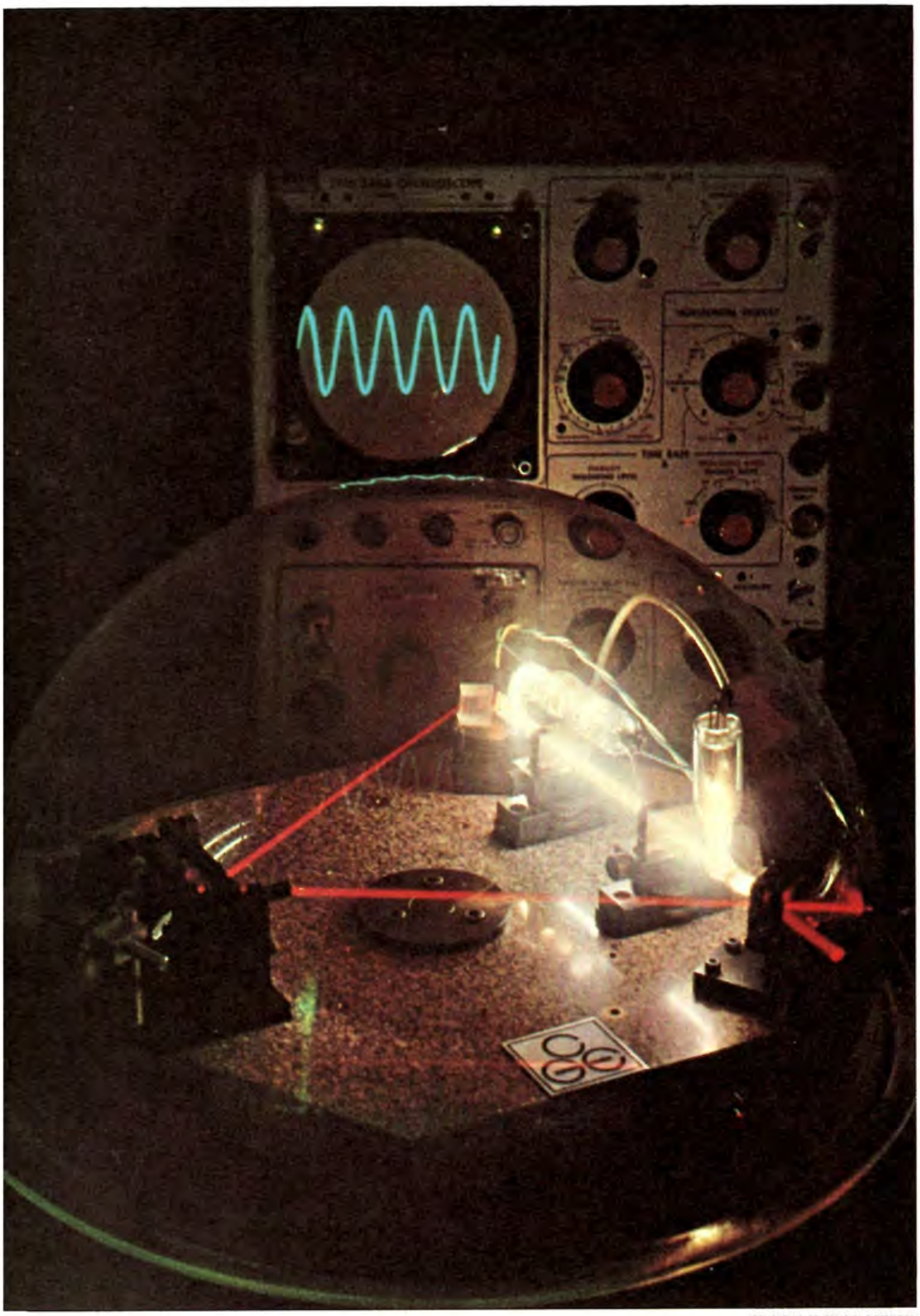
MICROWAVE SYSTEMS LTD.

AMPEX CORPORATION



GRUMMAN AIRCRAFT ENGINEERING CORPORATION

Graphic layout by Dick Koe



OPERATOR (top left) is aided by a Tektronix oscilloscope as she welds integrated circuit into a sub-unit for a phased-display aerial system at England's Microwave Systems Ltd. Grade schoolers in Palo Alto, California (far left) watch video tape of "Julius Caesar", starring themselves. A Tek waveform monitor accompanies the VT recorder. Tektronix oscilloscopes are prominent in research at Grumman Aircraft Engineering Corporation (left), where an orbiting astronomical observatory is being build. A scope (above) displays an experiment with a laser gyrometer at Marcoussis Research Center, Paris.

successfully combine the forces of technology with the force of humanism. The corporation that fails to do so will fail a world which at long last possesses the power to make men human in the very best sense."

Physicist Niels Bohr wrote, shortly before his death:

"All experience, whether in science, philosophy or art, which may be helpful to mankind, must be capable of being communicated by human means of expression. Confronted with the great diversity of cultural development, we may search for those features in all civilizations which have their roots in the common human situation."

And William Baker in Bell Telephone Magazine added:

"How happy it would be if it turned out that this age found common roots in the human situation through worldwide experience in science and technology."

An old story tells of three brickmasons who were asked what they were doing. One said that he was laying bricks. The second, that he was earning so much an hour.

But the third said with pride that he was building a cathedral.

Each person in electronics is both a humanist and a technologist: Living his life as a citizen, and contributing productively to the technological society. The value of his life depends on how he lives it; but the value of his productivity hinges, ultimately, on where technology is headed.

Oscilloscopes *have* been used for war—or the prevention of war. But, more importantly, the 410 monitor has been used to save human lives; the 564, to help deaf children talk; the 565, to study the abnormal mind; the spectrum analyzer, to detect impure air; and a wide and growing variety of instruments, to improve understanding through education. Human uses, in the finest sense.

Man, for all his technological finesse, may be doing nothing more than constructing a tomb for himself, as pessimists maintain.

But it's possible—still, and maybe just barely—that he is building a cathedral.

THE UBIQUITOUS OSCILLOSCOPE

medicine man: 20th century

In a choked tropic clearing, still begrudged by the jungle around it, stands an old man wearing tribal regalia. A young native girl, in pain, lies before him. His hand holds a sharp knife. Natives at the clearing's edge chant ritual blessings for the sick.

The scene is primitive and timeless. It might well be taking place in some other century—were it not for the piercing electronic beep of a Tektronix 410 physiological monitor, connected to electrodes on the patient's arms. With the sound, the natives' singsong fades.

In less than five minutes, the "doctor" has removed a cancerous section of large intestine. The girl is helped away.

This Brazilian medicine man routinely performs major surgery, using neither anesthetic nor hypnosis. A team of cardiovascular experts from New York, having learned of him, is now monitoring and recording his operations, using the 410.

And so, from the capabilities of electronics and from arts of healing passed down for generations, new insights may come—to the medicine men of today.

stamp out explosions

Story by Ingrid Louiselle

Explosions can be stopped—literally "put out"—if the erupting pressure they represent can be safely released faster than the explosions themselves can build and ignite.

The wavefronts of expanding atmosphere in an explosion of methane gas, for example, reach the speed of sound in 55 milliseconds after the pressure is suddenly let go.

But if a safety device can relieve the pressure before those waveforms reach Mach I (the speed of sound), the explosion can be snuffed out.

Fike Metal Products Corporation of Blue Springs, Missouri, designs and develops such devices. The company manufactures a variety of rupture disks—thin metal circles with a pattern milled into the surface which makes them sensitive to changes in pressure.

One of these disks, installed in a gas pipeline near a release valve, would remain closed as long as the pressure in the line remained normal. But any change of pressure within the pipeline—the sign of a possible explosion forming—would break open the disk and release the pressure.

In developing and testing the disk valves, Fike Metal technicians Rene Guerra and Chuck McAlester used a Tektronix 502A oscilloscope to measure both the time required for pressure in a given system to reach the explosion point, and the reaction time for one of their disks to burst under the increased pressure.

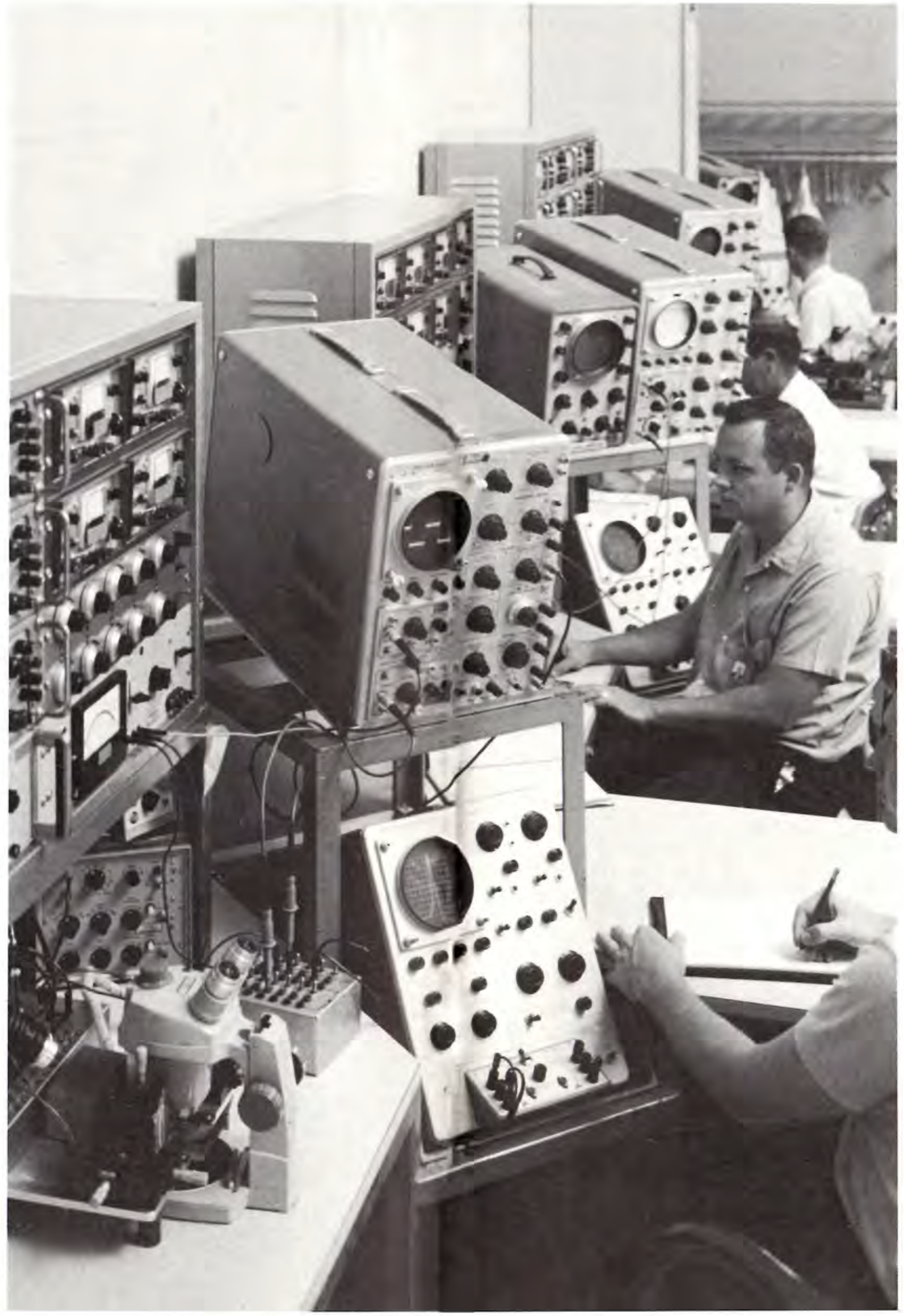
They used shaped explosive charges ignited in a special detonating chamber, and connected each disk being tested to a pressure-transducer, a device that senses changes in pressure and converts them into electrical signals.

With the 502A connected to the transducer and a Tek C-27 camera mounted on the scope's faceplate, Guerra and McAlester were able to capture the trace of each explosion on film and evaluate the timing and performance of the disks.

These products find their way into many industrial applications and even aerospace projects—almost any situation, in fact, which demands that an explosion be prevented, or "tamed" and put to constructive use.

Shutting down a runaway chemical reaction, preventing a dust explosion in a grain elevator, or bringing together the volatile elements of a rocket fuel at just the right moment to ignite a spacecraft's second stage—these are a few of the things rupture disks can do, after being perfected with help from Tektronix.

EIGHT OSCILLOSCOPES—six of them Tektronix models—are part of the reliability-testing equipment at Texas Instruments, Inc. The TI Failure Analysis Laboratory analyzes the performance of semiconductors. (Photo courtesy Texas Instruments)



rocket boosted

Story by Ingrid Louiselle

One member of the formidable arsenal used by US forces in Vietnam is the M-72 rocket launcher—a light, shoulder-fired anti-tank weapon, manufactured in Massachusetts by Hesse-Eastern Division of Norris Industries.

The Army's Redstone Arsenal Small Rockets branch contracted Hesse-Eastern to develop a training device like the M-72, a device that would be more economically practical for heavy use in training, while giving trainees the same "feel" in firing drills as the M-72.

Hesse-Eastern's technicians set out to design a "launcher trainer" that would be a scaled-down version of the M-72, would fire a smaller, less expensive rocket and would ignite the rocket motor electrically.

The trainer's trigger mechanism contains a small magneto, a device that produces an electric charge by quickly drawing a magnet through a magnetic field. The electricity generated by the magneto ignites the rocket motor, firing the round.

