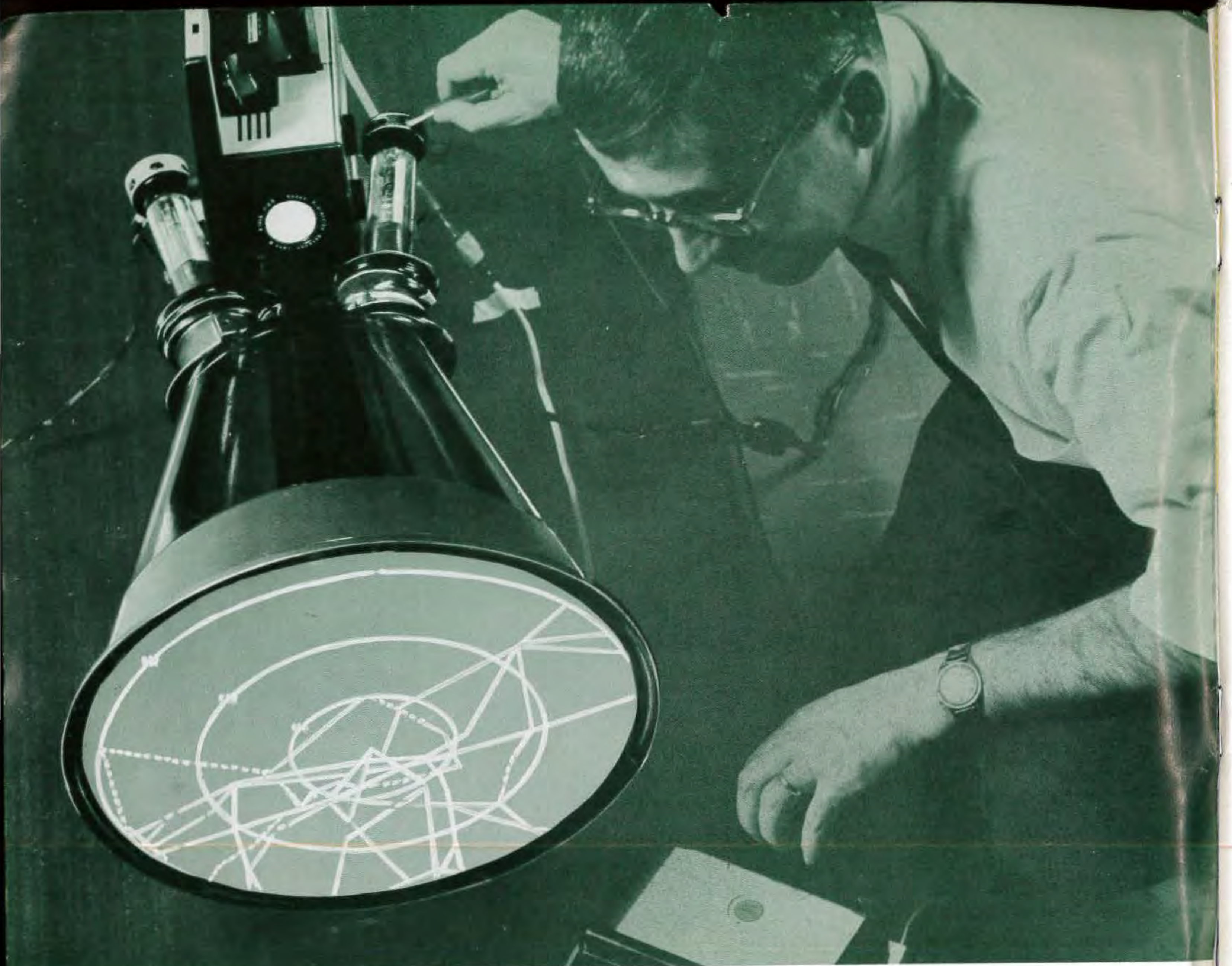
Volume 5 Number 3 May/June 1968

Information Display

Journal of the Society for Information Display



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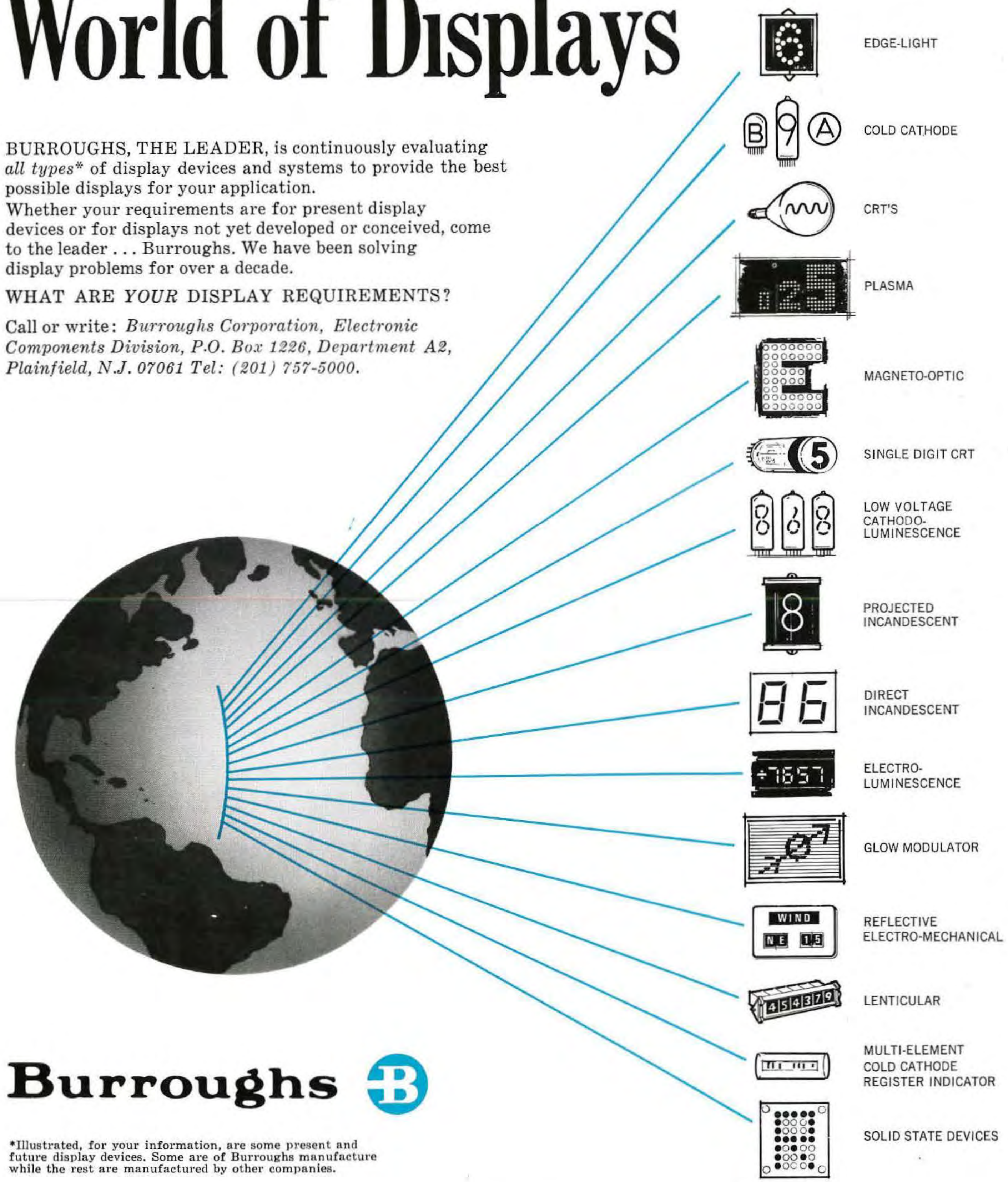

Burroughs

*Illustrated, for your information, are some present and future display devices. Some are of Burroughs manufacture while the rest are manufactured by other companies.

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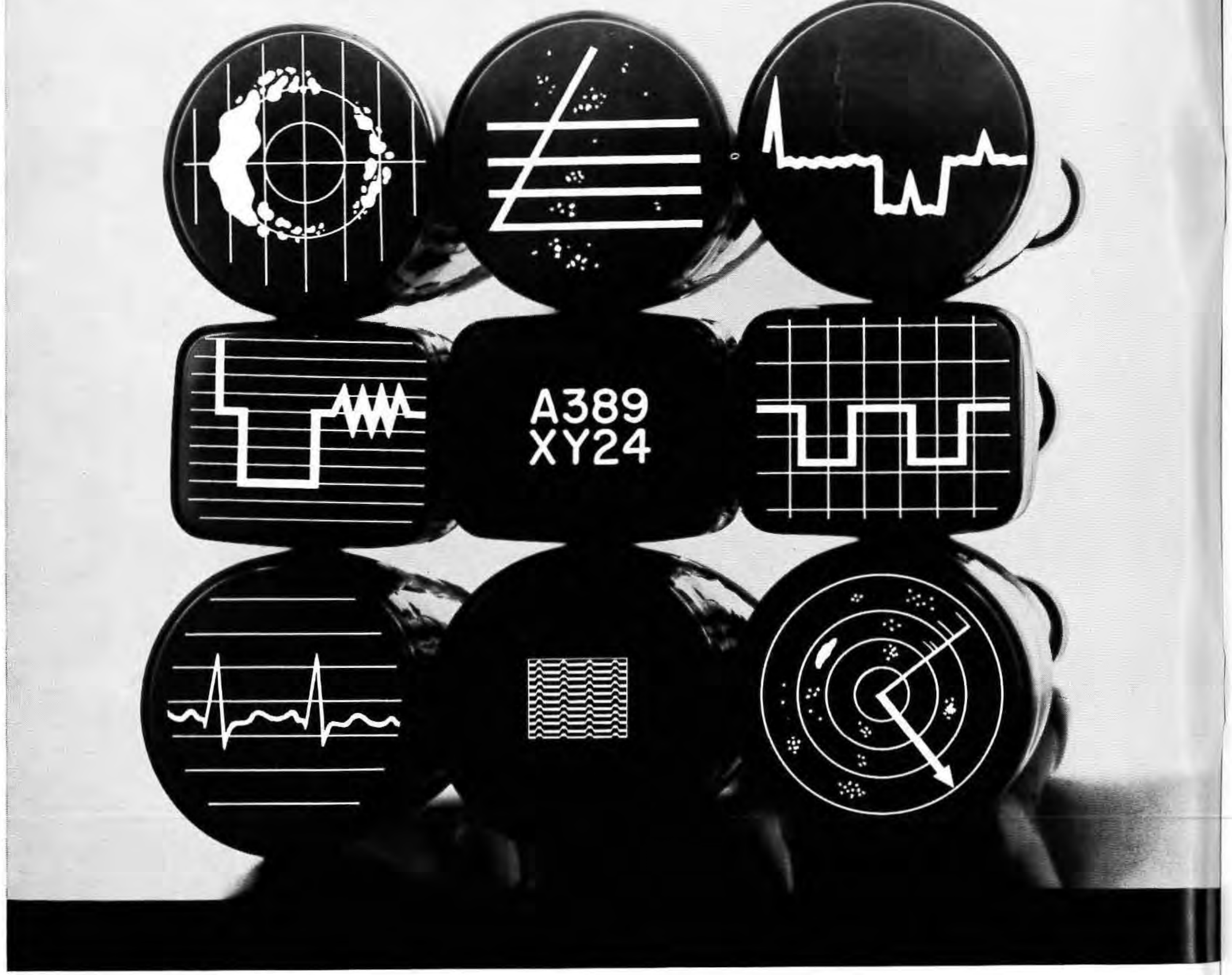

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Volume 5 Number 3 *May/June 1968*