When Hesse-Eastern engineer Gerald Forest began testing the trainer, he used a 533 oscilloscope and a Polaroid camera to record the output of electricity from each magneto firing.

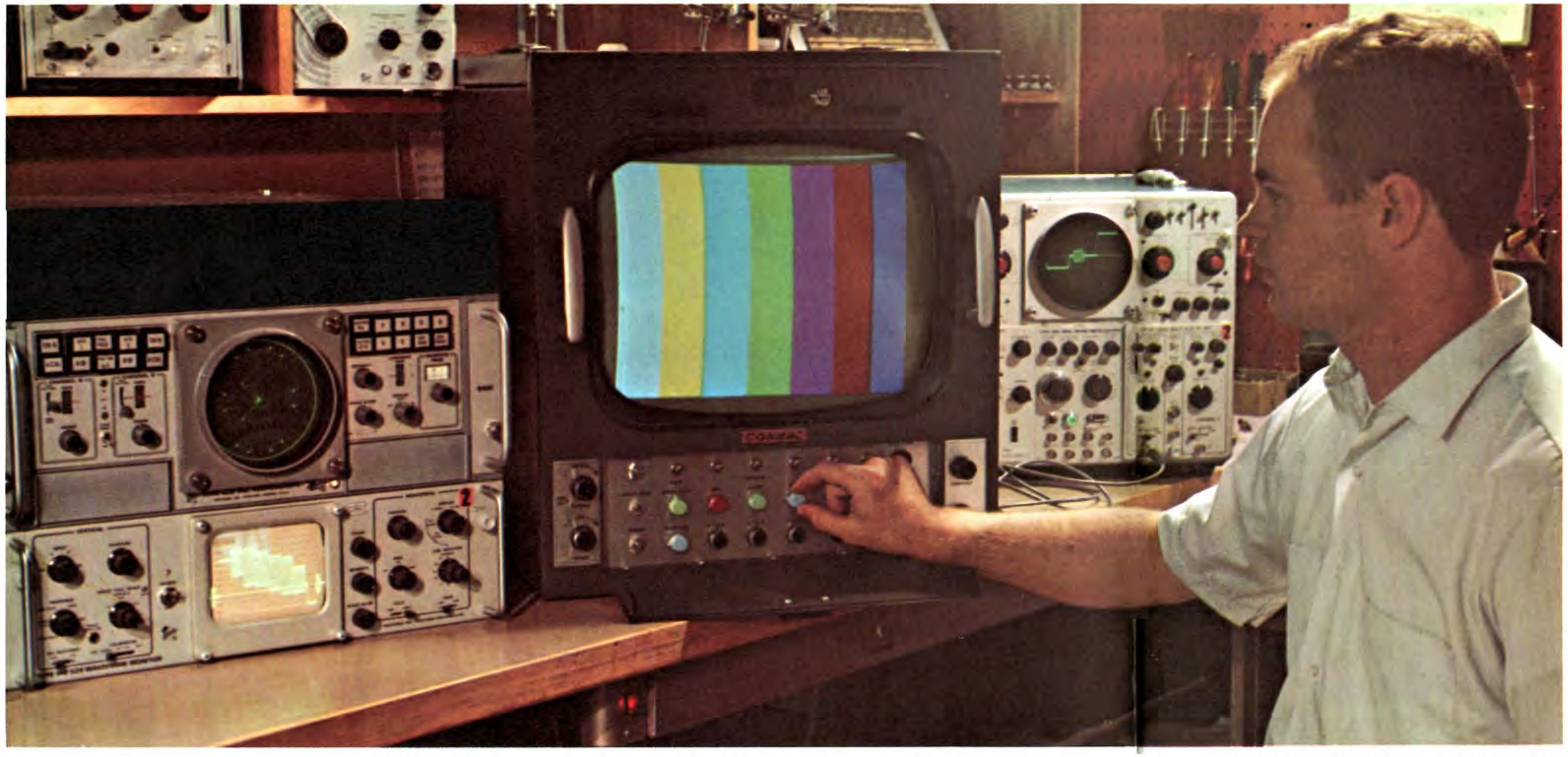
It quickly became clear that this procedure would involve a lot of time, not to mention a large quantity of film. Each shot had to be photographed, the film developed and compared to the previous shot pulses, adjustments made to the trigger linkage, another shot fired, its film record developed—and so on.

The technicians spent several days and countless rolls of film on this process. Then Tek Field Engineer Mike Goldberg was called out from Boston on another instrument problem. When he saw the test set-up he suggested that a 549 storage scope be used, and arranged for one to be loaned to the Hesse-Eastern project.

With the help of the 549, the project was completed in less than half the time originally estimated, and a considerable volume of film was saved. Each pulse stored on the 549's CRT faceplate could be compared quickly and easily to the technician's image of the desired pulse-waveform, and the camera could be reserved for recording the final shots, after all adjustments had been made.

The tests proved that there's usually a better way to do things—even within the Tektronix "family"—and that one of our jobs is to **find** that way.

THE VECTORSCOPE: ELECTRONIC COLOR WHEEL



VARIETY of television measurements is shown on Tektronix instruments by Steve A. Roth (TV and Conventional Oscilloscopes). Type 520 PAL vectorscope is at left, with typical vector display. It rests upon a type 529 waveform monitor, showing a single-line display of the same information. At right is a type 556 Tek oscilloscope, depicting the packet of "burst" information transmitted by the studio to help TV receivers correctly display the color picture. Color picture monitor in center contains standard color-bar test pattern.

The "typical" owner of a black-and-white TV set will put up with a lot. He'll squint and swear at an imperfect picture for months before he gives up and calls the handy corner TV repairman.

But the color-set owner is far less patient. A green sky or a purple Ed Sullivan, he won't put up with. Color faults are **intolerable** to the viewer.

This means there must be some way to make sure that colors are being transmitted faithfully. The Tektronix Type 520 vectorscope is the way.

The vectorscope is the only instrument that makes detailed measurements and comparisons of the components of color as transmitted by television. To understand how the 520 works, you will first need to know a bit about color itself; how it's transmitted; how it's received, and how it's measured.

TAKING WHITE LIGHT APART

What we see as white light may be produced by adding blue, green and red. (This is unlike color pigments, whose primary colors are said to be red, blue and yellow. It's best to forget, for now, what you know about mixing paints.)

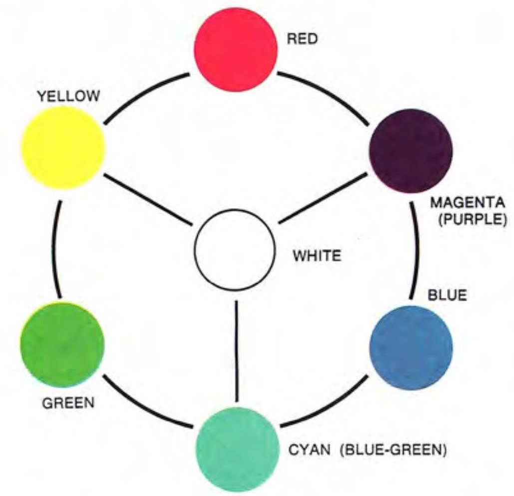
Colored light has three components, and thus three ways it can vary:

One is **hue**—Red, orange, yellow, etc. are names of hues.

Another is **saturation**, or purity. A **fully saturated** red (containing no blue or green, which would whiten it) is pure red. A **slightly saturated** red (whitened by blue and green) is pink. The more hue and the less white, the more saturated a color is said to be.

The third component is **intensity**, or brightness. On a gray scale, intensity would range from white to black. (A black-and-white TV camera registers brightness only.)

The entire spectrum of colors can be shown in a variety of ways. A common display is the color "wheel":



As we said, the three primaries can be combined to make white light. But **two** primaries, combined equally, give secondary colors: Red and green produce yellow, green and blue produce a blue-green called cyan, red and blue produce a purple called magenta. These secondary colors are fully saturated; that is, not whitened.

Looking at the color wheel, we see that each color may be correctly thought of as white with the **absence of its opposite color**. (That is, magenta is white minus green; green, white minus magenta.)

This plus-or-minus way of looking at colors will be useful when we consider that, in TV, color signals are transmitted by positive and negative voltages.

Very briefly, before we study color transmission, let's review how video signals are sent in a black-and-white TV system.

(This subject was covered at length in a non-technical article, "What a Monitor Monitors," in the summer 1967 Tek Talk.)

The TV camera scanning a scene sees it as a pattern of darks and lights. This pattern is converted into an invisible charged image, a voltage "picture," on the camera's light-sensitive face. Then the camera's electron beam "reads" the picture information from the screen, bit by bit, and converts it into a corresponding current sequence. This sequence is transmitted to your TV set, at the rate of about four million "bits" a second.

The video signal drives your set's cathode-ray tube, whose electron beam bombards the phosphor TV screen, bit by bit, causing it to light up in proportion to the beam's force (which depends on the strength of the signal from the studio at that moment.)

The CRT beam crosses the screen, left to right, 15,750 times a second, repeatedly "drawing" 525 horizontal lines, each made up of as many as 430 "bits" of black and white (or gray) information.

In this way (much oversimplified) the original scene has become, first, an invisible voltage "picture", then a fluctuating current, and finally the pattern of dark and light "bits" that make the picture you see on your TV set.

TV BLOOMS IN COLOR

Take the black-and-white TV picture. Add color. That's the recipe for color television.

Sound simple? It isn't.

Color television, compared to black and white, is a dandy dressed in finery—and a Yankee Doodle dandy at that. For color TV was an **American** achievement—one that took courage and many Yankee dollars, and one that overcame not only difficult technical hurdles, but also the strong feeling of much of the industry at that time that it wasn't even worth trying.

The picture on your "full-color" set is the same picture your neighbor sees on his black-and-white set. The difference is that, to your picture, color has been **added** —somewhat broadly, much as you'd fill in the pictures of a coloring book.

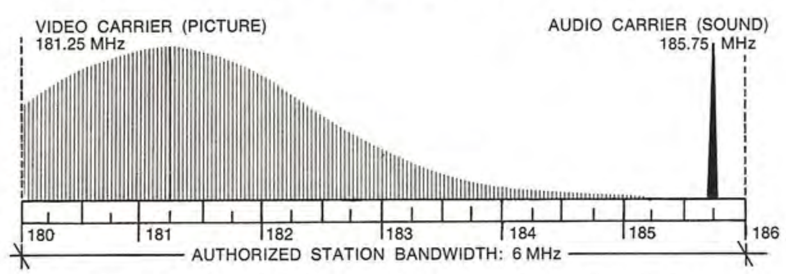
The TV industry, when it set out to develop a color system, made two major decisions: First, there would be **minimum compromising** on color quality; second, to have a broad economic base, color broadcasting would be **compatible** with black and white. That is, so that black-and-white programs could be received on color sets, and color programs received—in black and white—on non-color sets.

These requirements put what seemed at first to be impossible challenges before the industry's few far-sighted believers:

It meant there would have to be some way to transmit red, green and blue information, in enough detail to satisfy the human eye, to commercial television channels whose assigned bandwidths were already clogged with black-and-white signals, and to be received on home TV sets with even narrower bandwidths.

It was like, on a piece of paper already full of writing, having to find room for three more messages of that same length.

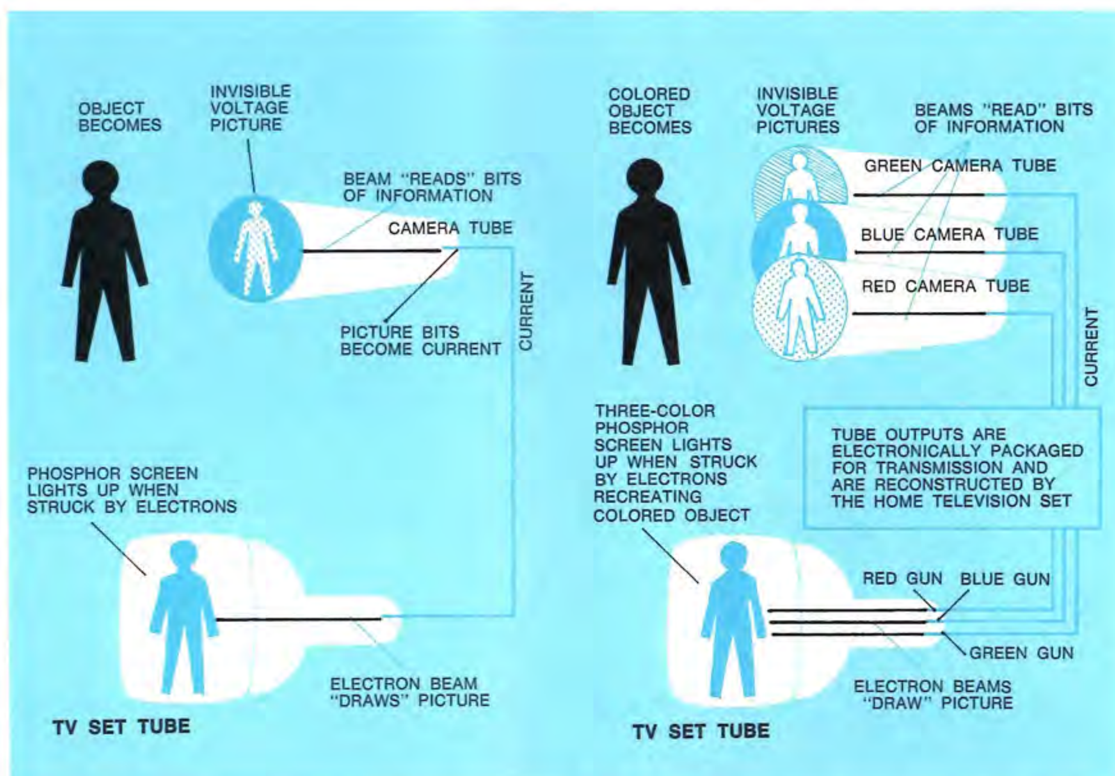
Each commercial TV channel is assigned a portion of the broadcasting spectrum, a bandwidth of 6 MHz (six million cycles per second). The range of one Portland channel is from 180 MHz to 186 MHz, for instance, and looks like this:



Within its broadcasting band, the station transmits the black-and-white video signal and, properly spaced to avoid interference, the audio signal. The picture and sound information is carried in the sidebands generated by frequencies adjacent to the video and audio carriers.

It looked like there was no room to add a color carrier. And, even if there were, the carrier's strong voltage would be bound to interfere with the black-and-white signal. What's more, to send detailed information in red, in blue and in green, in addition to black and white, would require a bandwidth over three times that of commercial TV stations—and more than four times that of home TV sets!

Small wonder the industry had its doubters.



BLACK-AND-WHITE TRANSMISSION

COLOR TRANSMISSION

But, one by one, the problems were solved. First, it was found that full color detail **didn't** have to be sent. Second, that there **was** room to sneak in a color subcarrier. Third, that the subcarrier itself could be suppressed at the transmitter and only the weak sidebands sent—along with very brief sample "bursts" of the subcarrier, so it could be "reinserted" **inside** your TV set itself.

Just **how** all this was managed, although it gets into some tricky electronic concepts, makes for an interesting story:

BUILDING THE COLOR SIGNAL

The black-and-white, or **monochrome,** TV signal describes intensity, or brightness. But the video signal in color TV must also contain hue and saturation information.

At first it seemed that full detail on each primary color would have to be transmitted, in addition to the black-and-white signal. This would have been impossible. Besides the complexity of sending it all, neither commercial channels nor home TV sets had anywhere near enough bandwidth to receive all that information.

So, the need was to simplify the information to be sent, by "repackaging" it.

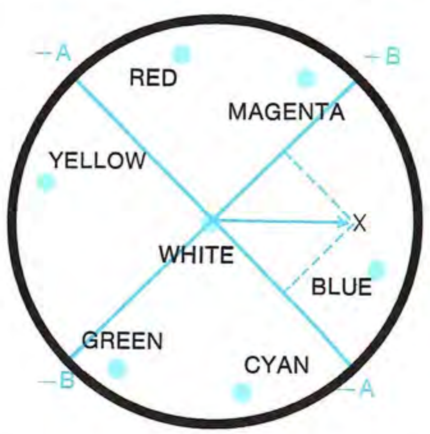
The color TV camera splits up light into its primary colors. It has three camera tubes (four in some new systems): One receives only red, one only green, one only blue: Their combined output contains all the hue, all the saturation and all the brightness information present in the scene being photographed.

Because color TV had to be compatible with black-and-white broadcasting, the first step was to create a monochrome signal—one that would go to all sets, color or not. This signal was obtained by electronically subtracting the brightness component from each color camera tube output, leaving only hue and saturation information.

That information then could be read as the **difference** between each tube's output and the composite brightness signal. The term "color difference" has thus come to be used to describe these three signals.

The second step was to mix the three camera-tube color-difference signals so as to come up with only **two.** We'll call them signal A and signal B.

One of these signals carries color information (both hue and saturation) ranging from cyan to its color-wheel opposite (orange, or absence of cyan); the other carries information ranging from green to **its** opposite (magenta, or absence of green).



You see that any color can be located on the wheel if we know the proportions of these two signals, and whether they are positive or negative. For example, point X above would be a moderately saturated blue.

Think of the color wheel, then, as a **graph.** It will help you understand the vectorscope when we discuss it later. (Notice also that the two color-difference signals are in **quadrature**; that is, at 90 degrees to one another.)

The greatest detail is carried in the black-and-white signal. The eye can respond to only so much color detail; anything beyond that, it wouldn't know the difference. TV is much like the child's coloring book; the black lines define the picture precisely, and the colors are "filled in" broadly.

So, in color TV, only three picture signals are transmitted:

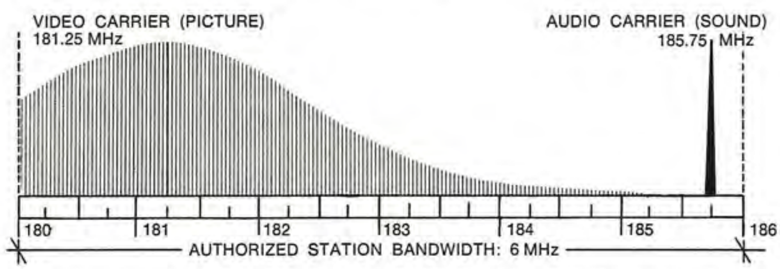
A **black-and-white** signal, which carries extremely detailed picture information to all TV sets, color or not; it varies only in brightness.

And two **color-difference** signals, each containing hue and saturation information. These two signals have only about one-eighth as much detail as the black-and-white signal has.

So we see that the "full-color" picture on your set has been created **without** sending masses of red, green and blue detail, as was first feared.

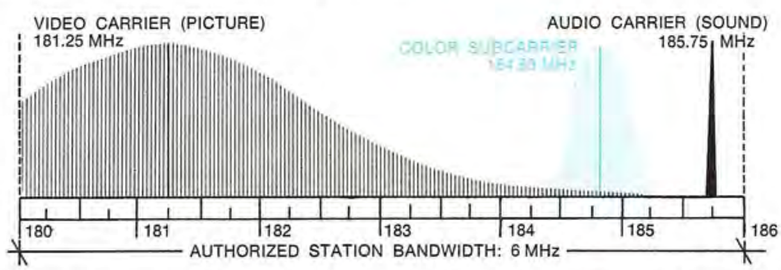
So much for simplifying the information to be sent. The next problem was to find a place to put a color carrier. Remember, commercial TV channels had limited bandwidth, and that bandwidth was already crammed with monochrome and audio signals.

But, as it turned out, there **was** room for a color subcarrier:



Once again, compare the channel bandwidth (above) full of signal information to a piece of paper full of writing. If you wrote between the lines of the first message, you could produce a second message that would be readable.

In essence, that's how the color subcarrier was inserted—**in between** two distant sidebands of the black-and-white carrier.



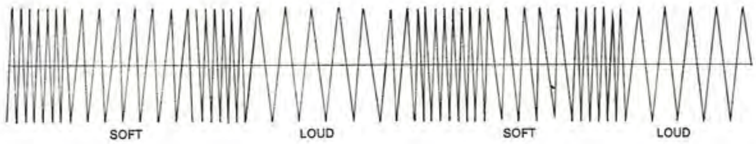
The exact frequency had to be very precisely selected. First, it should transmit color information in adequate detail; second, it should clash as little as possible with the black-and-white picture. Hence the resulting subcarrier frequency was an "oddball" one—3.579545 MHz.

Then, so it wouldn't interfere with the black-and-white signal, the color subcarrier itself was **suppressed** at the transmitter—that is, not transmitted at all. Only the weak sidebands are sent—along with very brief sample "bursts" of the subcarrier, so it may be regenerated inside your set.

There was room, then, for one color subcarrier frequency; but there are **two** color signals. How to transmit them both?

THE ANSWER: QUADRATURE AMPLITUDE MODULATION

An unmodulated carrier is like a blank piece of paper. A carrier wave carries no information until it's modulated. In electronics, one way to vary a signal is **frequency** modulation, known as FM. An FM signal varies in frequency, or number of cycles per second. On an oscilloscope screen, an FM audio signal resembles this:



Some radio is FM; the audio signal on your TV also is frequency modulated.

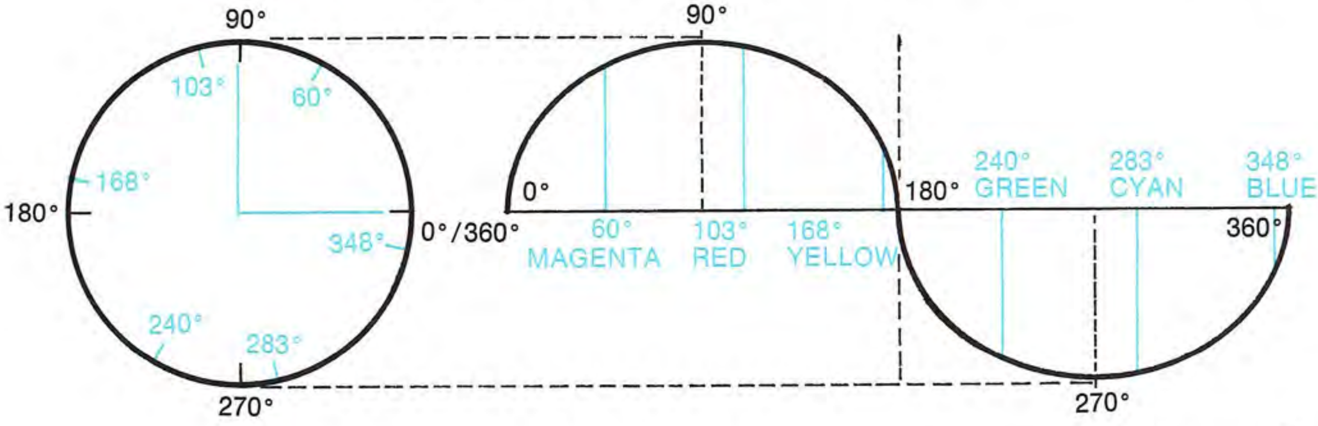
Another technique is **amplitude** modulation. Here the frequency doesn't change; the signal varies only in strength, or amount of voltage. On a scope, an AM radio signal looks about like this:

Most radio signals are AM; so is the monochrome video signal.

Whereas AM signals vary only in strength, and FM signals only in frequency, **quadrature-amplitude-modulated** signals vary in not one but **two** ways. For this reason they can carry two distinct information "packets."

One way QAM varies, of course, is in **amplitude** (the combined strength of the two color-difference signals at a given moment), which fluctuates with the saturation of the particular color being transmitted.

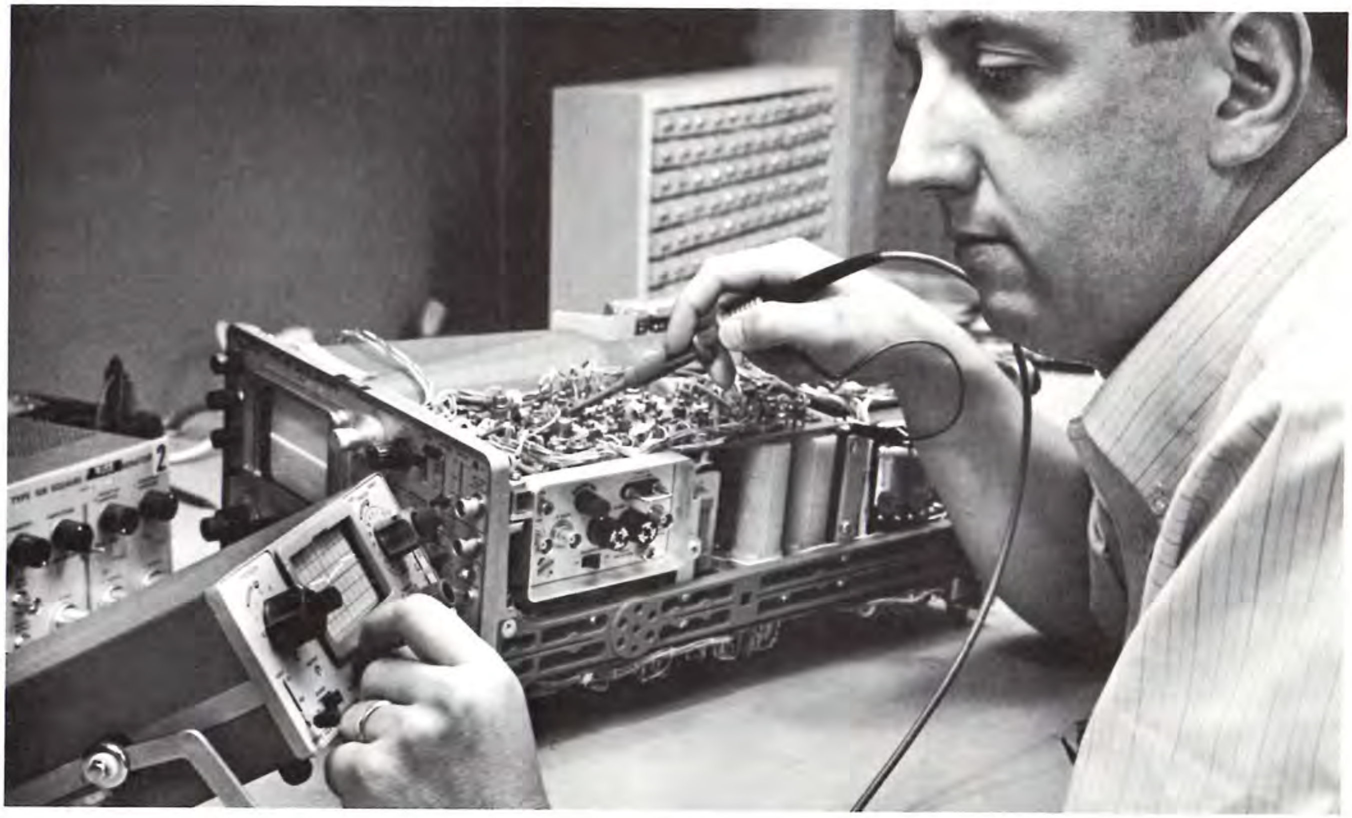
To understand the second way it varies, first remember that any single cycle of a sinewave, if you could look at it, may be broken down into 360 degrees (just as our color wheel itself may):



(Continued on page 32)

Story by Willie Henning

small wonder
JOHN GATES



The 323 mini-oscilloscope is 4¼″ high and weighs 6¾ pounds with batteries. John Gates is 5′11″ tall and weighs 175 pounds, with clothes on.