Information Display

Journal of the Society for Information Display

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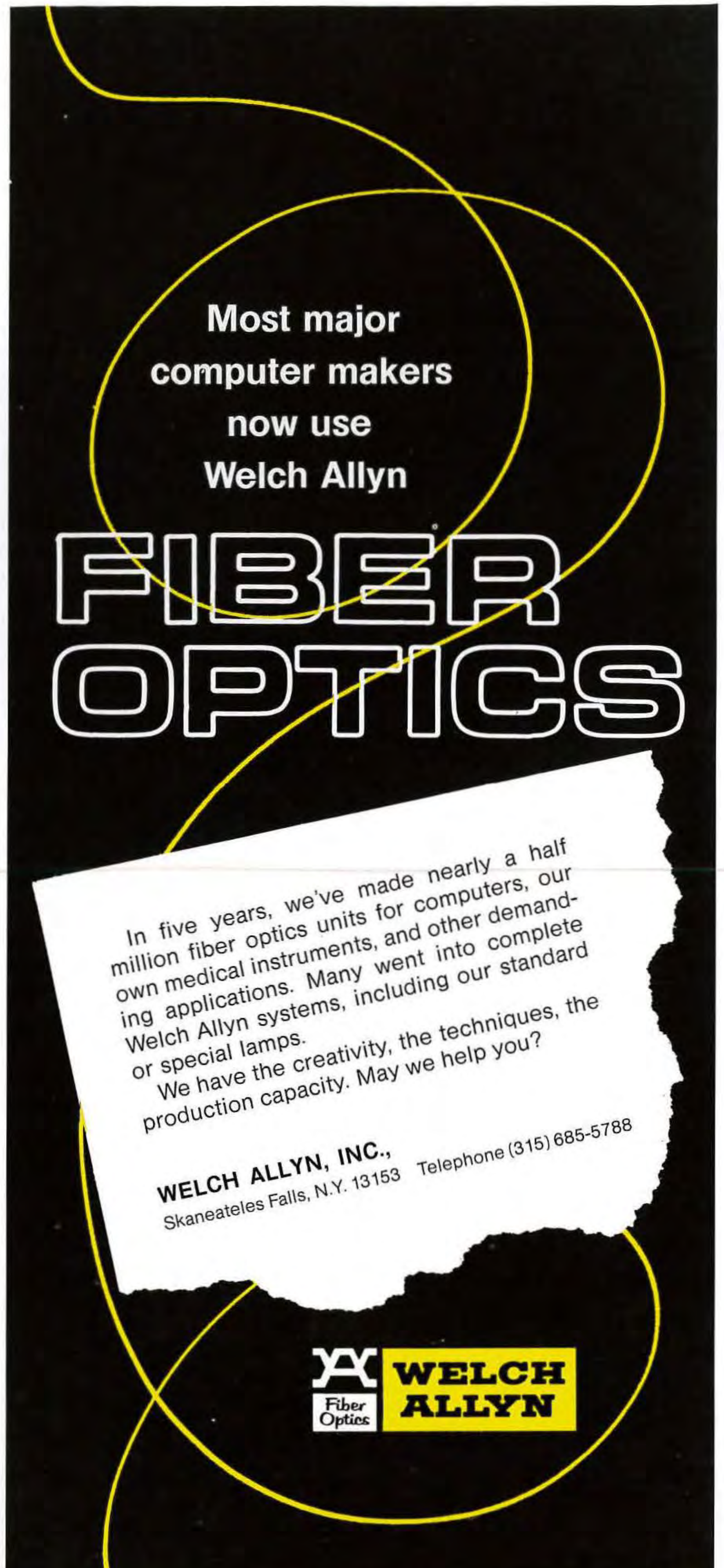
INFO 68 — Set against a background of Midtown Los Angeles, 9th National SID Symposium headquarters, James Belcher's graphic logo, depicting information display's basic symbols: the eye, and its information storage bank, the brain. Painting by John Desatoff, TRW Systems, Redondo Beach, Calif.



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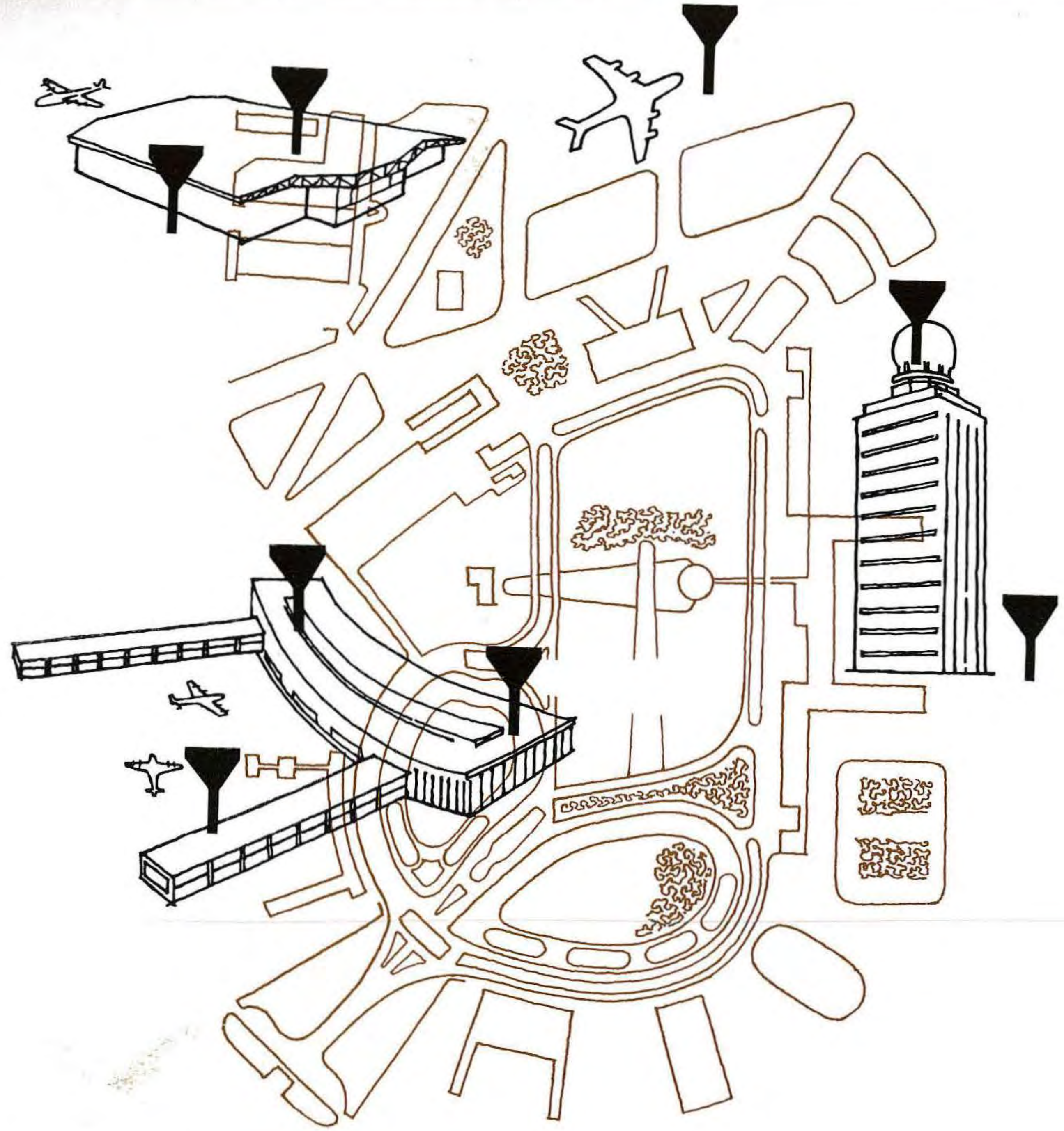

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For further information on avionic CRTS or for tubes in computer, medical electronics, oscilloscope or any other display or recording applications, write or call.

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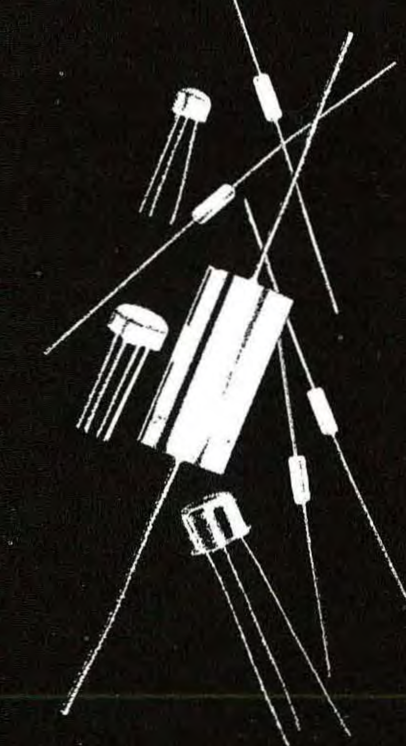

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Data Display Devices from Raytheon

New Raytheon Recording Storage Tubes extend your system capabilities

Two new miniature types, new high resolution tube added to Raytheon's broad line.

Raytheon's wide range of Recording Storage Tubes enable you to design additional capability into any system which stores and transfers electronic information. Applications include: scan conversion, stop motion, integration for signal-to-noise improvement, time delay or phase shift, correlation and slow-down video.

The new miniature types—Raytheon's CK1516 and CK1519—are designed for compact packaging, such as in airborne and space satellite applications. Both tubes provide high resolution and erase capability in a fraction of a second. The CK1521 is a new standard type featuring ultra-high resolution of 2500 TV lines and fast erasure in milliseconds.

Raytheon Recording Storage Tubes are electronic input-output devices which feature: fast write, immediate and nondestructive read, long storage, high resolution, and fast erase. Information can be written and stored using sequential scan techniques or by random access writing. Erasure can be complete or selective. Dual and single gun types are available.

For more information or demonstrations, contact your Raytheon Regional Sales Office.

New Raytheon Projectoray* Tube produces more than double the light output of standard projection-type cathode ray tubes. The tube's light output is 30,000 foot lamberts, which results in a light level of 15-foot lamberts on a 3′ x 4′ lenticular screen.

The tube's expected minimum operating life is 500 hours—20 times the life of a standard projection tube.

The Projectoray's high light output and long life are due to its novel design. The design incorporates liquid cooling of the phosphor backplate. This allows the phosphor to be energized with a very intense electron beam. At high beam levels, very high peak light output is obtained. The light image is projected through a 5″ optical window in the face of the tube. The electron gun is set at an angle to the phosphor and the deflection system compensates for keystone effects.

Datavue* Side-View Tubes. New Type CK8650, with numerals close to the front, permits wide-angle viewing. These side-view, in-line visual readout tubes display single numerals 0 through 9 or preselected symbols such as + and − signs. Their ⅝″-high characters are easily read from a distance of 30 feet. Less than $5 each in 500 lots, they also cost less to use because the bezel and filter assembly can be eliminated and because their mating sockets are inexpensive.

Symbolray* CRT Tube. The new Raytheon CK1414 Symbolray tube provides alphanumeric inputs for computer readout devices. The tube's 2″ target can be scanned electronically to select symbols, characters, and punctuation marks in sequence to form the readout on a display tube. This type has applications with data processing equipment as an economical method for generating characters for hard copy print-out or for cathode ray display. Design with 64 and 100 characters are available.

Dataray* Cathode Ray Tubes. Raytheon makes a wide range of industrial CRTs—including special types—in screen sizes from 7″ to 24″. Electrostatic, magnetic, and combination deflection types are available for writing alphanumeric characters while raster scanning. All standard phosphors are available and specific design requirements can be met. Combination deflection or "diddle plate" types include CK1395P (24″ rectangular tube), CK1400P (21″ rectangular), and CK1406P (17″ rectangular).

For literature, call your Raytheon regional sales office. Or write to *Raytheon Company, Components Division, Quincy, Mass. 02169.*

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RAYTHEON

New keyboard switches. These keyboard switches—an original Raytheon design—are low cost yet extremely reliable. They are ideal for computer input/output devices, learning and business machines, and other advanced information and control equipment.

Just a featherlight (2½-oz.) touch activates the switch, providing momentary contact at a current rating of 0.25A, 32V.dc. Life expectancy of the dry reed type is more than 100 million cycles. Bounce is less than 250 microseconds. Yet, these switches cost less than $1 in production quantities.

The contact pins snap into 0.125″ PC board, locking the switch firmly in place for automatic flow soldering—thereby reducing assembly time and costs.

All switches are made of high-quality materials: polycarbonate plastic, stainless steel, beryllium, copper and noble metals. Bases can be flat or sloped to a 10° angle.

These switches are available with a wide range of standard and custom cap shapes, sizes, colors and alphanumerics. The caps are hot die stamped, cured and backed with an epoxy coating to provide wear resistance and reduced glare.

Raytheon key switches are available in single- and double-level dry reed types and in single- and double-level wipe-action types.

Complete, custom-made keyboards—using the switches described above—are also available from Raytheon. These keyboards can be designed, built and shipped to you in minimum lead time. All assemblies are supplied with alphanumerics, symbols and coding to your specifications. They are also available with data lines, electronic interlock, connector to external power sources, and with or without case.