John is project manager of the 323, the first Sony/Tektronix instrument.

John came to Tektronix in 1960 from Hickok Electrical Instrument Co., where he was involved in "copy" contracts for the military for three years—specifically, developing oscilloscopes for the Signal Corps and the Air Force almost identical to the Tektronix 535 and 543. The military requires that procurement bidding not be "sole-source"—hence their desire to put Hickok into the "copy" business. This activity on Hickok's (and other companies') part resulted in the suit Tektronix has pending against the government. In working on these instruments, John became very impressed with Tek. He also had a strong desire to gain more original design experience—particularly with a progressive, growing company.

He stopped by our IEEE booth in 1960 and talked to John Kobbe, now Advanced Instrument Development manager. After this conversation, he was flown to Beaverton for interviews, and subsequently hired.

Some of the projects he worked on were the 82 dual-trace plug-in, the 81A plug-in, and the 581 and 585 oscilloscopes. He designed the 82, 84 and 86 plug-ins, the vertical amplifier for the 545B and the calibrator for the 544, 546 and 547. And he worked on other advanced instrument designs and concepts in John Kobbe's AID department that have yielded some of our high-frequency techniques.

In May 1965 he was named to head the first Sony/Tektronix development project, the 323, and to start an engineering department at Sony/Tektronix in Tokyo. He had been active in product planning, which had discussed small oscilloscopes for some time; also, he had had design experience, plus interest and ability to adapt to new situations.

Soon after that, some Sony engineers came to Tek to begin work on the 323. In November he went to Japan; subsequent stages of the design of the project were done at the Sony plant. In July 1966 John and the engineers returned to Beaverton, where the project was completed.

The 323 is the first attempt to combine Tektronix' experience in oscilloscope design with Sony's skill in miniaturization—as exemplified by their "personal"-sized TV sets.

Other than its cathode-ray tube, the 323 is completely solid-state. Due to these solid-state components and an "instant heat" cathode, the 323 can provide a usable display in two seconds. By contrast, a typical scope "warm-up" is 15 to 30 seconds.

No oscilloscope is directly competitive. There are one or two about as small, but their CRTs are not as large and the instruments do not have the quality of the 323.

The 323 may be the choice for on-site applications that are within its performance capabilities, such as industrial controls, slower computers and business machines—and the military field, since the 323 is classed as an environmental instrument (which means it can be battered around quite a bit) as well as being very small. The quick-warm-up and its 10-hour battery time insures that the 323 will remain operational for a full work day. The instrument has a 4 MHz bandwidth. It is 3¼" high, 7" wide and 9" deep. The batteries can be charged at full rate while the scope is being operated from an AC line. There is no need to interrupt normal work to charge batteries; no other scope has this unique ability. Traveling electronic-service men may find it particularly useful.

The 323 is being manufactured and assembled in Japan at Sony/Tek. This is the first time one of our overseas assembly operations has depended primarily on local sources for manufactured and purchased parts. The CRT is being manufactured there also. However, the 323 was designed with components that for the most part have equivalent sources available in both Japan and the US.

John attended Oberlin College in Ohio, where he received his BA in physics in 1956. Later he attended Case Institute of Technology, and earned an MS in electronics engineering, while working part-time for Hickok.

John, his wife, Kathryn, and his two children, Jennifer and Ted, enjoy camping, fishing, hunting, hiking and sightseeing.

After the 323 project, John is in the process of fitting back into the engineering organization for new assignments. It will be hard, he says, to top the 323 for a different situation or design experience.

THE INDIVIDUAL

Story by Dick Koe

getting involved
JOHN WHITESIDES

His job: Get people to listen, to communicate, to be involved.

His title: Citizen's Participation Planner in Portland's Model City program.

For John Whitesides (CRT Quality Assurance manager), a Tektronix employee for almost 12 years, this challenging assignment promises to be both stimulating and worthwhile.

John is thoroughly familiar with Model City and other neighborhood-improvement projects. His interest goes back three years, to when he and his family bought a house in Portland's all-white Irvington district.

Although 1965 wasn't a "long, hot summer" for the City of Roses, John, his wife, Janet, and two children, Duane and Kimberli, found racial temperatures a bit warm in Irvington.

The first Negro family to locate in the immediate neighborhood, the Whitesides first found their new neighbors a little less than friendly. A note in the mailbox left John a bit nervous, but undaunted: "Get out Niggers," it said.

The incident became front-page news. White residents across the street and around the Whitesides threatened to move out. Some did. Others shunned the newcomers.

John stuck it out, and gradually his neighbors gave in. "They began accepting us as individuals—not because we're Negroes, but because of what we are as people."

Fears that real-estate values would decline soon gave way to admiration of John's well-kept property. The grass was always mowed; hedges trimmed; house repaired. For every white family that moved away, another entered the neighborhood.

Neighbors began "dropping by." John soon found himself involved in many community activities. He became coach of a Little League baseball team, member of the PTA and, finally, president of Irvington Community Association.

The ICA, a citizens' organization seeking to maintain and improve the neighborhood, gave John an insight into what "grass roots" participation could do in stimulating awareness of, and lessening, crucial community problems.

With assistance from two city agencies—the Planning and Development commissions—Irvington residents launched an ambitious program that included improvements in housing; schools; and public facilities and services, as well as better traffic conditions.

The US Department of Housing and Urban Development (HUD) announced the Model Cities program in 1966. Portland applied for a planning grant in early 1967, and John offered his services. His offer was quickly accepted.

Last year, he was appointed chairman of a temporary citizens' committee, helping organize elections for the Model City planning board. HUD accepted Portland's application in November 1967. Last March, 16 persons were elected to the board.

His mission accomplished, John had decided on behind-the scenes rather than direct involvement. Then Paul Schulze, Model City coordinator, approached him with a fulltime assignment.

Accepting meant a temporary departure from Tektronix. John was granted a leave of absence in April. He attended leadership and organizational meetings and communicated with local citizens—often well into the night hours.

John's Citizen Participation Committee, one of 11 groups in the Portland Model City program, was probably the most important, since none of the others—such as education, housing, public safety—could function **without** citizen participation. These were two of the functions begun during John's tour of duty:

One, setting up a "pyramid of communication" to inform all residents on the progress of the program and descibe upcoming events. The "pyramid" began as John contacted three or four assistants, who in turn contacted three or four others, and so on.

Two, establishing information centers to answer questions posed by the 41,000 persons in the Model City area. These centers will be staffed with persons well-informed on matters from welfare to job training to legal aid.

"The hope is to create a program of action to help solve some of Portland's urban problems", says John, "not to dominate, but to motivate."

THE INDIVIDUAL

Story by Jean Auel

seems like home
MARJ THORN

Tektronix has occupied its Beaverton industrial park for over eight years now. Sixteen of our 18 major buildings are there, and most of our employees call it home. Still, to many motorists along Sunset highway, two miles away, "Tektronix" still means the Sunset plant at Cedar Hills.

Marj Thorn might be forgiven if she felt the same way, for nearly all her 16 years at Tek have been spent at Sunset.

Marj moved to Oregon in 1951 from North Dakota, and started in 1952 on swing shift in Unit Wiring. Three months later she went on days. In those days, the Sunset plant was all there was of Tek, and the total number of employees was around 300, including field engineers. The atmosphere was relaxed. If a part was needed from stock, for instance, you just walked over and got it.

Marj recalls a time when Miles Tippery, one of the original owners, walked past and asked how she was. She had wired many of the same simple parts that day and, not recognizing Miles, said she was bored.

"But," she comments, "16 years later, and I'm still here." Still at Tek, but not at the same job—even though she presently works almost next door to her original location.

After a year in wiring, Marj moved into Kit Prep. She remembers they built their own kits, then; today, hand bending has been eliminated and the whole process is much more mechanized.

When the Preproduction department was formed under Henry Scott and Charles Jay, Marj was its fourth employee. She moved to the Metals building, but only for a short time. Preproduction was then, as now, a link between Engineering and Production and, in fact, involved all areas of the company, including pricing and manufacturing. Many of the concepts and ideas begun at that time are still in existence.

After five years in Preprod, Marj moved to Special Products under Chuck Nolan. Her job there was diversified. She kept track of parts, accounted for hours and costs, modified mechanical parts and drawings, and had them built.

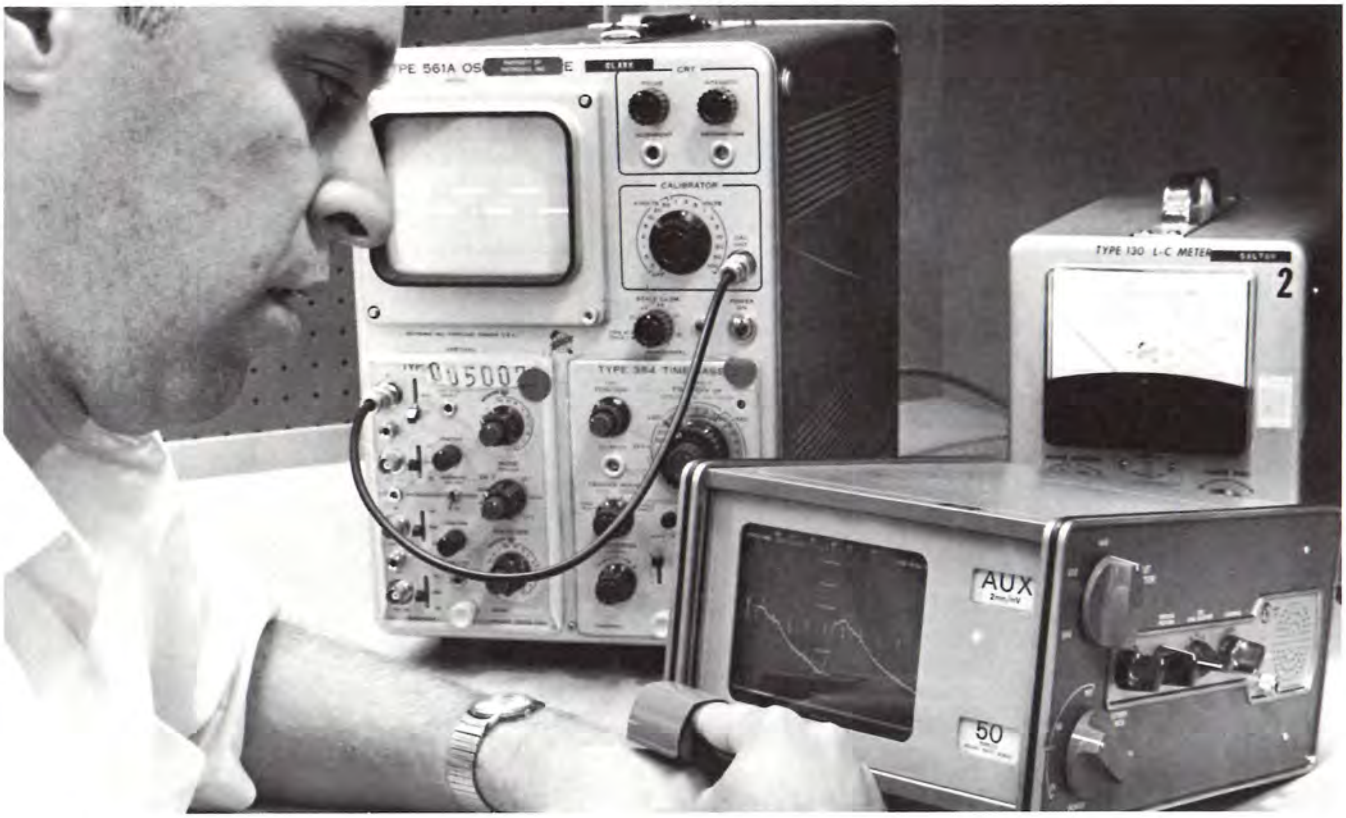
Marj moved into Information Display in 1966, when it was a division. She works on the preproduction of new products. Marj has gained an impressive knowledge of electronics from experience. She is a capable etched-circuit-board designer and builds prototype instruments.

Attractive and vivacious, Marj rides horses for relaxation. She has a married daughter, Barbara, and a 16-year-old son, Terry. The Thorns have 10 acres where she trains her horse and keeps nine others, plus two dogs, numerous cats and rabbits. Terry's horse, Kinken, is a champion jumper. Marj also enjoys jumping, and often takes her favorite horse, Naz, to the fox hunts that start after show season, in Tacoma.

Marj, in her 16 years at Tek, has been in on the beginning of many innovational developments—sometimes as the only woman. She has qualities that Tek strives to encourage—the ability to learn, and the enthusiasm and curiosity to go with it.

WANTED, IN SURGERY

Story by V. K. Sawhney



Medical science is being forced to re-evaluate its definition of death.

There was a time when a man was judged dead if his heart stopped beating. But that criterion can't be accepted now, since the heart can be shocked back into beating again, and it is likely there will be no permanent brain damage if it stopped for only 20 to 30 seconds.

The possibility of heart transplants injects an entirely new series of legal questions into the definition of death. If a man loses his heart and gains another one, when, then, is he "dead?" When his brain stops functioning? But, will it be possible also to transplant a brain? and, if so, who is **really** alive?

As mankind grapples with these and other questions, including moral and ethical ones, the everyday problems of keeping a critically ill patient alive continue to demand medical attention.

And three important physiological signals continue to guide doctors to evaluating the condition of patients in surgery: An electrical signal produced by the heart, monitored as an electrocardiogram (ECG or EKG); pulse, the pumping of blood as sensed outside the body, which depends on the condition of the blood vessels; and an electrical signal produced by the brain, monitored as an electroencephalogram (EEG).

Our 410 physiological monitor is a small, battery-powered instrument capable, at the turn of a switch, of monitoring these three important signals from the human body.

Introduction of the 410 in August 1967 marked our entry into clinical medicine. Most of our products in the medical field before that were used primarily for research.

It would be possible to monitor the same information with one of our 540-series oscilloscopes equipped with a Type 1A7 plug-in unit. But the total package would be nearly 10 times as large as the 410. You could not monitor the information by turning a switch; instead, you would have to connect and disconnect wires. And the display on the oscilloscope would often not be as distinct as that on the 410.

The electrical performance of the 410 differs significantly from that of any other Tektronix instrument, due to its **guarded input circuit.** When a signal is fed into the 410, electrical interference from the local environment (fluorescent lights, for example) also goes into the monitor. The guarded input circuit uses the interfering signal to cancel itself out.

Without the guarded circuit, part of the interference would appear on the monitor's screen along with the physiological phenomenon being monitored. The display in that case would appear as a very thick line—difficult to interpret. With the guarded circuit, however, the display appears to have been written by a fine-point pen, and is far more meaningful.

In addition to high resolution, the 410 provides simple operation: It has only six knobs, of which three—the input selector, ECG lead selector and loudness control—are not on any other instrument.

The 410 stands 5⅜ inches high, is 8½ inches wide, weighs

PULSE SENSOR (photo left) attached to finger of Gary Vance (Low-Frequency and Biomedical Instruments) converts pulse pressure changes into a graph on screen of 410 physiological monitor. (Below) Use of 410 monitor in emergency situation is demonstrated by members of Aloha Fire Department: Bob Herb (left) and Earl Reynolds. (Photo by Art Stipe)

12½ pounds, and has a five-inch rectangular cathode-ray tube with an 8 x 10-cm viewing area. The short depth of the monitor and its large display are made possible by using a magnetically deflected CRT. In our product line, only one other instrument uses a magnetically deflected CRT—the 611 display unit. All other instruments use electrostatic deflection.

The television industry uses magnetic deflection almost exclusively, because it enables a large picture size compared to the CRT depth. In fact, the 410 CRT is a television tube, made by Sony Corporation, with a different phosphor.

With magnetic deflection, low operating voltages in the deflection circuit are possible, permitting simpler power supply when battery operated. Power consumption of the 410 is only two watts—it would take 50 instruments to equal the power consumption of a common light bulb.

A unique feature of the 410 is the audible "beep", coinciding with the rate of the heart beat. The speaker operates with the ECG and auxiliary input for sensing the pulse. This feature enables a surgeon to monitor a patient's heart rate without having to look at the instrument, allowing him to concentrate on the surgery.

The ECG function of the 410, along with the audible "beep," is very helpful in the operating room, since irregular heart rhythm that is not quickly detected is the greatest danger in surgery. It can be fatal, or cause permanent brain damage, if not discovered rapidly.

The physiological monitor is designed primarily for use in an operating room by anesthesiologists (physicians specializing in anesthesiology) and anesthetists (registered nurses who administer anesthetics.)

The monitor could be of use, as estimated in 1966, to about 7000 anesthesiologists and 20,000 anesthesists in the US. In addition, it is estimated that monitors could serve 34,000 internists and 1700 cardiologists, and be used in an unknown number of recovery rooms and intensive-care units.

The monitor, however, is not specifically designed **for** intensive-care units, since that would involve designing or coordinating with an entire "system" of instruments, including recorders, alarm systems and meters.

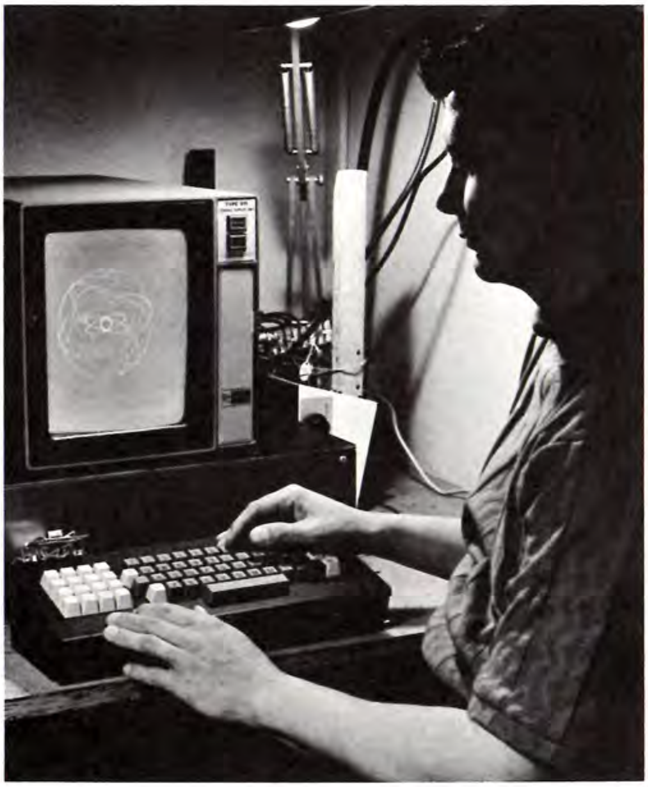
The first working model of the 410 monitor was completed in March 1966. The following year, in August, the monitor was introduced into the market. The response has been excellent, particularly to the audible "beep" feature, large size of the CRT display and the convenience of an easy-to-use, lightweight instrument.

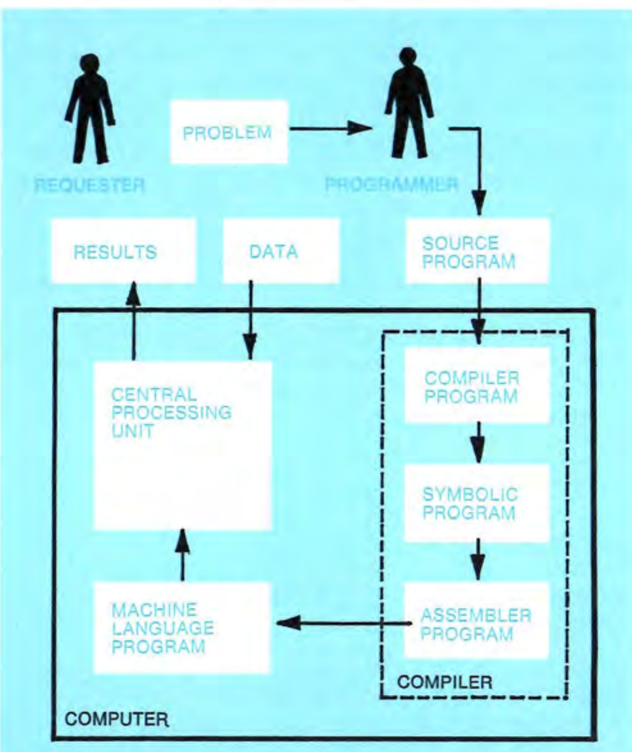
A dramatic use of the monitor occured in February, in an operating room of an eastern hospital, when a patient's heart stopped beating and the electrocardiograph being used in surgery broke down. Tek Field Engineer Bob Mahoney (Cleveland), waiting in the corridor to demonstrate the 410, was rushed into the operating room to connect the battery-powered monitor to the patient.

After the crisis passed and the patient's heart was functioning properly again, the anesthesiologist remarked: "It was a great demonstration of the instrument's capabilities in a live environment."

And Bob, still a bit shaken, agreed.

HELLO . . . .





PROGRAMMING SEQUENCE

John Jones wants to see the latest production figures . . . Mary Smith needs help with her math . . . The president of Widget, Inc. would like a reservation on the noon airplane to San Francisco.

In the near future, each of these people will converse with a computer.

John and Mary, as a matter of fact, will most likely talk to it **directly** and get their answers on a cathode-ray-tube screen, much like on their television set.

Tektronix' recently announced 601 and 611 display units provide a unique solution to the problem of displaying computer-generated information at terminals remote from the computer itself.

We are increasingly dependent upon computers to help us solve our daily problems. Direct communication with the computer by the user himself seems to be ultimately the most feasible and economical way of taking full advantage of the great service it can provide.

The growing use of computers, and the limits of programming techniques, have brought about the development of remote terminals—devices which, far from the computer itself, allow each user direct access to it, often on a **real time** basis. Remote terminals reduce the critical barrier to man-machine communication, a barrier that has resulted from the traditional computer processing method, called **serial processing**.

Batch processing handles only one problem at a time. The person with a problem to solve must submit it to a trained programmer, who prepares a program directing the computer, step by step, to solve the problem. His directions, written in a symbolic programming "language", are punched into cards and run on the computer, to translate the programming language into **machine language**, which the computer uses to process information.

It is common for the first run of a program to contain errors. These errors will prevent the computer from executing the prescribed operations. Detecting and removing the errors is called **debugging**. When the program is debugged and correctly assembled, the data for the problem can be included in the **production run**; the answer to the problem results.

The whole process takes from a few hours, for a very simple program, to several weeks, for a complex one.

The growing use of computers, and the need for faster answers, has led to the addition of the two techniques, **time-share programming** systems and **remote terminal** operations. They are directly related; one can not function economically without the other.

Time-sharing is a process whereby the computer switches very rapidly from one problem to another, giving each user the illusion that the machine is working on his problem all the time. The terminal is normally located in his working area.

. . . . COMPUTER?

Story by Tom Unthank

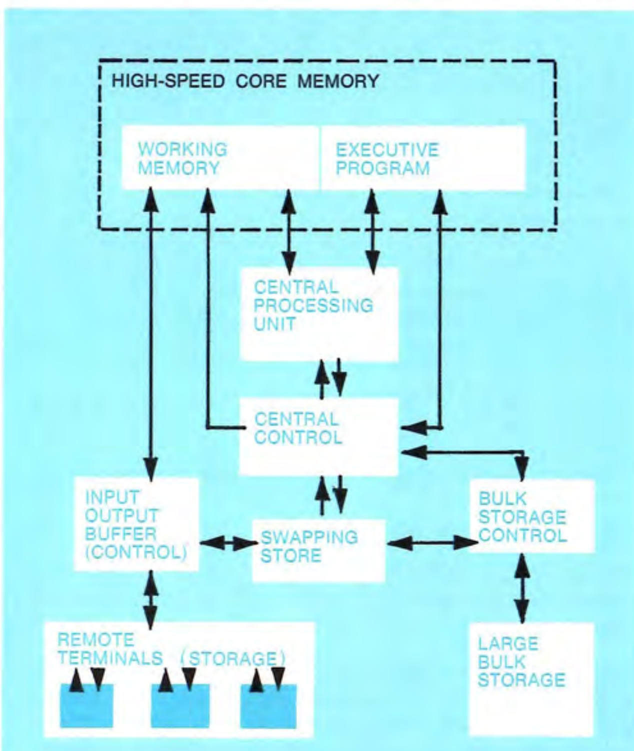
He writes a program to solve his problem, step by step. Any mistake or infraction of computer-programming rules is known immediately; the computer simply **tells** him he has "goofed". (In the time-share system, the programmer has a much more difficult role than in batch processing. He prepares the total system to accept, and solve, an ever-changing variety of problems.)

Efficient use of time-share operations requires the computer to have many users at a time, and a system of terminals that is flexible, convenient to the user and reasonably low in cost. The most workable terminal is a visual-display console using a cathode-ray tube and keyboard, located in the user's office and connected to a large central computer by telephone lines.

The 601 and 611 each contain a special bistable storage cathode-ray tube with unique capabilities for use in remote terminal systems.

These instruments provide a way of eliminating flicker. In a non-storage CRT, like on a TV set, the duration of an image on the screen is very brief, limited by the phosphor. To maintain an image that doesn't flicker, it is necessary for the computer output devices to rewrite, or "refresh", the image on the screen 24 to 30 times per second—a costly process.

In a storage CRT, by contrast, the image is transmitted, or written, only **once**, and the tube itself retains that image as long as needed.



TYPICAL COMPUTER WITH TERMINALS

Since storage display units provide visual output for computers, let's review how a computer operates:

A typical computer consists of a central processing unit (CPU), a memory (known as core), auxiliary storage (usually on tape or disks), a control console and an input/output unit (to control the card reader and printer).

For terminal and time-sharing operation, the computer has additional storage to handle the many programs required. In this system, the high-speed memory is reserved for two functions: Providing working memory; and controlling the computer's interchange of programs and users and handling other time-share "bookkeeping" chores.

The computer communicates information using binary numbers rather than the familiar decimals (1, 2, 3, . . . etc.). A **bi**nary digi**t**, (hence, **bit**) has a base of two; the more common decimal has a base of 10. Just as in the decimal system, the position of the primary digit represents the magnitude of the number.