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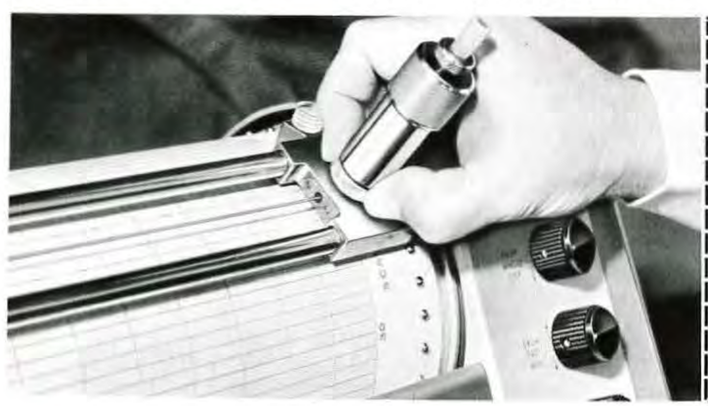

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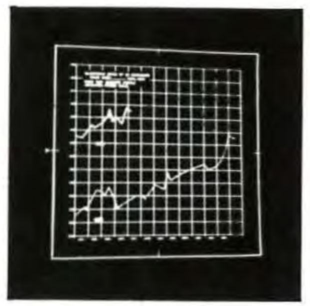

Actual photos taken of 7 foot by 7 foot display screen.

Actual photos taken of 7 foot by 7 foot display screen.

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Windows are of non-glare type in a choice of colors.

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To arrange to borrow a Dialight demonstrator unit, write us on your company letterhead.

For copy of our current catalog, circle reader service number below. Dialight Corporation, 60 Stewart Ave., Brooklyn, N. Y. 11237. (212) 497-7600.

DIALIGHT

$3.99 each (less lamps) in 1000 lot quantities

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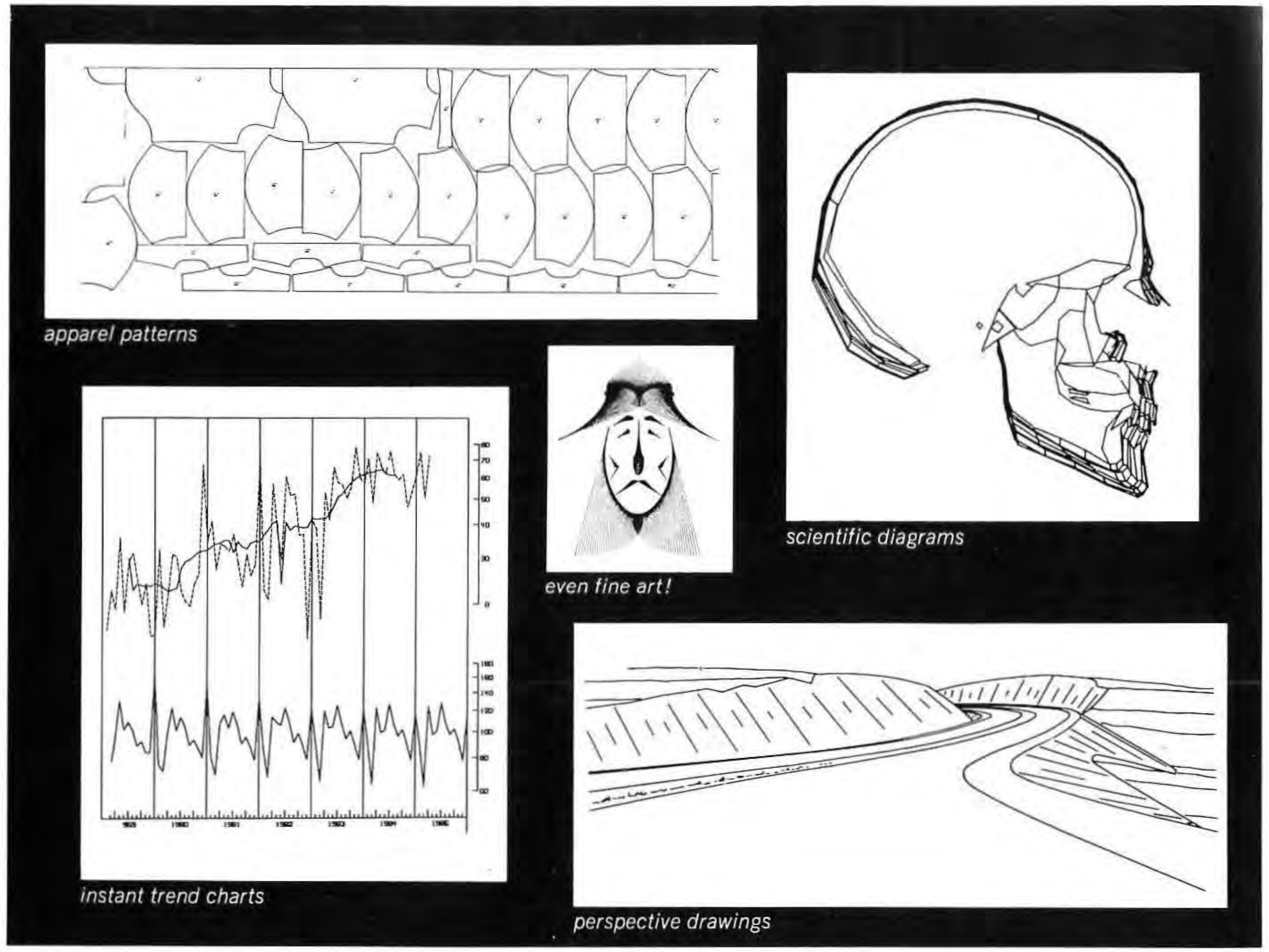
Do you know what it takes to make *your* computer draw like this?



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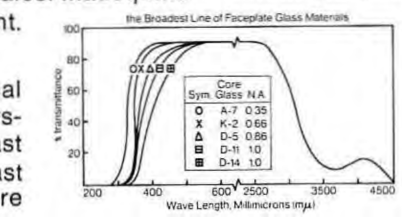


Typical* spectral response of various Bendix faceplate glass types; transmission measurements taken at 1/4" thickness (core glass)

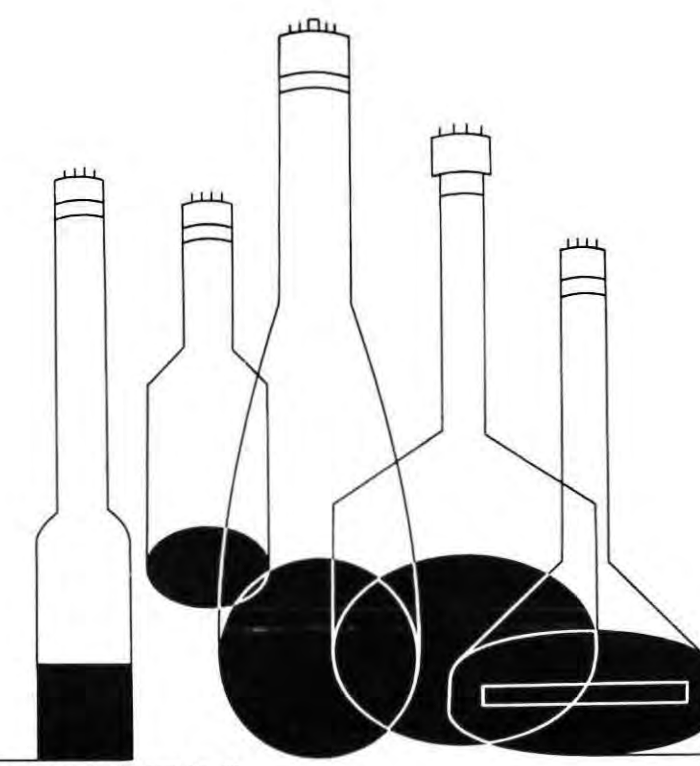
*Actual spectral transmission will vary with tube design, photo-cathodes and phosphors used, plate thickness, contrast, and fiber packing fraction.

Tube designers using Bendix fiber optics have changed the CRT industry! Now let us help you develop your prototype for the optimum in transmission, resolution and contrast, in any configuration, in any size up to 12" (larger sizes are available on special order). Cost? Not as much as you think!

There's a new light on the face of CRT's . . . and Bendix has put it there!

Write for a copy of the "Fiber Optics Handbook" and complete data on Faceplates. Bendix — Mosaic Fabrications Division, Galileo Park, Sturbridge, Mass. 01518. TEL: 617 / 347-9191. TWX: 710 / 347-1190.

See Bendix at "INFO '68", Booth No. 14, May 22-24, Ambassador Hotel, Los Angeles, California



Bendix

Electronics

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Typical Communications Keyboard
Shown Below: Typical Data Preparation Keyboard

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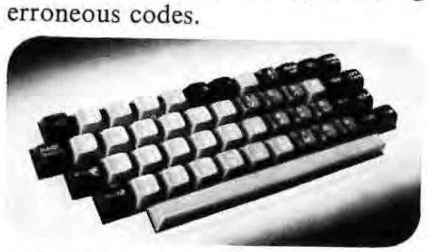

But that's not all. Coming very soon is Happening No. 2. Through advanced design concepts, complete engineering facilities, innovative assembly techniques, and unique quality assurance procedures, MICRO SWITCH is preparing to supply your every keyboard need. This means new reliability and flexibility in mass-production quantities with attractive customized appearance giving new sales appeal to your equipment.

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WIDE RANGE OF INDUCTANCES

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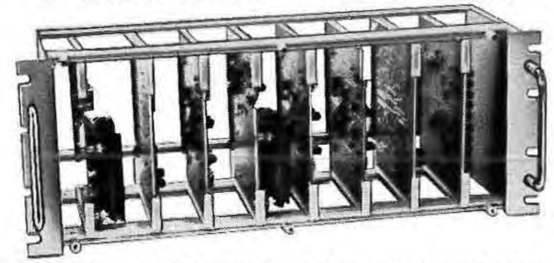

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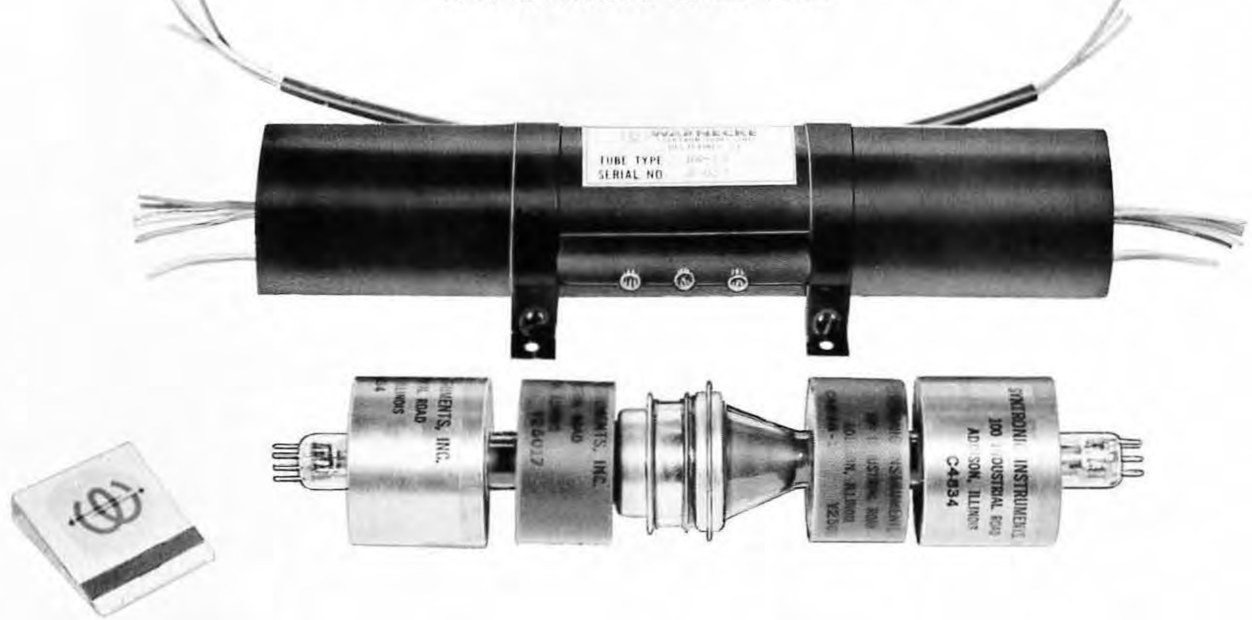

PACKAGED MINIATURE AND SUBMINIATURE SCAN CONVERTER TUBES
FOR MULTI-SENSOR DATA STORAGE AND PROCESSING

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Small size has been achieved without sacrificing resolution. The RW-5EM resolves 1200 TV lines and the RW-13 resolves 840 TV lines, at 50% relative output amplitude for orthogonal writing and reading.

The storage surface is of the EBIC type, and information can be stored indefinitely until readout. Readout time can be custom tailored from a single scan to several thousand depending upon the application.