The typical computer handles one unit of information (called the "computer word") at a time. This word, representing 10 to 12 decimal digits and a control sign, contains 30 to 40 bits. All information from computers— numbers, letters, or drawings —is transmitted in these binary-coded "words".

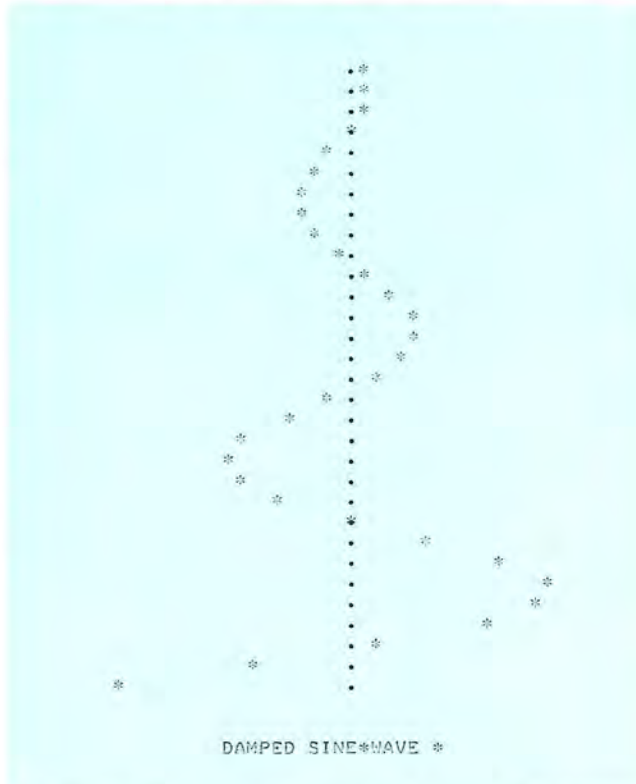
There are two modes of transferring information between computer and terminal. These are **serial** and **parallel.** In serial transmission, all pulses occur on the **same** path, one after another. In parallel transfer, all pulses occur at the same time on **different** paths. Most data transfer within computers is parallel, because of its higher speed; but it is seldom used in connection with terminals, because one wire is required for each bit of the computer word being transferred.

For the average terminal, serial transmission is used, utilizing telephone lines.

To enable phone lines to handle maximum information, **datasets** or **data phones** are used, to convert digital information into phase-modulated voice frequencies.

The long-familiar teletype machine—which has a keyboard, produces a "hard" (permanent) copy and uses an existing communications network— became the initial tool to provide both local and distant multiple-terminal systems. Teletype terminals **are** useful in limited applications. However, the scientific or engineering user soon discovered that teletype consoles had a lack of capacity, in these respects:

1. **Fixed format:** the teletype must print like a typewriter, top to bottom and left to right, and use only standard teletype symbols.
2. **Slow print rate:** Maximum teletype speed is approximately 100 words per minute—undesirable for two reasons: It does not use the full available telephone bandwidth, and the output from the computer is not immediate.
3. **Lack of graphics:** The fixed format and limited speed of the teletype prohibit the use of graphic (pictorial) output, except for time-consuming and limited-quality teletypewriter plots, arranging letters, numbers and symbols into pictures; like this:



4. **Noise:** The teletype is very noisy. It must be in a soundproof enclosure if any other activity is to be conducted in the room at normal sound level.

The need and desirability to provide graphics, and to overcome the other limitations of the teletype system, stimulated the development of communication terminals using **cathode-ray tubes** as the display media, with telephone lines linking computer and terminal.

Telephone-line transmission limits are normally about 2400 bits per second per cycle. The average user requires a minimum repertoire of 64 alphanumeric symbols, each represented by six bits. Thus an **unrefreshed** CRT, to achieve a flicker-free display, was limited to 11 symbols, letters or numbers.

This small amount of data is inadequate for most applications, so the need arose to increase capacity. A local memory unit was added to the console itself to accomplish the refresh function. A display format of 50 symbols high by 50 symbols wide—a typical usable display—requires a memory capacity of 13,000 bits and a high-speed switching circuit to cycle the memory and produce the symbols at the flicker-free rate. The memory unit increases the cost of the terminal.

There are indications of great growth of terminal time-share systems in the near future. A number of remote systems are emerging with distinct functions, characteristics and requirements.

Some of them are:

Inquiry systems, with many terminals connected to one computer center to keep continuous track of a particular category of information. Examples are airline-reservation and hotel-reservation systems; centralized inventory control, and, in the future, a telephone directory-information system.

Data-collection systems, reporting the status of items from many terminals within the company or transactions of an organization, such as stock-market and weather-reporting systems.

Conversational systems, allowing the user to enter programs, one statement at a time, and carry out calculations on the computer, using a large program library in the central system. These can be tailored to a wide range of specialized needs.

Interactive graphic systems, displaying computer-supplied pictorial information on the CRT in response to a request from the terminal. A main application is computer-aided design, say, of electrical circuits, and the display on the CRT of the circuits' dynamic response; or design of three-dimensional structures, such as ships' hulls and automobiles.

Computer-aided instruction, a combination the above systems plus an information-distribution function. Pictures and drawings play an important part in addition to text, to simplify the presentation of information or to make it easier for the student to interact with and respond to course materials.

TYPICAL graphic display is shown on the 611 screen. (Photo, and those on pages 30 and 36, by Tektronix Photography department)

Information-distribution systems, related to the inquiry systems, actually broadcast information selectively to customers. Projected applications include stock quotations, freight-traffic information, bibliographies, abstracts, technical documents, timetables, address lists and similar documents.

Remote document production, still a future application, calls for a central computer to process data for many locations in an organization, by producing documents for display on high-speed reproduction terminals.

The key to effective and economical use of remote terminals is low-cost graphic/visual information display. The Tektronix 601/611 storage display units are basic components of an economically feasible terminal.

The 611 and its smaller-screen version, the 601, each include a storage CRT and the related electronics to make it function. They do **not** contain any peripheral equipment that would let them operate directly from the computer. The user must provide that equipment.

The 601 and 611 are the first major Tektronix products not designed primarily as measuring instruments. A display unit is not an oscilloscope, which displays an electronic "event" so it may be measured. The display units grew directly from our development of the bistable storage cathode-ray tube in 1962, which made our 564 storage oscilloscope a practical item.

The story of the display units began in spring of that year. It was users of the 564 who found a new, non-measurement, application for this scope: Connecting it to a computer system and using it as a graphic-information (display) output device.

These early applications by customers helped define the requirements for storage display units. These uses showed that, with proper peripheral equipment, our storage tube would provide high-resolution, non-refreshed alphanumeric and graphic display. Guided by customers' reports, Tek began to develop a five-inch storage tube optimized for display use. An 11-inch tube, our largest CRT, also went into development, using our exclusive ceramic funnel construction. The tube is approximately 11 inches diagonally across its face.

The 601 and 611 are designed as integral parts of a remote terminal system. They are engineered for individual use at a terminal, at a close viewing distance to take advantage of the very fine detail that can be displayed.

Using cathode-ray tubes for computer graphic output is not unique to Tektronix. An early application was on a computer at Massachusetts Institute of Technology. The program and its related system, completed in 1962 and known as "Sketch-

PETE PERKINS (left) and Larry Virgin (CRT Design Engineering) check out the writing gun for the 611 storage tube. Two completed tubes are pictured.

pad", was a purely graphic system, using a cathode-ray tube and a light pen.

The system was highly sophisticated, yet limited. The user could "draw" on the screen with the light pen and make two lines parallel. But he could not solve **non**-geometric problems. Sketchpad was followed by a modified system that produced a perspective display when presented with front-view and side-view plans.

The first major industrial system of computer-aided design using a CRT for display was at General Motors Research Laboratories. It had the ability to manipulate an image in three dimensions. From knowledge gained there, a project was developed to permit two-way easy-to-use man-machine graphic communications.

Hardware consisted of a computer with disk and drum storage, an image processor (so the computer could read and generate drawings) and the graphic console, on which the designer could communicate with the computer.

The console consisted of a 17" display tube and a position-indicating pencil, a 36-position keyboard and 36 control-function keys. The system provided a meaningful—and instantaneous—"conversational" interchange of design and engineering information.

Another common CRT application is microfilm recorders. The microfilm plotter/recorder consists of an interconnected CRT, camera and electronic control equipment. The CRT produces a picture on the tube, which is photographed by the camera. The camera is advanced and the CRT deflection is controlled by the computer.

These microfilm systems are most commonly used "off-line" —not connected to the computer—by reading from a magnetic tape prepared earlier on the computer. The speed of microfilm recorders is in the range of 10,000 to 100,000 points/lines/characters per second.

The 601 and 611 eliminate the need for costly devices to refresh information displays, and provide high information density without flicker or fade, with excellent resolution, at high speed and at low cost.

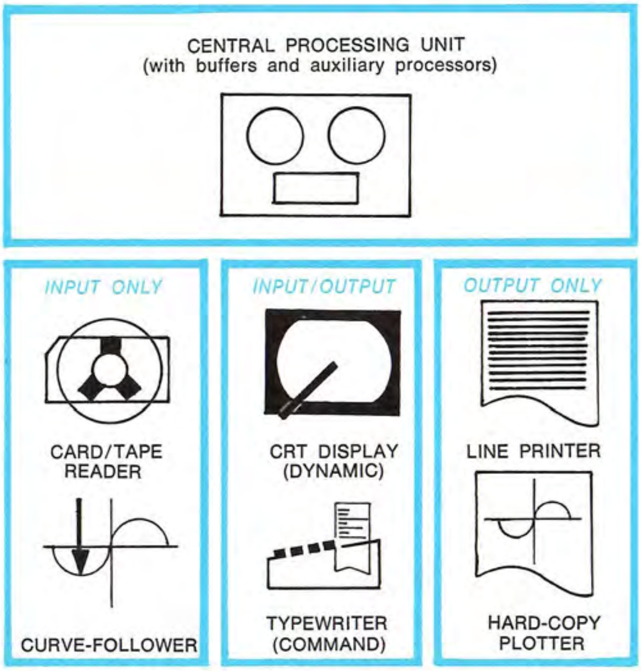
The key is the storage tube. This CRT has special features that allow it to retain the displayed waveform as long as needed. One electron gun "writes" the waveform on the screen with a strong beam. A second gun then floods the screen with a stream of slow-moving electrons that holds the written areas bright and the unwritten areas dark.

The bright image and dark background both being maintained by one flood current is called **bistability.** (A more complete non-technical discussion of the storage tube was published in the Spring 1966 Tek Talk.)

The 601's five-inch tube has a display area 8 x 10 cm, providing, sharply and clearly, 400 letters, numbers or symbols, bright on a dark background. The 611, with its 11-inch tube and a display area 21 x 16.3 cm, can display about 4000 alphanumerics—10 times as many. The 601, because of its smaller size, can use electrostatic deflection, in contrast to the magnetic system used in the 611.

The ideal terminal would let the user respond to the displayed data with maximum convenience and minimum fatigue; and be able to enter—and alter—the graphics and alphanumerics, both in the computer and on the display.

This ideal terminal would use these elements:



The primary method of sending messages to the computer from the terminal is through the typewriter keyboard. This keyboard converts a mechanical motion, pushing the key, to an electrical signal that the computer can understand.

An alphanumeric or graphical display can be built on the screen by any of several methods.

To plot the display, the computer requires analog voltages to move the CRT beam vertically and horizontally. The vector, character and dot generators discussed below are special devices that convert digital computer words to special analog deflection voltages.

The most time-consuming method is the **random-plotting** mode, using a simple digital-to-analog convertor. In this case, the computer sends 21-bit "words" to the terminal, each one of which instructs the terminal to write one point on the screen.

However, using one computer word to write one point is a costly way of building a display. Money and time can be saved through the use of vector and character generators, which more efficiently use each word.

VIRGINIA PETERSON and Larry Virgin (CRT Design Engineering) observe part of testing procedure for 611 storage tube.

The **vector generator** can use the same 21-bit word to draw a complete line, of any length, between two predetermined points.

The **character generator** can use the same length word to trigger the drawing of any one of 96 standard alphanumeric characters—letters, numbers or symbols. It can write one character in 1.25 msec—about the same time it takes to plot one point in random-plotting.

In addition to communicating alphanumerics, terminals must resolve graphic problems. On the CRT there is no visual means of knowing where the electron beam will write its next spot—which is useful information when sending or manipulating drawings or other graphics. In both the refreshed and storage CRT terminals, a cursor is used to indicate the position of the electron beam.