The tubes feature a capability for quick erase of all stored information, or erasure of selected information.

Magnetic focus guns have been designed to eliminate the need for dynamic focus.

TYPICAL PACKAGED SIZE AND WEIGHT

RW-5EM	13⅜" long x 3" dia.	6 lbs.
RW-13	10" long x 2" dia.	2¾ lbs.

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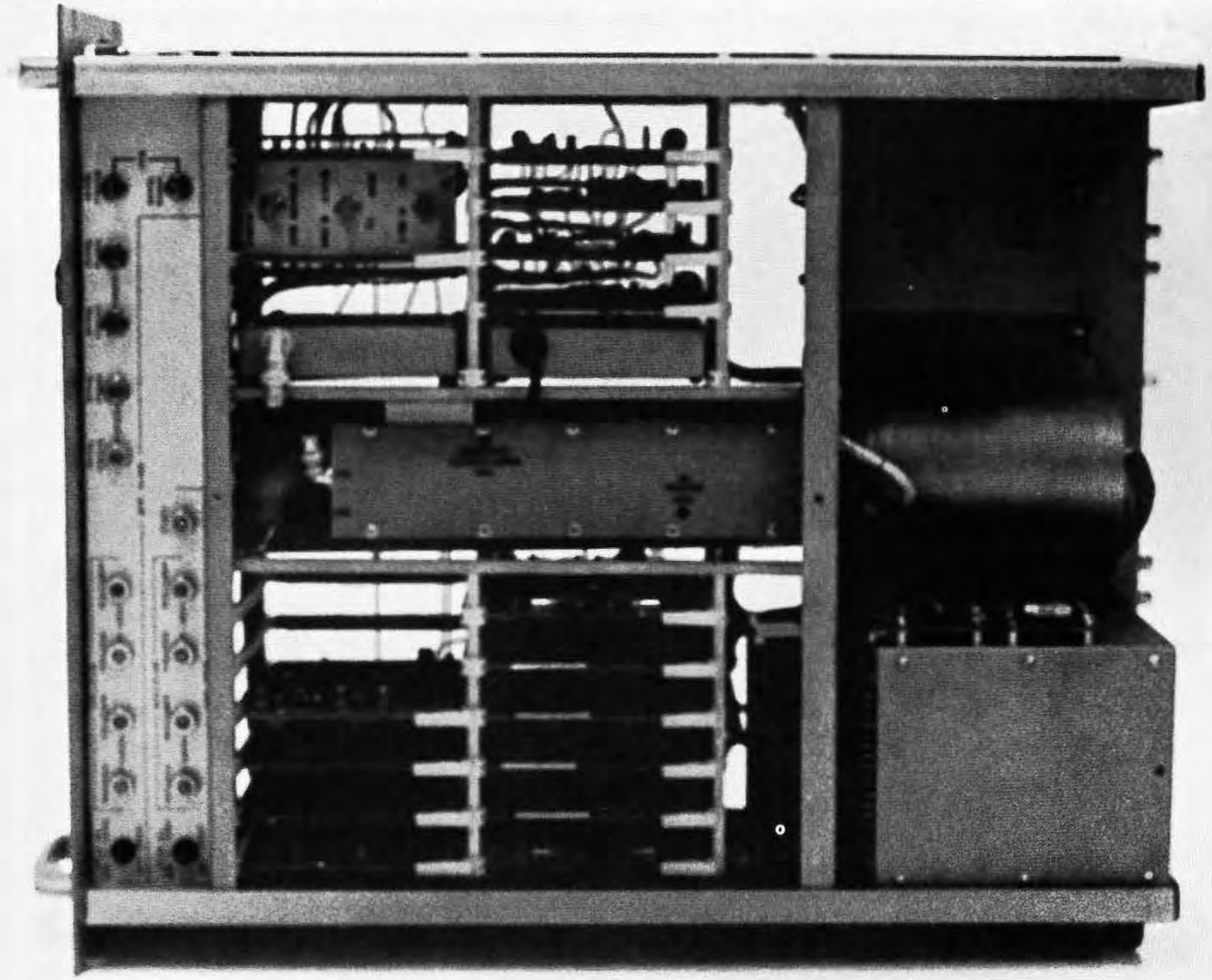

The strong box.

And its key.

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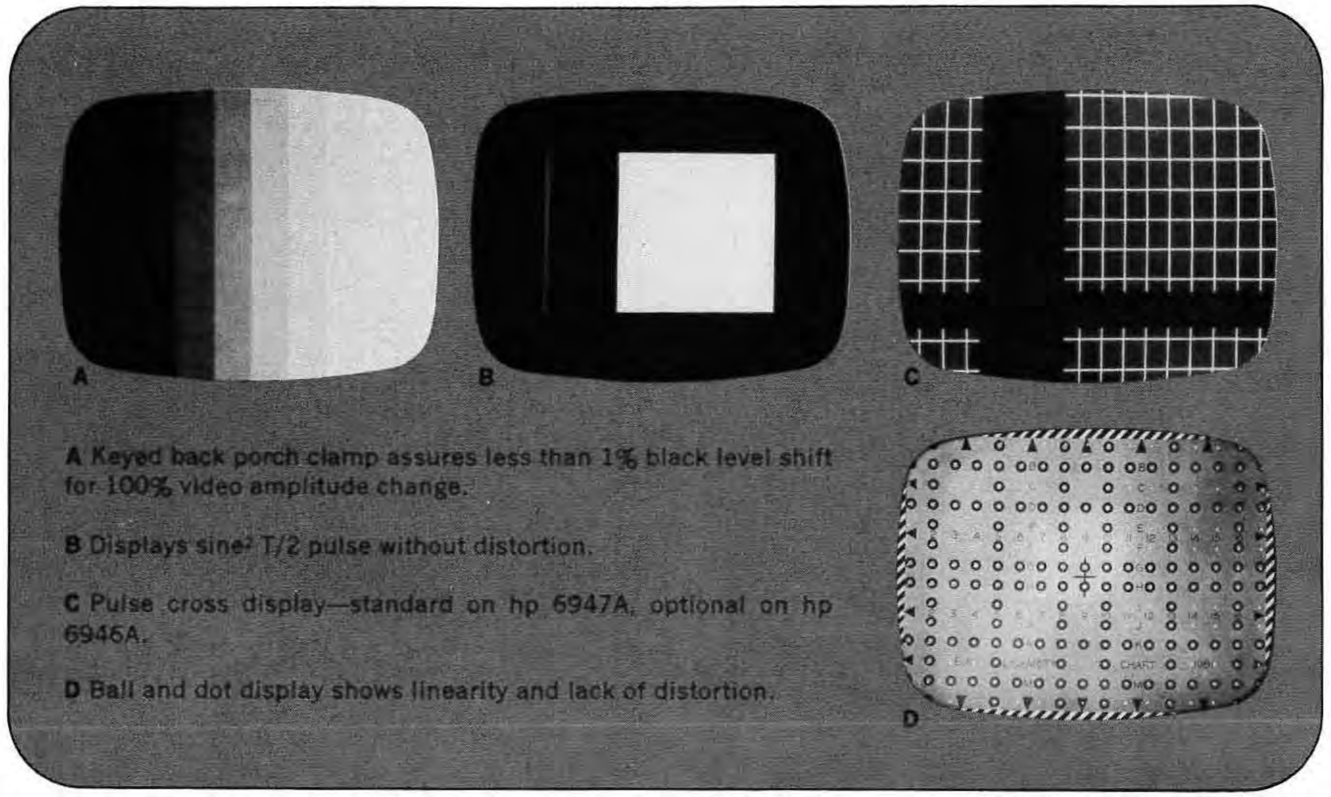

A Keyed back porch clamp assures less than 1% black level shift for 100% video amplitude change.

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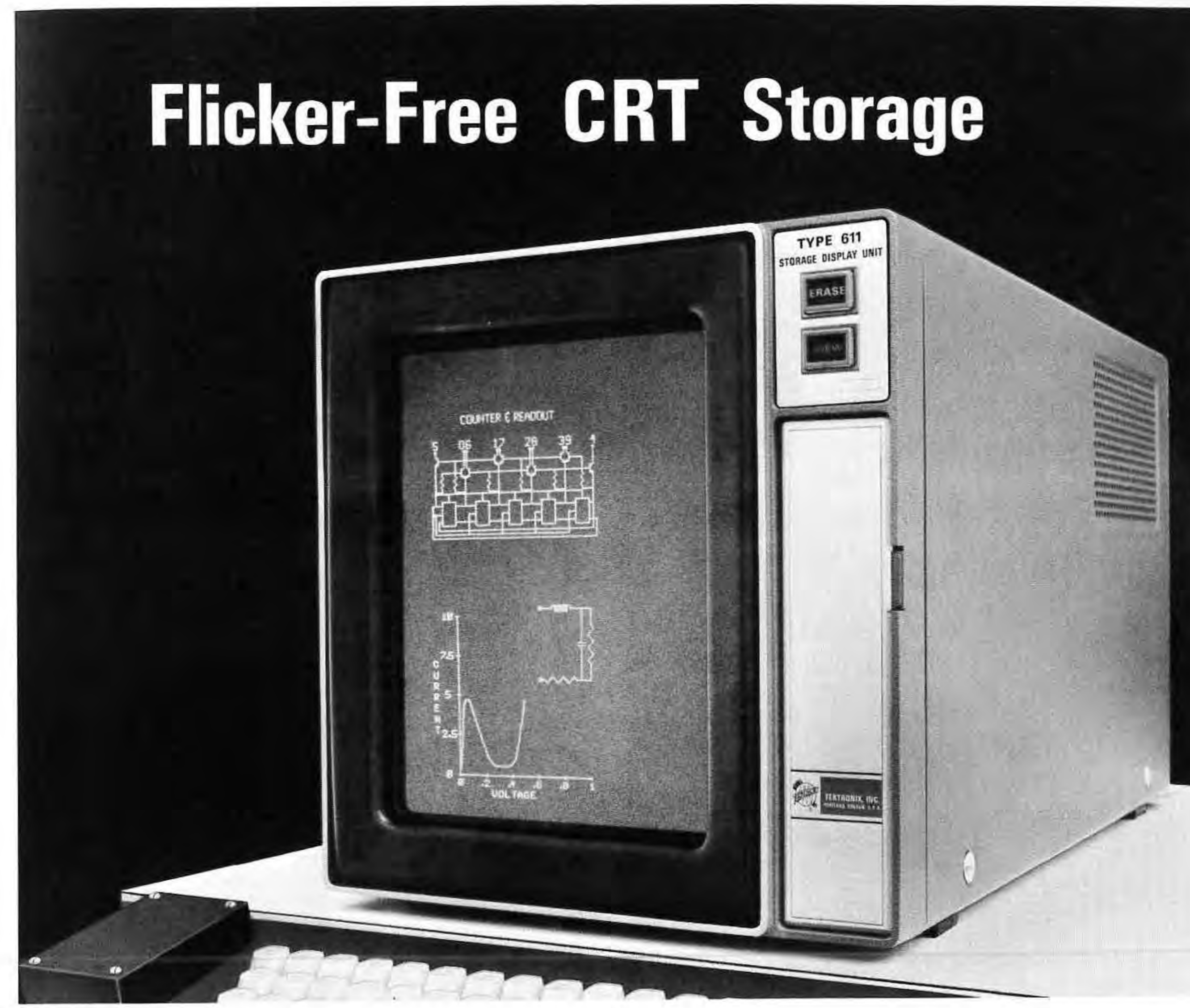

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EDITORIAL

It's your society

The *Society for Information Display* has passed its fifth birthday; I am sure it will see many more. However, unless we see much wider participation in policy determination and in activities at both National and Chapter levels, I believe *SID* is destined to mediocrity. We must substitute "how can I help make it better" for "what can I get out of it?"

The Society was conceived in 1962, and organized and incorporated the following year. During the five years following its founding, *SID* has greatly increased its membership, with nine chapters throughout the nation. We are installing our sixth president, along with his staff of officers and directors. From the modest start of the *SID Newsletter* and the *SID Readout*, we have developed a fine journal, *Information Display*. We have held numerous technical meetings, and are currently conducting our ninth National Symposium on Information Display, 'Info '68. We have contributed significantly to programs of national meetings and conferences of other professional societies and groups. Without question, our various activities have contributed to the fields of information display, and because of them we have earned the respect of the professional community and of industry and government.

However, our accomplishments are the result of dedicated and tireless efforts of the few. The vast majority of our members seem to be content to sit back and let someone else do the job. They want to reap whatever harvest there is, but they are too occupied otherwise to participate fully and to share effort and knowledge for the benefit of the whole.

Our governing officers and the more active members have done a splendid job, but they need your help. We need new ideas and we need more manpower to carry out our plans. Furthermore, as the *SID* continues to grow, we must shoulder more responsibilities. The help of all is essential if we are to meet adequately and effectively the challenges before us.

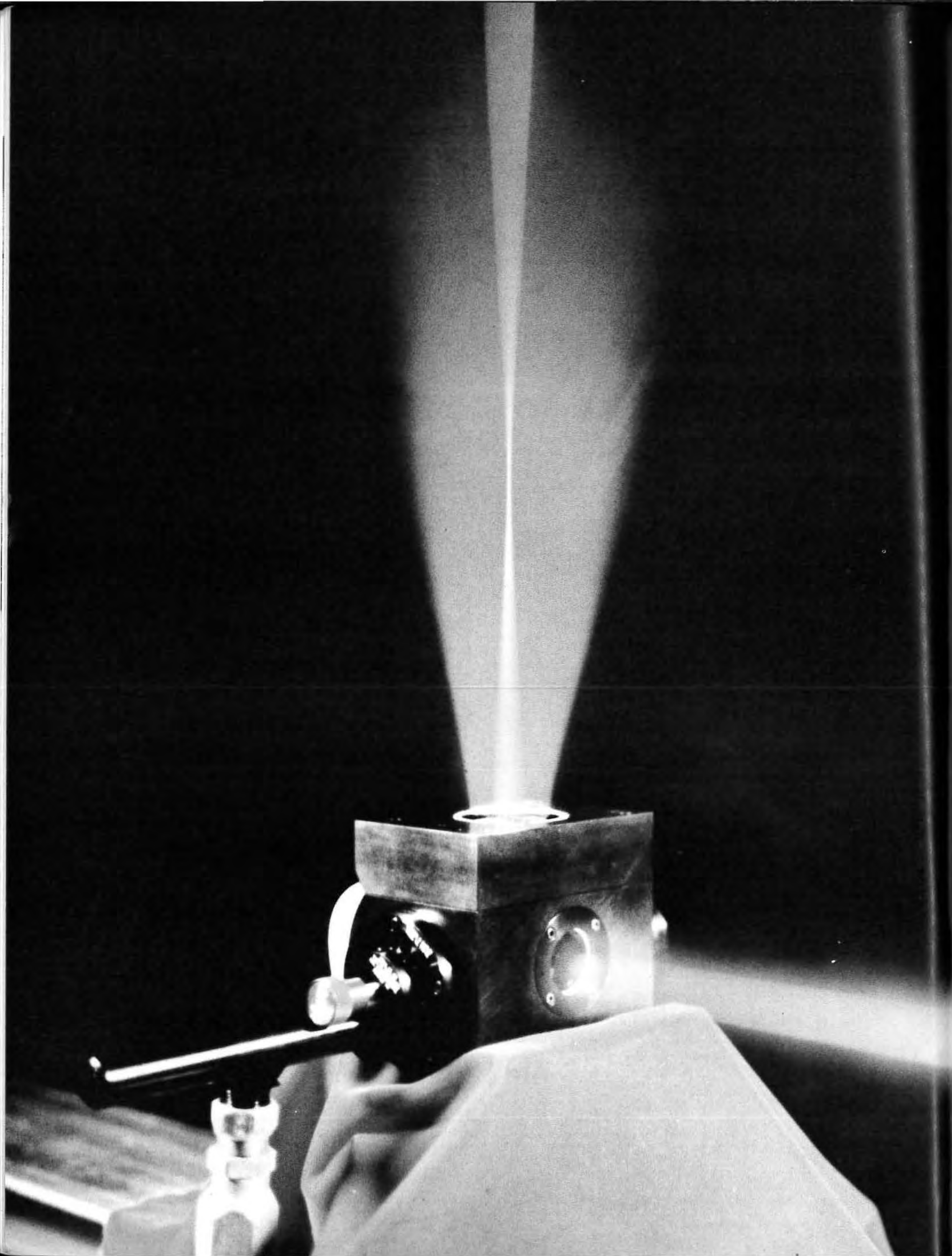
How can you participate more? I suggest: attend your local meetings and take part; share your knowledge through presentations and papers offered for publication in *Information Display*; take an active part in the nominating procedures for national and local officers and directors; take an active role in proposing members for honors and awards; give your initiative to suggesting plans and programs of the Society; require your directors to do their jobs and to respond to the desires of the membership. All of these things are possible. Let's also open the doors of a two-way communication channel that can and will make *SID* the society we all want it to be.

To ensure effective communications, I suggest that our journal carry the agenda of prospective meetings of the Board of Directors, and that it carry frequent and periodic reports of committee activities, especially those regarding plans and policy considerations. In these ways members can be better informed during formulative stages of our activities.

One often finds he cannot devote the time necessary to perform all functions demanded of officers and directors. It appears to me that in such cases the individual must give way to someone else. Things do come up unexpectedly, and one can easily become over-committed. However, our leadership must not be permitted to lower its standards. It must keep up on the move forward. The efforts must be total.

I congratulate *SID* for its accomplishments, and I congratulate its leadership and members for the tremendous progress made in so short a time. At the same time, I urge all of us to take stock. Should any of us find that he has been riding and not giving his full measure to the task of pulling an oar, then, let him change his ways so he can personally take far more pride in what we will have done.

JAMES H. HOWARD
Chairman,
Honors and Awards Committee



The technology of
information display
rises to new heights
as lasers come
of age

Laser display seminar

Previously understood by only a small minority, laser applications are developing rapidly, as research explores future potentials and possibilities. Eight distinguished scientists meet to discuss the current state of laser display art and new directions for research

Laser display seminar

A Laser Display Seminar was held April 10, 1968, at the Sheraton-Tenney Inn, New York. Sponsored by the Mid-Atlantic Chapter of *SID*, in cooperation with the Optical Society of America, Greater New York Section, the Seminar brought together a distinguished panel of authorities in Laser Science and Applied Technology. Purpose of the Seminar was to establish definitive statements on the present state of Laser Display art, the remaining major problems, and the directions for new research. The general subject matter included: Human Factors and Needs for Laser Display; Technology Limitations; Research Directions and New Advances, and Future Potentials. Detailed subject matter included: Laser Sources; Laser Power Requirements; Systematic Power Losses; Laser Deflection Techniques; Laser Modulation Techniques; Non-Scanned, Holographic and Reactive Displays; Holographic Image Transmission; Spectral Requirements (for color and monochrome); Coherence Requirements and Consequences; Coherent Speckle and Techniques for its elimination; Consequences of Lack of Light Storage, and Safety Considerations.

Panel Members included the following renowned experts:

FROM EDUCATION AND BASIC RESEARCH:

DR. DENNIS GABOR, Staff Scientist, CBS Laboratories, and Prof. Emeritus of Imperial College of Science and Technology, London, England.

PROF. W. R. BENNETT, JR., Director of Laser Research, Department of Physics and Applied Science, Yale University.

FROM INDUSTRIAL AND APPLIED RESEARCH:

DR. ROBERT ADLER, Vice President, Director of Research, Zenith Radio Corporation.

DR. LAWRENCE K. ANDERSON, Department Head, Optical Memories and Ultrasonics, Bell Telephone Laboratories.

MR. CHARLES BAKER, Manager, Opto-Electronic Systems, Texas Instruments, Inc.

MR. VERNON FOWLER, Manager, Optical Devices and Display Group, General Telephone and Electronics Laboratories.

DR. ROBERT V. POLE, Manager, Optical Physics Group, IBM Thomas Watson Research Laboratories.

MODERATOR:

LEO BEISER, Staff Physicist, CBS Laboratories, and Chairman, Mid-Atlantic Chapter *SID*.

Although renowned in many research activities, each Panelist represented major areas of interest as follows:

Dennis Gabor: Information Theory, Holography, Coherent Processing, Human Factors.

W. R. Bennett: Laser Theory, Basic and Applied Laser Research.

Robert Adler: Bragg Diffraction, Coherent Physics, Commercial and Human Factors.

Lawrence Anderson: Materials Research, Solid State Lasers, Bragg Diffraction.

Vernon Fowler: Laser Deflection, Laser Modulation, Color Considerations.

Robert Pole: Scanlaser, Wide Aperture Lasers, Reactive Processing.

Information Display herewith presents, in near-verbatim form, the complete proceedings of the Laser Display Seminar.

MR. BEISER: Greetings—On behalf of the *Society for Information Display*, Mid-Atlantic Chapter, and with the welcome cooperation of the Greater New York Section of the Optical Society of America, we are pleased to offer you this opportunity to exchange ideas with our distinguished team of experts—on a subject of rapidly growing interest throughout our community—Laser Information Displays. Before this afternoon is over, we hope you will have established a firm basis for the why and how of Laser Display—from the laser as a component to the human factors in the system.

The Seminar will consist of four parts:

The Introductions consist of brief statements by each Panelist regarding his fields of activity and recent advances in his spheres of interest.

The second part, Panel Discussions, will be a rather free interchange of ideas among the Panelists and Moderator. Thus, we have provided a rare forum for the panelists themselves to air their apprehensions in a spontaneous exchange of opinion and fact.

After a coffee break, we will open the third part for Audience Discussions. We will be responsive to a generally spontaneous array of questions and ideas from you, the audience.

Finally, during Conclusions, the panel will summarize the salient features of our program.

Let us take a look at the main subject—the Laser—a subject which may easily be overwhelmed by the desire for its application.

With understanding of the fundamentals of the Laser, we can appreciate the why and wherefore of its great utility in this field.

Most of us are familiar with the laser, and many participated in our orientation programs on the laser conducted at CBS Laboratories on January 18, 1967, and our field trip to Prof. Bennett's laser laboratories at Yale University the following week. Thus, I shall not dwell on the things that should be familiar to us all.

That the laser generally requires an amplifying medium in a resonant structure; that standing waves are set up in the resonator and maintained during excitation or pumping of the amplifying medium.

That the useful radiation which is permitted to escape from one end of the resonator is almost perfectly coherent—near-monochromatic for each "line" selected; that the intensity and beam collimation may be extremely high although the absolute efficiency of most lasers is extremely low.

We know, too, that the most popular C-W sources are the gaseous lasers, because of their available energy level transitions in the visible region, their excellent spectral purity and wavefront uniformity. They are, for all practical purposes, diffraction-limited. That is, resolution determined only by the wavelength of radiation and the size of the optical aperture.

We know that a good selection of wavelengths is available in the visible, as demonstrated, for example, during our field trip to GT&E on September 13, 1967, and by Charles Baker at T.I. Although Dr. Adler's demonstration of Zenith's very efficient TV display was monochrome, the aspects of color laser TV generation have been carefully considered by himself and his team of researchers. Thus, color, for human consumption, may be quite acceptable if spectral range were the only criterion. Many more requirements will be discussed later which may not be so acceptable.

Let us concentrate on the gas lasers, since they are now the most adaptable to our needs.

In general, the power *inside* the laser resonator is many times more intense than the power drawn from the laser. But the gain, per pass, within the resonator is so low (a few percent) that insertion of components within the cavity for information handling is seriously hampered by excessive optical loss. Dr. Robert Pole has contributed much in this technology and will surely advise of progress in this field.

There are, of course, good reasons why gas lasers act as they do, in particular, regarding electron energy level separation, and hence regarding spectral or color characteristics. Equally important to us are the limitations on power output due to limited total population inversion, hence limited gain per pass (with a given resonator loss and saturation of the laser medium). Prof. Bennett has continued to contribute most significantly to this research since his co-invention of the gas laser in 1961, and will surely be called upon to foresee the future in spectral output, power output and efficiency.

The gaseous laser may be divided into three groups: neutral atom, ion, and molecular gas lasers.

The distinctions between these three groups is very pronounced in power output and spectral characteristics. The neutral atom laser typically provides relatively low power output, and, except for the one most important transition in the visible, HeNe @ 6328Å, it is almost completely confined to radiation in the infrared. The ion lasers, however, cover the visible spectrum very well. And, endowed with higher gain, the ion laser provides at least an order of magnitude more power in the strong lines as compared to the neutral atom laser. Compare, for example, the argon-ion laser power to that of the HeNe laser. The molecular gas lasers provide the greatest power output—hundreds and perhaps thousands of watts—but as demonstrated by the powerful CO_2 laser at 10.6 microns only in the infrared.

Of the solid state lasers, the Nd/YAG laser which radiates CW @ 1.06 microns has been frequency-doubled at Bell Labs with a barium-sodium-niobate crystal to 0.53 micron radiation—an excellent green. Surely, progress on this important source of radiation need be reported here by Dr. Anderson of Bell Labs.