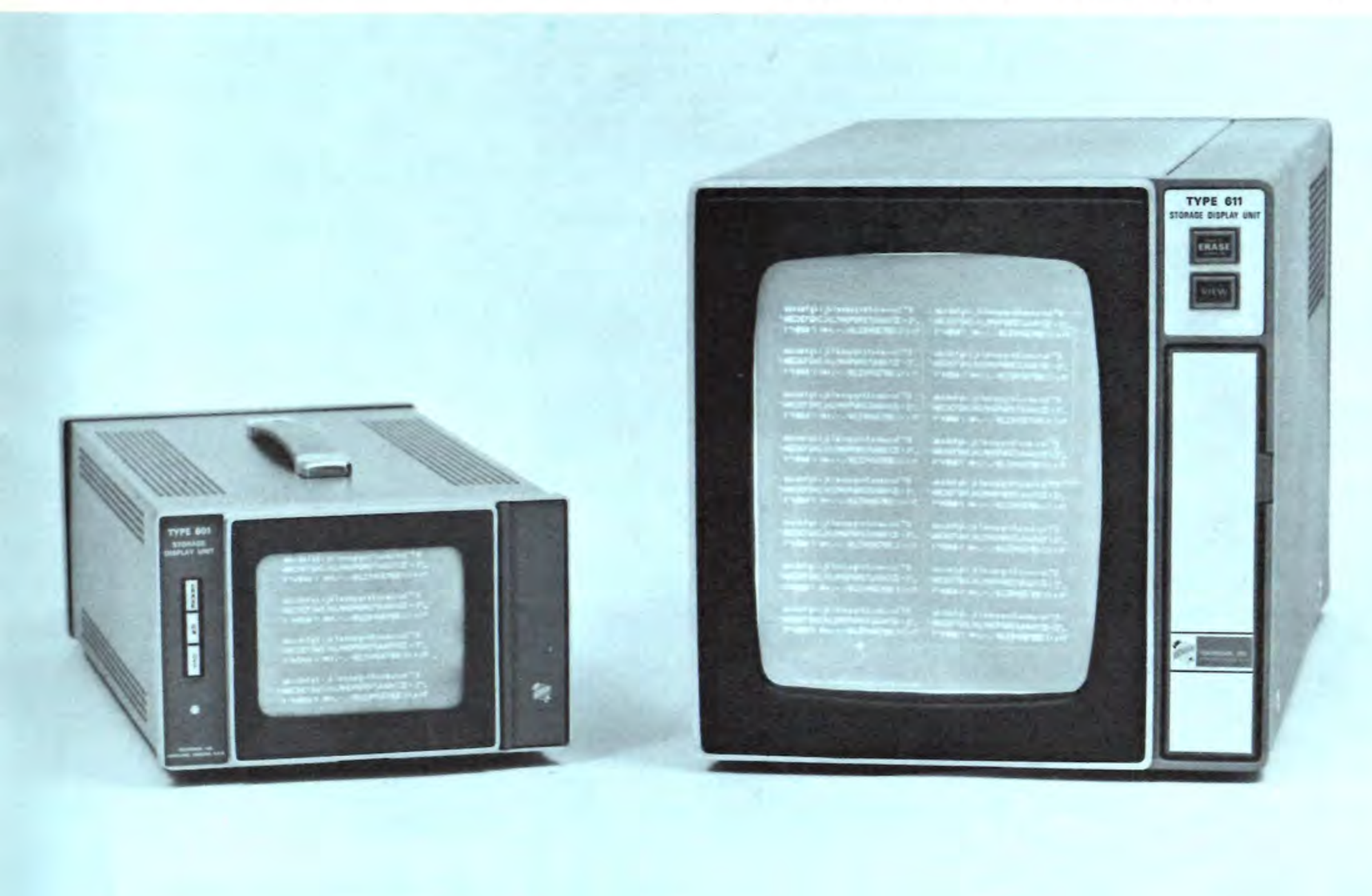
This cursor is a marking signal that tells the operator where the next character will be written, just as the position of the carriage does to someone using a typewriter. In our display unit, the cursor exists as a "write-through" signal, a signal strong enough to be seen, but not strong enough to make its image store. The cursor must be refreshed by the computer.

In the not-distant future, many functions of our daily lives will be monitored by computers. Our ability to "talk" to these computers in a language we understand will give us increased control over the technical world we are creating. A remote terminal at every necessary location is possible. Many times we will be far distant from the computer that is helping us in our work, or in our education, or in designing a new car.

The storage display unit is the heart of a terminal system that can, at low cost, provide access to the computer for large numbers of users.

Tektronix, with the 601 and 611, will help make the use of computer almost as simple as the use of your telephone. If John Jones and Mary Smith talk to the computer in the near future, it may well be by using our storage display unit.

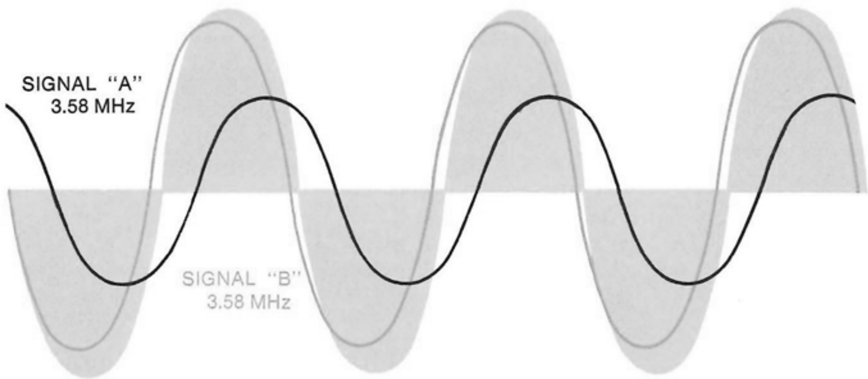
PHOTO SHOWS relative size of type 601 (left) and 611.



THE VECTORSCOPE: ELECTRONIC COLOR WHEEL

(Continued from page 17)

In television QAM, each of the two color-difference signals modulates a separate 3.58 MHz carrier. These two AM signals are then transmitted, not together, but one displaced 90 degrees from the other. Another way to say it is that one is shifted one-quarter cycle **out of phase;** still another way is that one signal lags the other by a fraction of a millionth of a second:



The waveform sum of these two signals (shaded above), when compared with its 3.58 MHz reference sinewave, will continuously vary in two ways. One is in **strength**, which depends on the **combined** amplitude of the two signals at a given moment. The other is in **phase;** that depends on their **relative** amplitude—which of the signals is stronger at that moment, and by how much.

Saturation information is carried as the two color signals' **combined** amplitude; hue information is carried as their **relative** amplitude.

CHARLIE RHODES, manager, TV and Conventional Oscilloscopes.

IN SUMMARY: COLOR IS PACKAGED

Now let's summarize. The problems in color transmission were:

1. To send color information in enough detail to create a high-quality picture.

2. To fit all this information into the already crowded bandwidths of existing commercial channels and home TV sets, and in such a way that color programs could be received (in black-and-white) on non-color sets.

This meant some way would have to be found to radically simplify the color information, and to sandwich it all into narrow commercial bandwidths. Few thought it could be done.

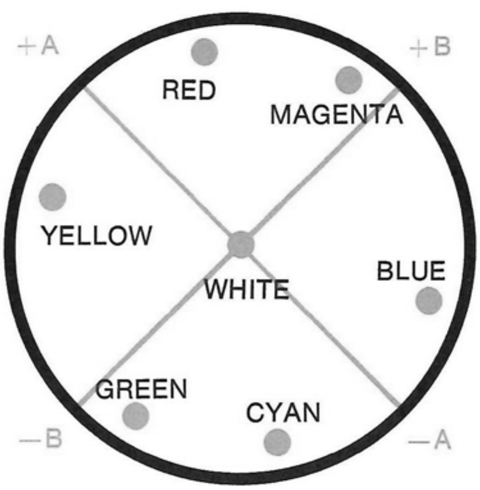
The color TV camera, scanning a scene, breaks it up into its primary colors. Each of its three color tubes sees only a part of that scene (the red, green or blue part) converts it into hundreds of thousands of "bits" of information, and translates them into a sequence of varying current.

Signals must now be created to give your TV set all the information it needs to reconstruct that scene. That is, as each "bit" is scanned, is that bit red or green? pale or vivid? bright or dim? (Remember that color isn't transmitted as color, but as signals representing certain **characteristics** of color).

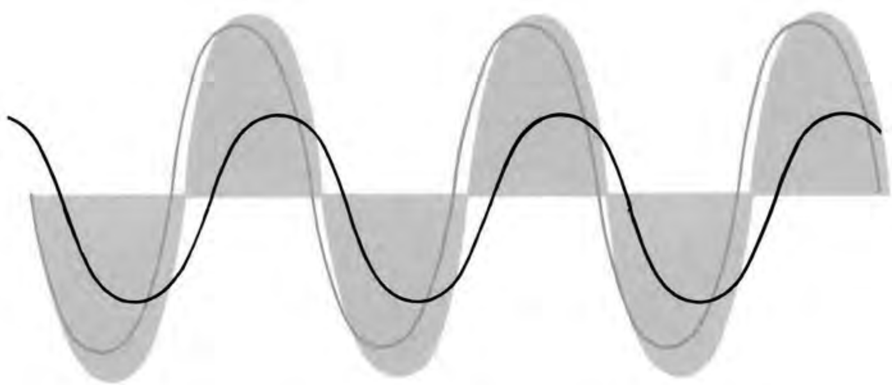
Through electronic "packaging," all this information is compressed into two video signals:

1. The first is a monochrome signal, ranging from black to white. From the color tubes' output, brightness information is subtracted, and transformed into a signal that goes to **all** TV sets; on black-and-white sets, it is the picture; on color sets, it "draws" the detailed picture and the color is "filled in"; the illusion is a full-detail color image.

2. To make the second video signal, the three tube outputs are mixed and **two** hue/saturation signals are created (On a color wheel they are in quadrature to one another:)



Each of these "color-difference" signals modulates a separate 3.58 MHz carrier; the two modulated carriers are then transmitted, one a fraction of a millionth of a second behind the other—that is, shifted 90 degrees in **phase:**



The resulting waveform varies in both **phase** and **amplitude** (compared to the 3.58 MHz reference phase). Thus it can carry two kinds of information.

Just as the hue we **see** depends on the proportions of primary colors it contains, the hue that's **transmitted** depends on the proportions of the two color-difference signals at that moment. Those continuously changing proportions are transmitted as continuous shifts in phase.

The **combined** strength of the two signals (transmitted as continuously changing **amplitude**) describes the saturation at that moment.

The 3.58 MHz subcarrier had to be carefully chosen, for it had to somehow fit into a channel bandwidth already apparently filled with signals. It was placed **in between** two distant sidebands of the black-and-white signal, where it would interfere only slightly.

Even so, if the subcarrier were transmitted, it would degrade the black-and-white picture. So, instead, only the weak sidebands are sent; the carrier itself is withheld, except for very brief eight- to 10-cycle "bursts."

The color picture on your TV set is made up of 525 horizontal lines; the 525-line picture is drawn 30 times each second. The short 3.58 MHz color "burst" is received by the set just **before** it draws each line. Thus triggered, the set itself "reinserts" the reference subcarrier, and the burst doesn't interfere with the picture.

The TV studio takes the black-and-white and "color" signals, transmits them all to you in a very high-frequency band by amplitude modulating a carrier wave, and sends an FM carrier for the audio.

To "unpackage" all this information and recreate the detailed full-color picture that the camera sees, your color TV set must be a very complex instrument indeed. And so it is.

YOUR TV SET PAINTS THE PICTURE

A color television set must decode the composite video signal and translate it once again into a color picture.

First the set separates the video and audio signals from the carriers. Next it separates the black-and-white signals from the color signal. Third, it splits off the "burst" from the color information, and other synchronizing signals from the black-and-white information. These so-called "synch pulses" are essential to make sure the set recreates the picture "in time" with the transmitter.

(Your set contains a 3.58 MHz crystal oscillator. The eight-cycle "burst", received 15,750 times a second, is a sample of the color subcarrier, used to keep the oscillator in phase with the transmitted color signal.)

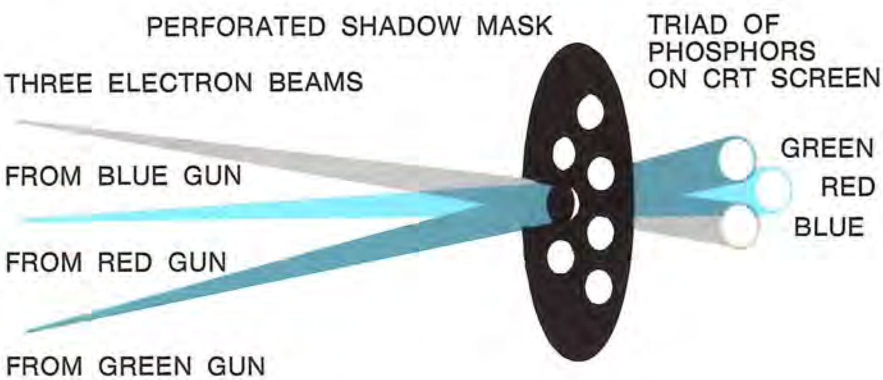
The black-and-white signal needs no further processing. But the color signal does, and so it's run through two 3.58 MHz demodulators. The three original color difference signals emerge, and are added to the black-and-white picture information.

Now to "paint" the picture on your television screen:

Unlike a black-and-white TV set (or an oscilloscope), whose cathode-ray tube has only one electron gun, the CRT in most color sets has **three.** The addition of the color information to the black-and-white information is usually done at the picture tube by feeding the monochrome signal to all three guns; and each of the three color-difference signals to a separate gun control. Comparing control voltages determines how hard each of the guns will be turned on—which depends on the proportions of the three primary colors being transmitted at that moment.

The red, green and blue guns "fire" their electron beams at a screen made up of nearly a million phosphor bits, arranged in triads. One triad phosphor glows red when struck, one green, one blue. (They're so small the eye doesn't see them individually, but integrates all the color bits and sees a "true-color" picture.)