There are, of course, other lasing media; gases, liquids and solids—and a startling large number has been shown theoretically and experimentally to exhibit lasing transitions.

Let us look toward the future; the adaptation of this exciting new light source to information display—as initiated by many pioneers—in particular, by our panel team today. With the advent of the laser, for example, Dr. Gabor's invention of holography introduced a whole new vista of laser display technology which continues to inspire the attention of some of the world's most creative minds.

We'd better understand the fundamental workings of the laser before we are overwhelmed by desire for its use—*Leo Beiser*.

Thus, let us begin to explore expert opinion in this entire new field of Lasers for Information Display.

Dr. Dennis Gabor, could you start us off, please.

DR. GABOR: Ladies and gentlemen, I am honored to be invited to give you the opening words.

I am somewhat embarrassed by the honor of giving the introductory talk to this Laser Display Seminar, because the laser owes nothing to me, but I owe a lot to the laser.

It was the invention of the laser which put holography on the map from 1962 onwards, in the skillful hands of the teams in the University of Michigan.

What distinguishes the laser from all natural sources is not so much the enormous spectral purity, and therefore high coherence, as the large power and the controllability of emission. The power in a laser focus has the highest density, exceeding, for short times, even electron beams and far exceeding nuclear explosions. The laser focus can be made to a diameter of a wavelength, and this has recently enabled a U.S. firm to produce a tape with laser punched holes and an information density of 100,000 bits/cm. The electric field strength in a laser focus can be 100,000 volts/cm and can produce a microscopic plane with the record density of 10^{18} and 10^{19} elements/cm^2.

The achievements of lasers need not obscure the sober fact that laser pulses contain only energies of a few joules and CW

I owe a lot to the laser; it put holography on the map—*Dennis Gabor*.

lasers have light outputs of only a few watts. Also that, with the exception of the CO_2 laser, they are very inefficient light sources. Moreover, that while these lasers reasonably cover the visible spectrum, we have as yet no solid laser with blue light—it can now be produced only by frequency doubling. These are gaps which may probably, but not certainly, be filled by further research.

But what remains is still a formidible field.

Pioneering work has been done on scanning by laser beams, competing with and sometimes exceeding the performance of cathode ray tubes.

And optical stores have been developed with information densities far exceeding those of solid state electronics and also those of magnetic stores.

We shall hear of all these, and of many other developments straight from the pioneers, themselves.

I am eagerly looking forward to the many exciting things which they will have to say.

MR. BEISER: Thank you very much, Dr. Gabor. Dr. Adler, please.

DR. ADLER: Leo Beiser is responsible for the sequence of speakers at this meeting. And this wasn't meant to be shock treatment. But the transition from basic to applied research has probably never been as clear as here, and you will see the differences between the topics of Dr. Gabor and my own.

What I want to do in these few minutes is to report to you on the recent progress in laser TV displays which use acoustic light deflection. This technique is capable of producing respectable resolution (Fig. 1). Let me briefly recapitulate what has already been published, and then give you the present state of the art.

Acoustic Bragg diffraction of light is illustrated in Fig. 2. It is possible to deflect all the incident light into a new direction, and that direction is changed by changing the acoustic frequency f. The total scan angle is therefore proportional to the acoustic frequency swing Δf. We can focus the light beam into a smaller spot if the beam is wider to begin with; resolution therefore increases with the width of the light beam or with the time τ required for the sound wave to travel across the beam, and one finds that the number of resolvable points is equal to the product $\tau \Delta f$.

There is an important difference between TV displays and devices which require random access. If points follow each other at random, τ may be no longer the access time; but with the linear scan used in TV, τ can be of any length. A practical limit is the horizontal blanking time, about 10 μsec. So, for a system with 400 resolvable points one needs about 40 MHz of acoustic frequency swing.

The experimental system published in fall 1966 used a Δf of 16 MHz. By stretching τ to 12.5 μsec, we obtained 200 resolvable points. This corresponds to a frequency response which is down to zero at 3 MHz. To obtain a display which is reasonably flat out to 4 MHz, one would like to have about twice the horizontal resolution of that earlier system.

The original deflection cells used water, a highly efficient interaction medium. Unfortunately, sound attenuation in liquids increases with the square of frequency. The cells worked over a 60% band centered at 27 MHz; at the upper limit of 35 MHz, sound attenuation was about 2.5 db per cm, or nearly 5 db across the width of the light beam. This was already more than it should have been. Other liquids do not seem to be better than water. We therefore looked at solids.

The laser is a latecomer; we ought to be a little bit humble about what we're trying to do—*Robert Adler*.

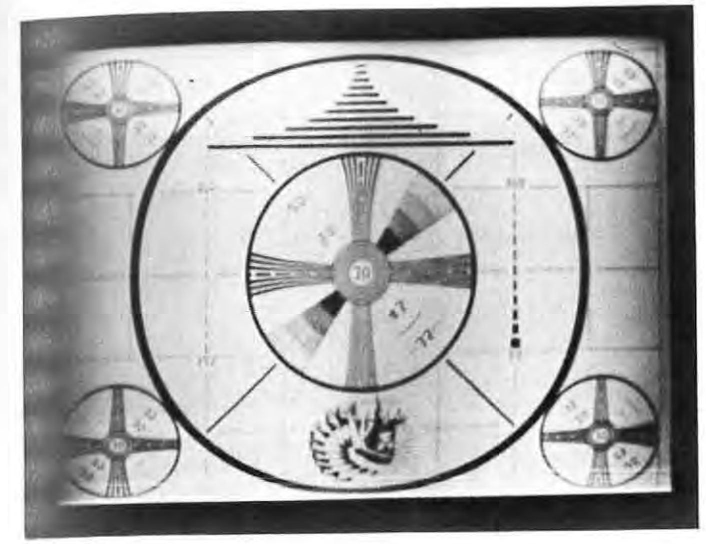


FIGURE 1

A good material should have high refractive index, low sound velocity and low attenuation for high-frequency sound. Figure 3 shows measured data for three heavy glasses selected from a long list. The figure of merit M is a measure of interaction efficiency relative to water; for a given cell geometry, materials with lower M require more acoustic power. Sound attenuation is given in db/cm at 60 MHz. We see that glass A is lossy and also has poor M; glass B has fairly low loss and better M, while C, with the best M, is again too lossy.

We have made experimental cells with glass B, for a frequency band from 45 to 75 MHz. About 2.5 watts of electrical input to the transducers is needed to deflect all the light. The low-frequency water cells require about 1 watt.

We have also experimented with an alternative—two water cells in cascade. Light deflected in the first cell is deflected again in the second. In practice, it seems better to use two separate sound beams in a single body of water in order to avoid unnecessary light reflections. Each sound beam is generated by a separate array of transducers; all transducers are driven from a common electrical source.

This arrangement provides twice the resolution obtainable with a single cell; the picture of Fig. I was taken this way.

One of the important features of ultrasonic deflection cells is what has come to be called acoustic beam steering. As the sound frequency changes during the scan, the sound beam continuously adjusts its direction so as to meet the incident light beam always at the correct angle. We have used phased arrays of small transducers to perform this function. The arrangement previously published (Fig. 4) consists of transducer elements alternately connected forward and backward, mounted on stair steps which provide stepped acoustic delays. This arrangement is quite adaptable; for instance, in the cascade arrangement just described the second sound beam must be steered over an agle three times as large as the first beam, and this is accomplished without difficulty. But it is rather costlv to cut precise steps into most materials, and the required precision increases at higher frequencies. On the other hand, small inductors and capacitors are quite inexpensive in the 50 to 100 MHz range, and it appears that a phased array made up of transducer elements mounted on a flat surface, with the required phase shifts provided by an electrical network, may be more economical. Such a network may also provide more accurate beam steering than the present array which rotates the sound beam by an angle proportional to —1/f, rather than proportional to f as it should. We are studying this alternative.

To sum up, it is now relatively easy to make monochrome pictures by means of ultrasonic light deflection, with all the resolution which the current U.S. television standards permit.

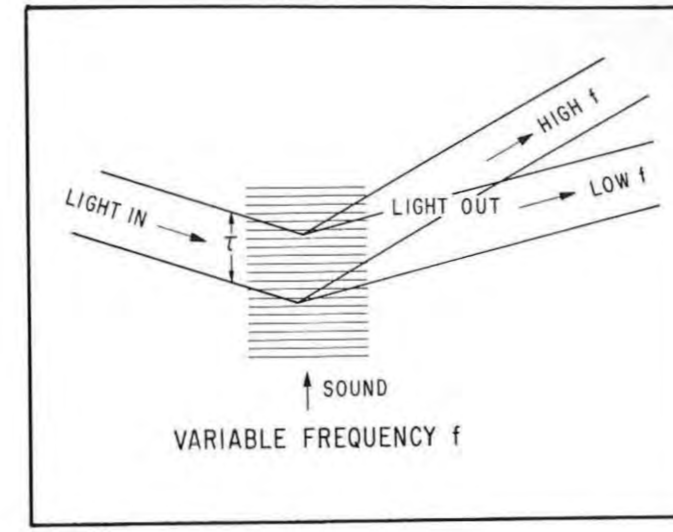


FIGURE 2

Type of Glass	A	B	C
n — refractive index	1.74	1.68	1.94
v — sound velocity m/sec	5500	3900	2900
M — figure of merit db re water	—23	—14.5	—12
a — sound attenuation (60 MHz) db/cm	2.6	0.8	5.8

FIGURE 3

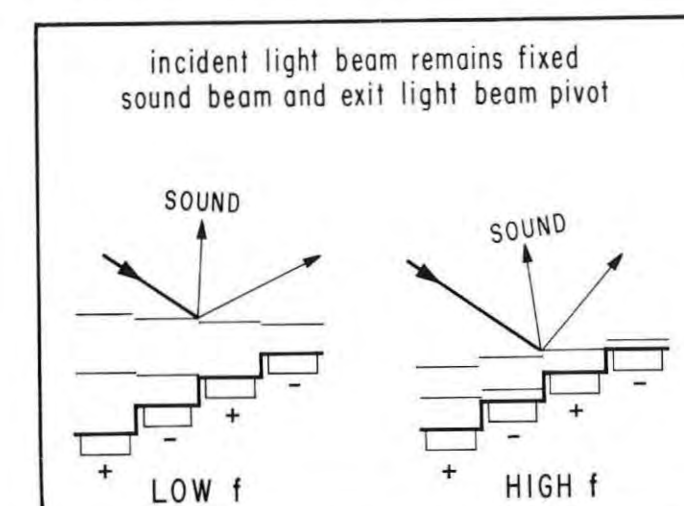


FIGURE 4

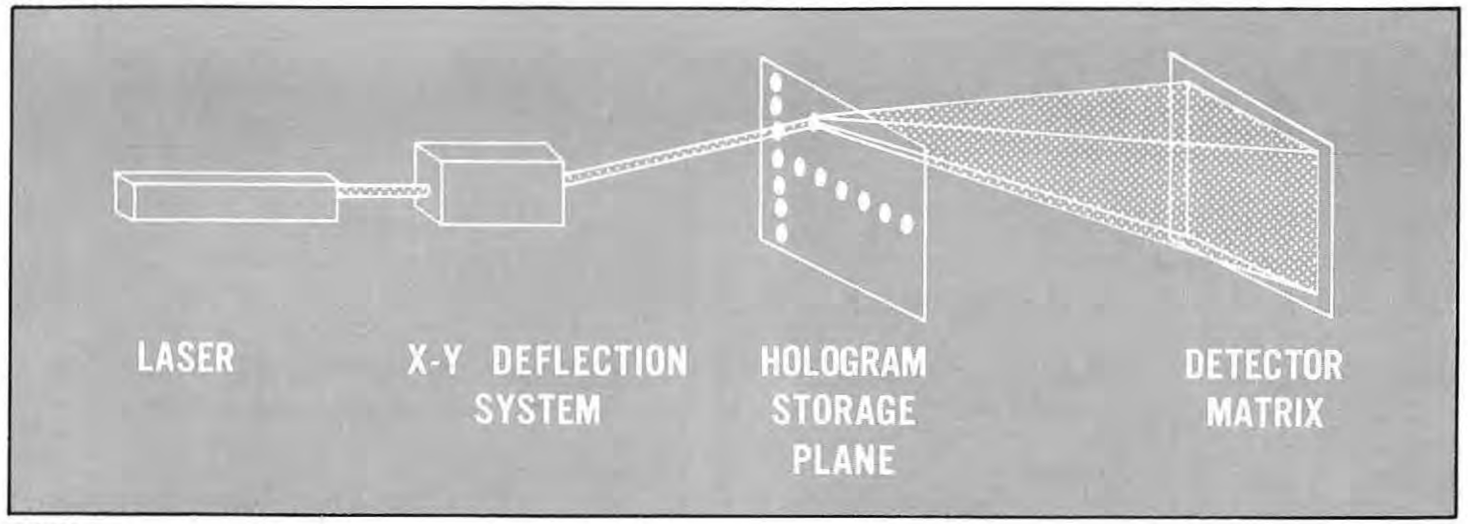


FIGURE 1

MR. BEISER: Thank you, Dr. Adler. Dr. Anderson, please.

DR. ANDERSON: Thank you, Mr. Beiser.

As Bob Adler pointed out in his introductory remarks, laser deflection systems tend to fall into two broad categories. The first is a relatively slow raster-scan type of display where high resolution, perhaps as high as 1,000 by 1,000 elements is required. The other is a high speed system where modest resolution can suffice, perhaps 100 by 100 fully resolved elements, but where random access to a single element must often be obtained within the cycle time of a computer processor, which might be of order 1 μs. It is within the framework of this latter deflection problem that my remarks principally will be made. An example of our interest in such a deflector is shown in Fig. 1, which is a block diagram of a high-capacity read-only holographic store. Here, a high speed randomly accessed XY deflection system deflects a beam from a laser to any one of a large number of holograms in a storage plane. Proper addressing of a given hologram by the laser beam results in the projection of its contents onto a detector matrix. To be most useful, such a memory system should contain at least 100 by 100 separate holograms. Then, if each hologram contains say 10,000 bits, the entire memory can have a capacity of 10^8 bits. The practicality of such a system depends on the availability of high average power lasers and high-speed random access deflectors.

Of the visible CW lasers currently available, the Nd-YAG laser with an intra-cavity barium sodium niobate frequency doubler seems to offer the best performance. At BTL, J. E. Geusic and his coworkers* have recently demonstrated one watt CW output at 5300 Å in the lowest order mode from such a laser. The configuration is shown in Fig. 2. The two mirrors are made 100% reflecting at 1.06 μ, the fundamental laser wavelength, and the doubler crystal, along with the laser rod, is placed inside this cavity. Since the only way out for the light is via harmonic generation, it is possible by correct design to critically load the cavity by the doubling process in such a way as to get, at 5300 Å, all of the power that would have been available from the laser at 1.06 μ. Since CW power outputs of 50 watts at 1.06 μ have been obtained from Nd-YAG lasers with 1% efficiency, the prospects for a practical high power CW source in the visible seem very good indeed.

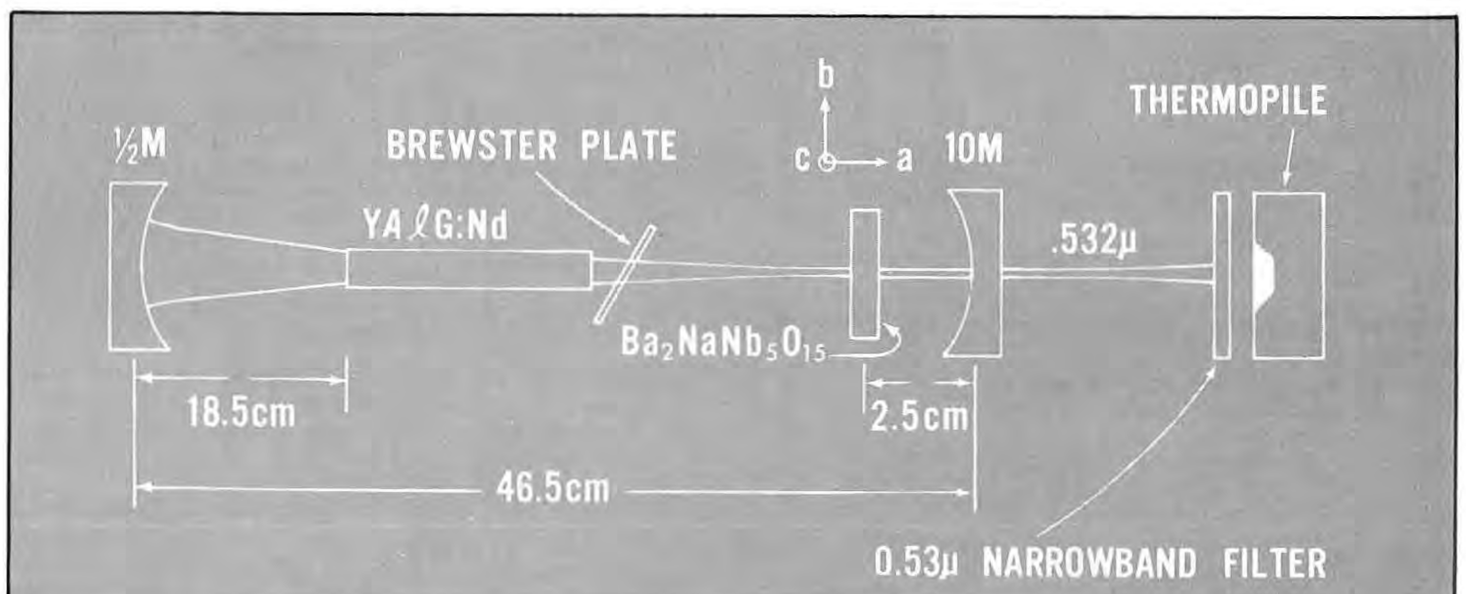


FIGURE 2

For the high speed deflection systems of interest to us, only the essentially inertialess electro-optic or acousto-optic interactions seem feasible. Here the crucial problem with either approach is one of material availability. The materials problem for a deflector is enormously greater than that for a simple amplitude modulator, since an amplitude modulator for coherent light can be restricted in volume until it passes only a single laser mode; however, a deflector which has, say, 100 by 100 resolvable spots has to pass 10^4 modes. The difference in the crystal volumes required is indicated in Fig. 3. The upper part of the figure shows a lithium niobate crystal for an experimental 100 spot 1 μs deflector. In the lower part of the figure is shown a lithium tantalate crystal used in a high speed optical PCM modulator.

FIGURE 3

The material properties of some of the interesting electro-optic materials are summarized in Table I in terms of a figure of merit

$$M = \frac{n}{kV_\pi^2}$$

which is inversely proportional to the drive energy required per resolvable spot. Here, n is the optical index, k the low frequency dielectric constant, and V_π the half-wave voltage. Notice that the differences in the figures of merit are not as great as the differences in the half-wave voltages, since a low half-wave voltage tends to be offset in part by a high dielectric constant.

Table II shows some properties of interesting acousto-optic materials in terms of a figure of merit

$$M = \frac{n^7p^2}{\rho v^2}$$

where p is the elasto-optic coefficient, ρ the density and v the sound velocity. This figure of merit in inversely proportional to the acoustic energy required per resolvable position to Bragg refract all of the light in an incident optical beam. Water is included as a deflector material in Table II because it is readily available and has a high figure of merit. However, its high acoustic losses make it unsuitable for use in a straightforward way in a high-speed deflector, since the required ultrasonic frequencies are very high, in the hundreds of MHz.

Of the solid materials which remain, then, one can see from Table II that the acousto-optic coefficients densities and sound velocities are all quite comparable. As a result, the best material tends to be the one with the highest index of refraction, especially since this enters the figure of merit to the seventh power.

In conclusion, Tables I and II show that materials with good figures of merit do exist, and a deflector made out of the best of either the acousto-optic or electro-optic materials could easily achieve a 100 by 100 resolution and a random access time of 1 μs with only a few watts of electrical drive power. Such deflectors, however, do not exist, simply because none of these "preferred" materials are available as sufficiently large samples with adequate optical quality. In fact, fully

*J. E. Geusic, et al., "Continuous 0.532 μ Solid State Source Using $Ba_2NaNb_5O_{15}$," submitted to Applied Physics Letters.

Figure of Merit: $M = \frac{n}{kV_\pi^2}$

Material	Useful Optical Wavelength Range (μm)	n	k	V_π volts	M $\times 10^{-8}$ volts^{-2}
$Sr_{.75}Ba_{.25}Nb_2O_6$	0.4 - 5	2.31	6000	37	28
$Ba_2NaNb_5O_{15}$	0.4 - 5	2.27	51	1570	18
$LiTaO_3$	0.45 - 5	2.18	43	2700	7.0
GaAs	1.0 - 15	3.37	11	10300	2.9*
KD*P	0.25 - 2.15	1.51	48	4000	2.0

*At λ = 1.06 μm. All others at 6328 Å.

TABLE I: Properties of Electro-optic materials

Figure of Merit: $M = \frac{n^7p^2}{\rho v^2}$

Material	Useful Optical Wavelength Range (μm)	n	p	ρ gm/cm³	v $\times 10^5$ cm/sec	M $\times 10^{-12}$ cm sec²/gm
GaAs	1.0 - 15	3.37	0.23	5.34	5.15	179*
GaP	0.6 - 10	3.31	0.188	4.13	6.32	93.4
H_2O	0.2 - 0.85	1.33	0.31	1.0	1.5	31.3
$LiNbO_3$	0.5 - 4.5	2.23	0.205	4.7	6.58	10.1
SiO_2	0.2 - 2.5	1.46	0.27	2.2	5.97	1.3

*At λ = 1.06 μm. All others at 6328 Å.

TABLE II: Properties of Acousto-Optic materials

A combination of research and sophisticated engineering will eventually lead to high speed deflectors —*Lawrence K. Anderson*

operational two dimensional deflectors have only been made using KD*P as an electro-optic medium or water as an acousto-optic medium. As a result, these deflectors either take far too much drive power (kilowatts for KD*P) or are too slow (10 μs for water). However, the optical quality of the remaining materials continues to improve, and a combination of progress on this front, together with more sophisticated engineering to minimize the aperture required, will eventually lead to practical high speed deflectors.

CHARLES E. BAKER: The very feature of the laser that makes its use in displays so attractive, that of spatial coherence, is also responsible for questions regarding the practicality of laser displays. A number of observers have commented on the characteristic speckle pattern produced by coherent light and there has been concern over the visual safety aspects of laser displays. The highly directional nature of coherent light, however, is essential to the design of efficient, wideband light modulators and high resolution light beam scanners.

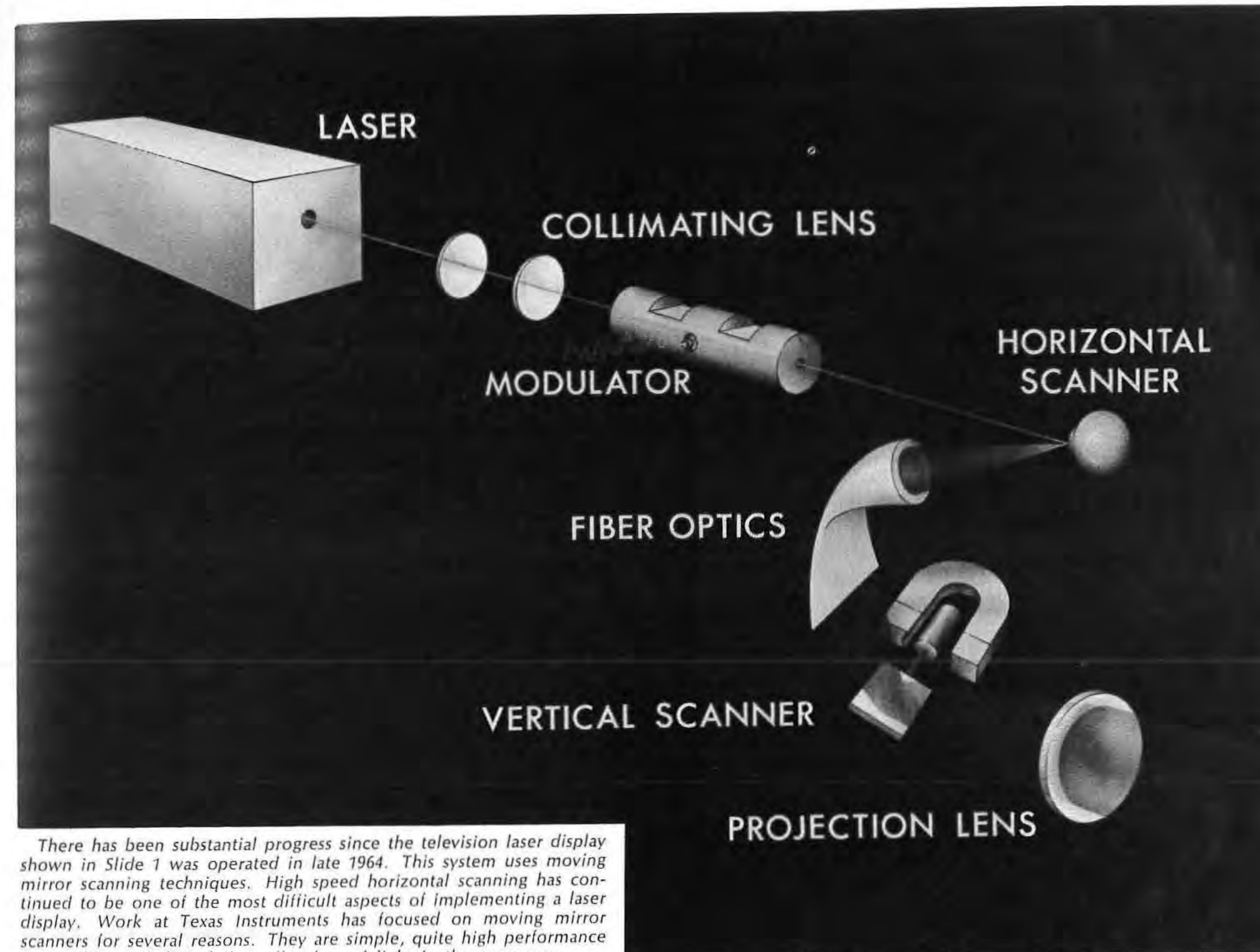
Many observers, when seeing a laser display for the first time, do not notice the image speckle since it has a much finer grain structure than the image being displayed. Even individuals who have spent considerable amounts of time observing laser displays do not find the speckle annoying unless they concentrate on it. In most installations, safety problems may be avoided by using a rear-projection screen with an enclosed projection path. Appropriate interlocks should also be provided to prevent anyone from placing their head between the laser and viewing screen while the laser is in operation. Scanning provides a certain amount of protection by reducing average power density and provisions should be made to turn off the laser in the event of scanner failure. Some types of light beam deflectors are fail-safe in that light can only reach the screen when the deflector is in operation. Conceivably, with the higher power lasers now becoming available, it would be possible for an undeflected beam to burn through some types of rear projection screens.