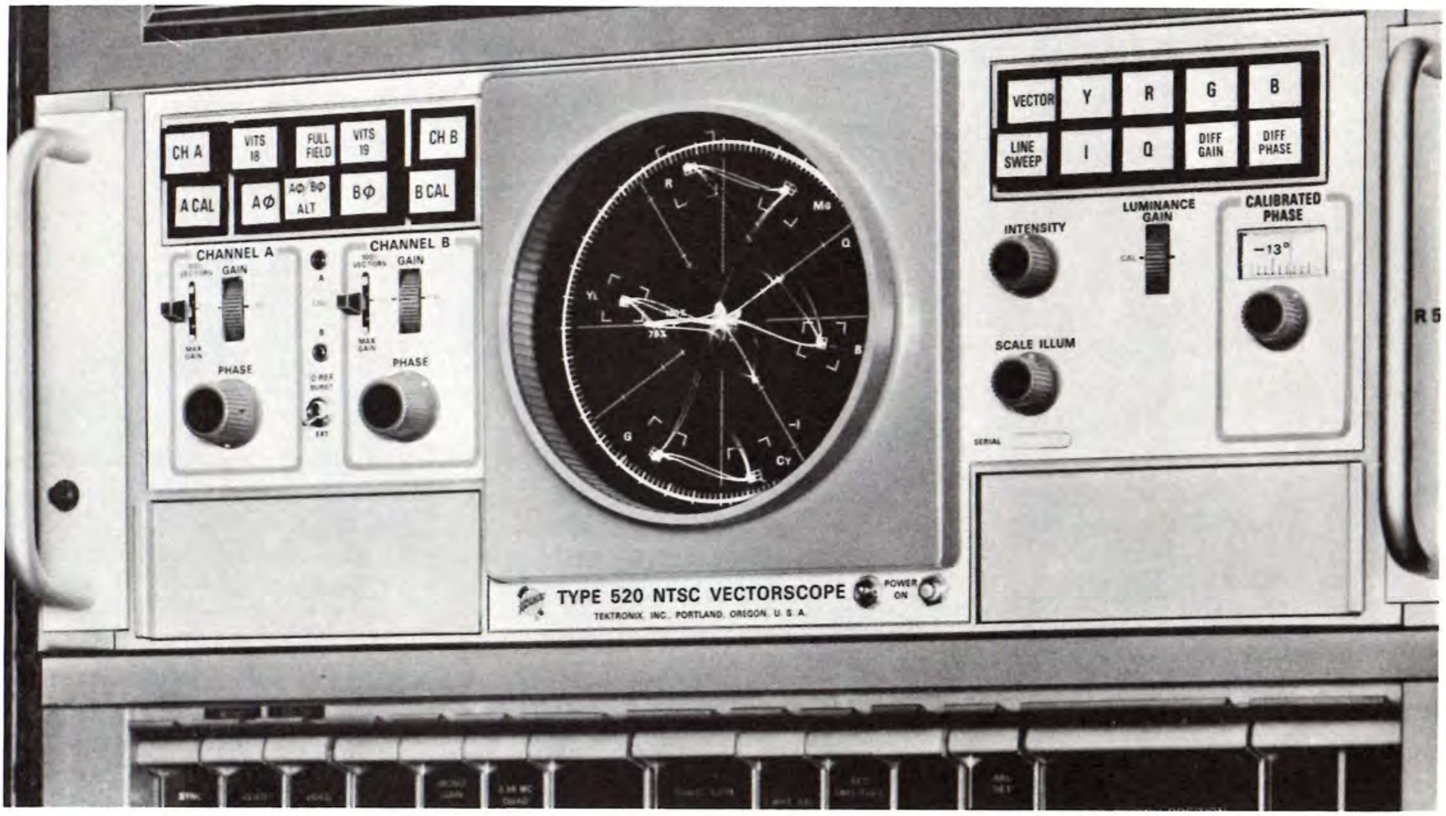
Each beam, to hit the screen, must pass through a shadow mask full of many small holes—one hole per triad. The beam angles are such that after they converge through the hole they separate again just enough that each beam will strike only the proper-colored phosphor:



The **hue** and **saturation** of the picture on your screen depends on **which** of the guns are turned on at that moment. The **intensity** depends on how much they are turned on.

Thus we see that the original full-color picture has been converted into carefully packaged electrical signals; then, on the screen of your set, back into the color image once more.

TYPE 520 vectorscope, NTSC version, was designed for television color systems in the US and Japan: the PAL version is used with TV color systems in most of the rest of the Free World. Only France and Russia have systems that cannot use vectorscopes.



THE 520: PUSH-BUTTON COLOR MEASUREMENT

There can be many a slip 'twixt the color signal in the studio and the color picture on your set. Opportunities for faulty transmission occur in the camera chain, during video taping, at the transmitter and at the approximately 1000 microwave repeaters through which the signal may pass.

Significant degradation of the color signal causes havoc. In black-and-white TV, your eye will tolerate picture distortions; but a flaw in a color picture is like a sour note in a symphony; you won't stand for it.

Most color TV reception now is pretty good, thanks in large part to the fact that there **are** vectorscopes. And the 520, which replaces our 526, TV's standard until now, should improve your color picture even more, believes Jerry Eastman (Product Technical Information).

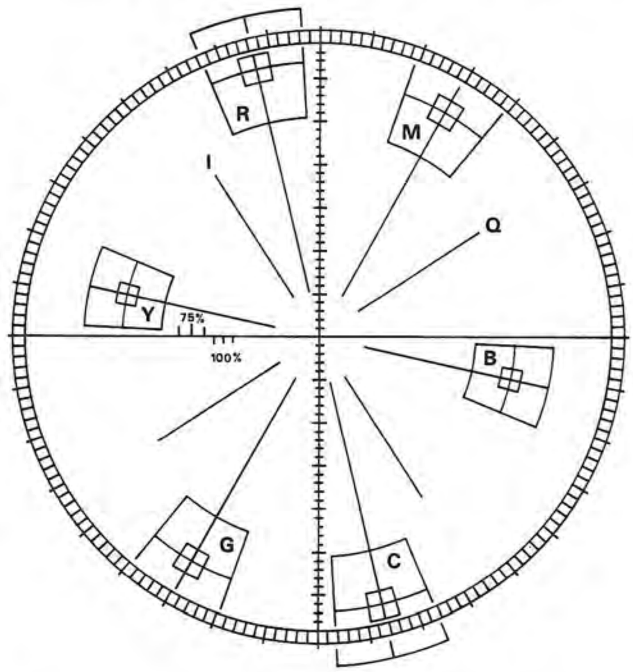
One reason, he says, is the 520's increased measurement capability. Another is that, when a studio buys a 520 for monitoring camera output, they may install their "old" 526 at the transmitter itself—thus providing color quality-control at one more point.

A vectorscope is one kind of X-Y oscilloscope; that is, one that allows presentation of two unknowns: A conventional scope usually presents **one** unknown (voltage) against a known segment of time.

The vectorscope **has** no time reference. On its color-wheel screen, it graphs two signals against one another—voltage against voltage.

The term "vector" describes a quantity that has both direction and magnitude. Wind velocity (southwest, 45 miles an hour) can be shown vectorially; so can color on a color wheel. Often a system of arrows makes up a vector diagram, as it did on our wheel on page 15.

The 520's circular screen contains marked-off boxes inside which, if properly transmitted, primary and secondary colors will appear, as dots of light:



The inner boxes indicate established numerical tolerances, limits outside which an expert can visually detect color flaws on a TV receiver; the larger, outer boxes indicate the limits outside which **anyone** can spot the color errors.

The 520 is much like a color TV set, only far more precise. In fact, comments Charlie Rhodes (TV and Conventional Scopes manager), the vectorscope would make an **excellent** color TV receiver.

In its innards, the 520 decodes the composite video signal from the studio much as your TV set does, except that the vectorscope doesn't rebuild the color picture. Instead, it comes up with a **luminance** signal, plus a **red**, a **blue** and a **green** signal. These can be combined and displayed in a wide number of ways, checking against a variety of test patterns and signals generated at the studio, to detect any error in hue, saturation or brightness.

Thus the 520 can be used to match the outputs of two color cameras; to provide accurate measurements of color video-tape recorders (a very important, and growing, use); to check the performance of amplifiers at hundreds of signal-transmission points; to test TV receivers on the production line; and for many other uses where color-signal measurements are critically needed.

The 520's displays are of two kinds:

1. **Vectorial**—It displays transmitted hue and saturation, using the color-bar pattern sent by the studio during non-broadcasting time. If the signal is correctly sent, it will appear as a dot of light in the proper box.

2. **Waveform.** Luminance, or brightness, is displayed as a waveform. So is another signal, showing luminance **plus** hue and saturation information; this is the retransformed color signal just as it's presented to each of the CRT guns on your TV set. Thus, full information about each of the primary colors can be read at the push of a single button.

(The 526, which preceded the 520, did not have these waveform measurement capabilities.)

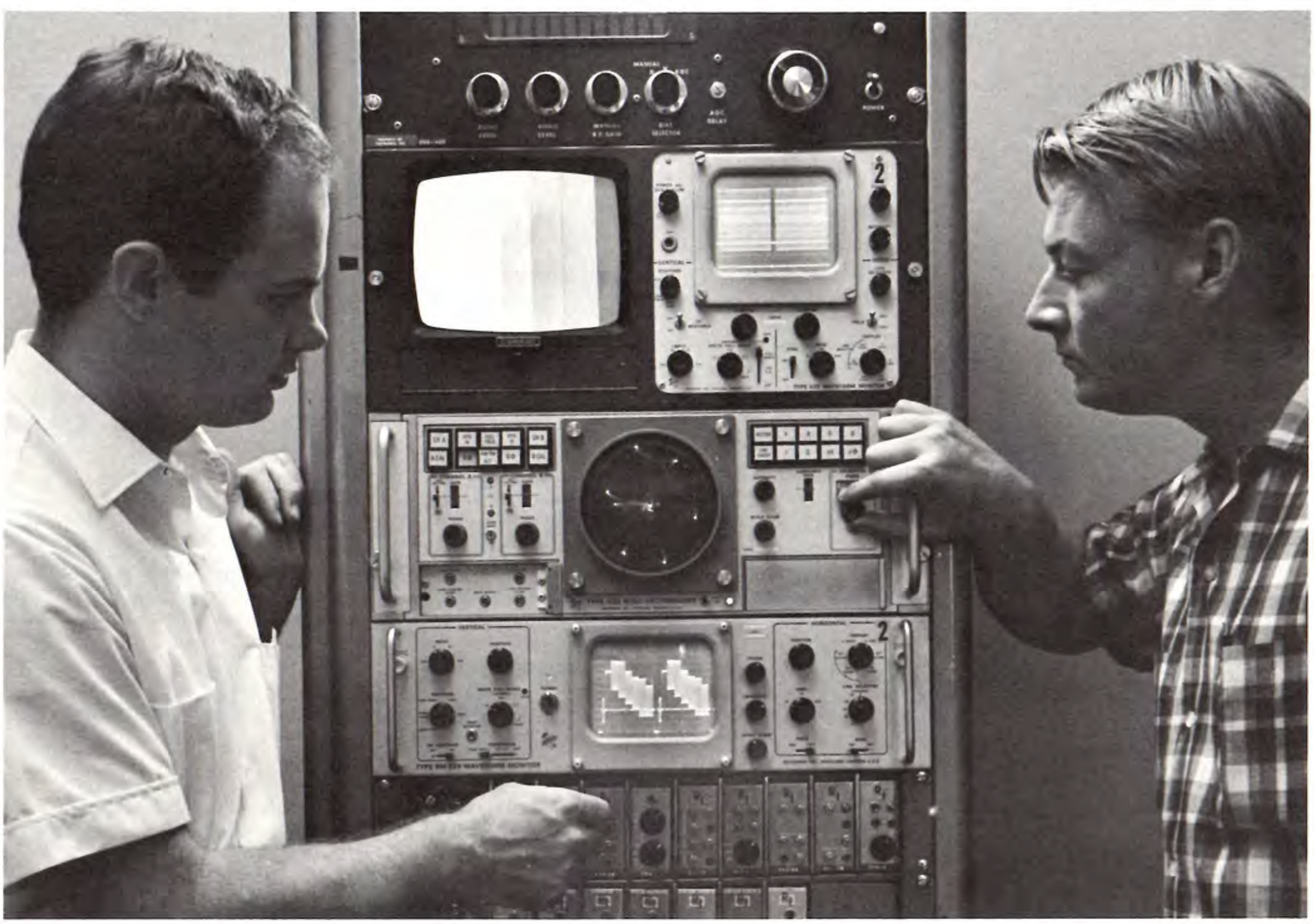
The 520, in addition to improved measurments and advances in customer engineering (push-buttons replace rotary knobs) is also all-solid-state, offering greater reliability and stability, and more performance in less space. The 520 comes in two models: One (the NTSC model) geared to measure color signals used in North America and Japan; the other (the PAL model) designed for color systems used in most of the rest of the Free World. Only the SECAM system in France and Russia cannot use vectorscopes.

When Tek built the first vectorscope in 1959, at Charlie's urging, color TV was no great shakes. Programming was meager, few color sets existed and color quality was inconsistent. Charlie felt that color video TV could go only one way—up—but it would need excellent measuring instruments to do so. The 526 was well ahead of its time, and quickly outdistanced what there was in the way of competition—mostly expensive, bulky and crude instruments, used for color research. It's no exaggeration to say that the vectorscope market has belonged to Tektronix ever since.

If there had been no vectorscope, it is true that quality color TV would have been impossible? Maybe.

But this much is sure: Without them, you'd hear a lot more color-set owners swearing.

STEVE A. ROTH (left) and Stan Tate display compact exhibit of current Tektronix television instruments. Pictured with a gray-scale brightness test pattern on a television picture monitor are our type 529 cabinet version (top right) with two-field display; type 520 (center) with vector display of luminance and chrominance; and type 529 rackmount, with two-line display.



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