To keep the laser safety problem in proper perspective it should be pointed out that a CRT envelope is a potentially lethal weapon if handled improperly and there have been cases of spontaneous implosion. Another aspect is the high voltage required for CRT operation and the resultant danger of shock and x-rays.

Fortunately, a rather simple solution to the dual problems of laser safety and image speckle is available. It was noted that an early laser display system that utilized fiber optics in the horizontal scanner did not exhibit image speckle due to the coherence destroying nature of fiber optic light transmission. Speckle may be eliminated and brightness of the projected beam greatly reduced by forming an image on an intermediate, moving diffusing surface such as ground glass. A conventional projection lens may then be used to form the final image on either a front or rear-projection screen. The penalty that is paid is a small reduction in transmission efficiency and resolution.

It seems appropriate to begin any consideration of the future potential of laser display technology with an analysis of existing displays and their shortcomings. Cathode ray tubes will quite likely dominate the display field for a number of years to come. Technology for large screen displays is still in a state of evolution and no single approach has obtained a pre-emptory position. For color displays, a laser display offers the outstanding advantage of scanning a single variable color, variable intensity beam to create an image. This may be compared to the complexities of multiple projectors or a device such as the shadowmask CRT.

Speckle is easy to get rid of; just move the screen —*Charles Baker*



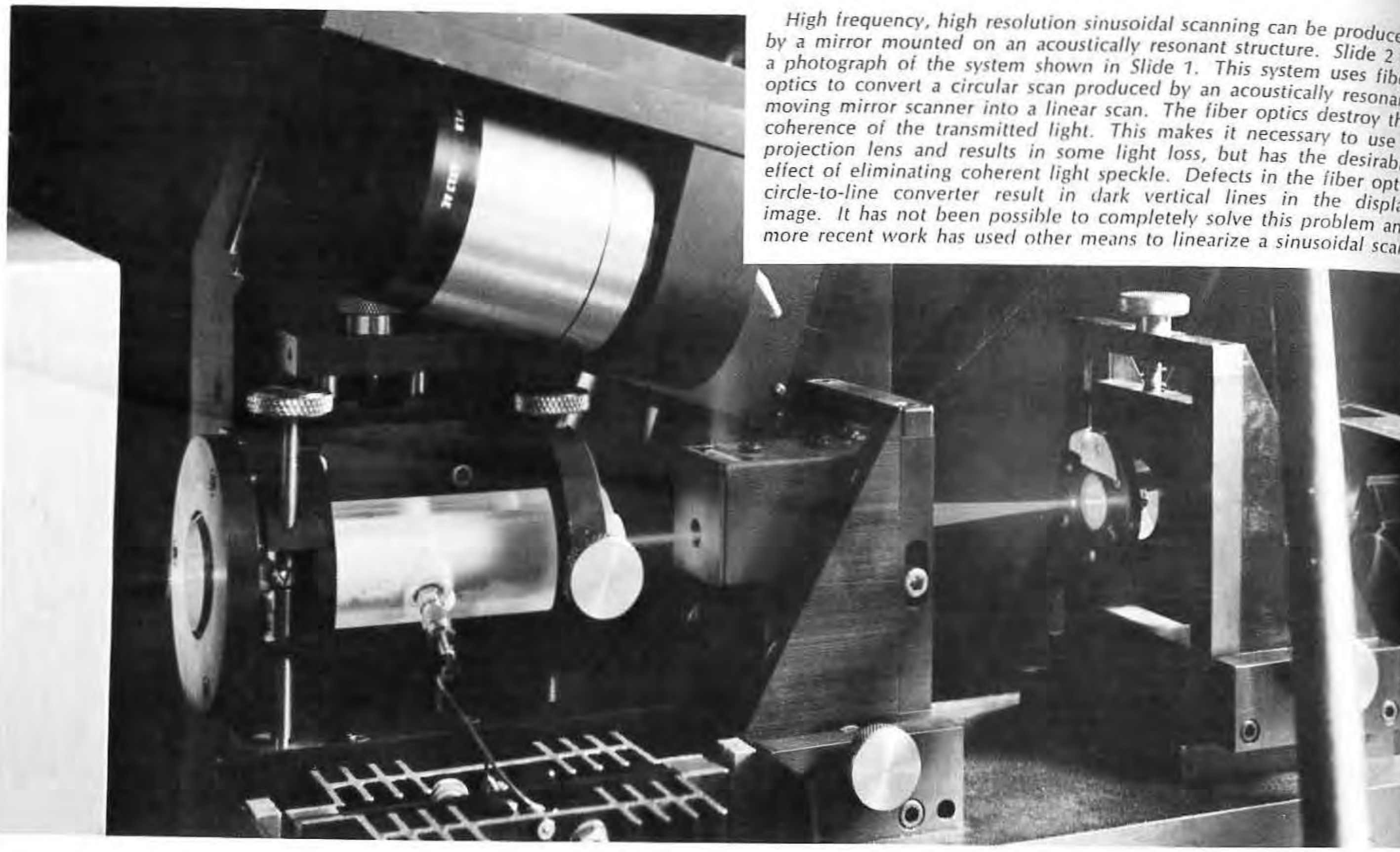
There has been substantial progress since the television laser display shown in Slide 1 was operated in late 1964. This system uses moving mirror scanning techniques. High speed horizontal scanning has continued to be one of the most difficult aspects of implementing a laser display. Work at Texas Instruments has focused on moving mirror scanners for several reasons. They are simple, quite high performance is possible, and they deflect all colors of light in the same way.

With one notable exception, the laser display systems that have been demonstrated have used a neon-helium or argon ion laser, electro-optic light modulators and moving mirror scanners. The use of moving parts is distasteful to many electronic engineers, but good image quality has been achieved by this means. Moving mirror scanners are also achromatic which simplifies the design of a color display. The various solid state scanners that are being developed are inherently dispersive in that they deflect different wavelengths of light by different amounts. Development of an intertialess scanner is mandatory, however, for stroke writing or randomly scanned displays. For raster scanned displays the inertia of a moving mirror scanner is even of some benefit in display stabilization.

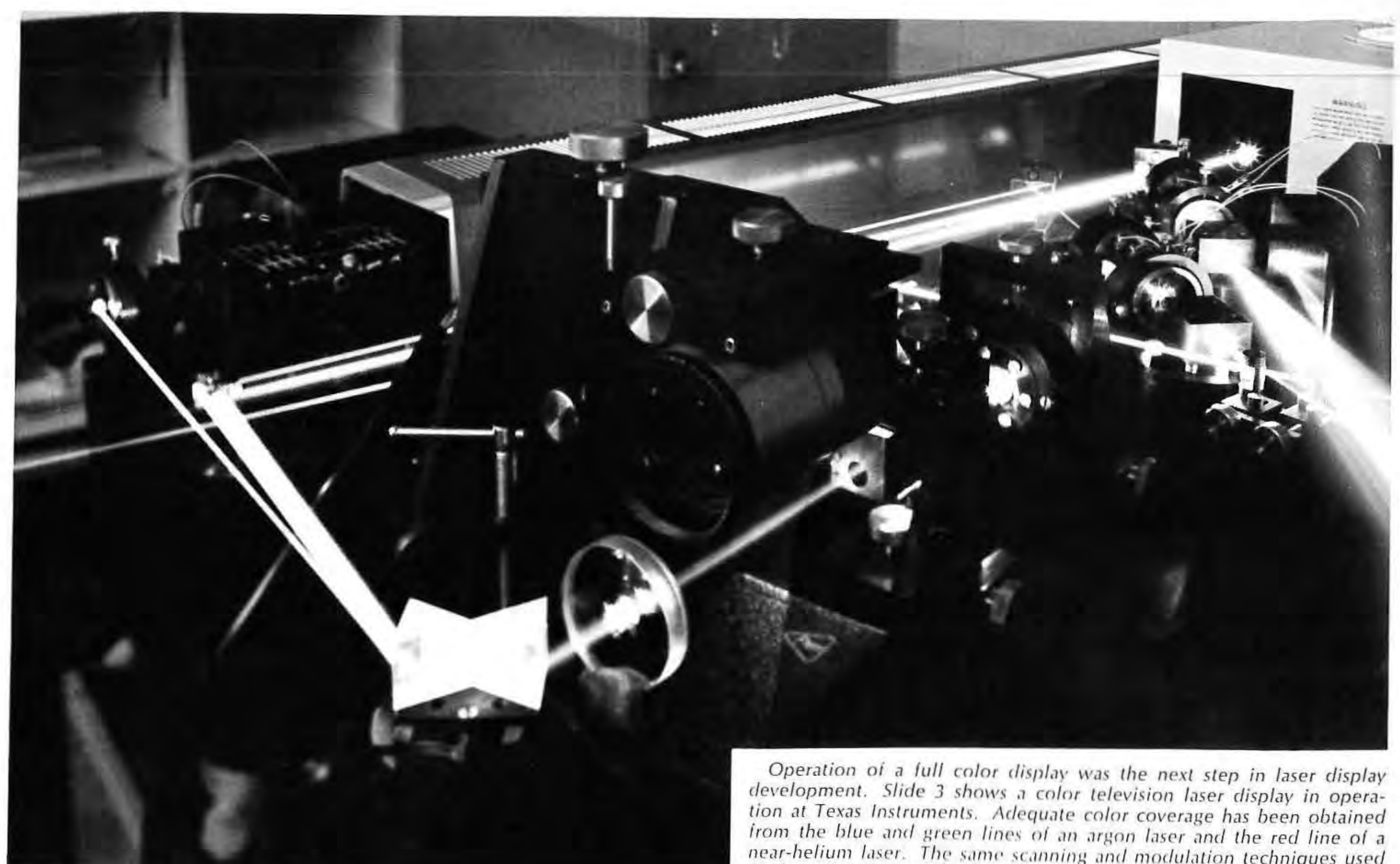
The low efficiency of presently available lasers prevents any serious consideration being given to immediately competing with CRT displays. For screen size and brightness consistent with home entertainment requirements, several thousand watts of power would be necessary to energize the laser. The red line from a neon helium laser, together with blue and green lines from an argon ion laser have been used to generate a color television display having satisfactory range of hues.

From the standpoint of simplicity it would be desirable to produce all of the primaries required for a color display with a single laser. The krypton ion laser is potentially such a device. If laser display technology is to be commercially exploited, however, the primary consideration is the development of a simple laser with an efficiency approaching 0.5 per cent.

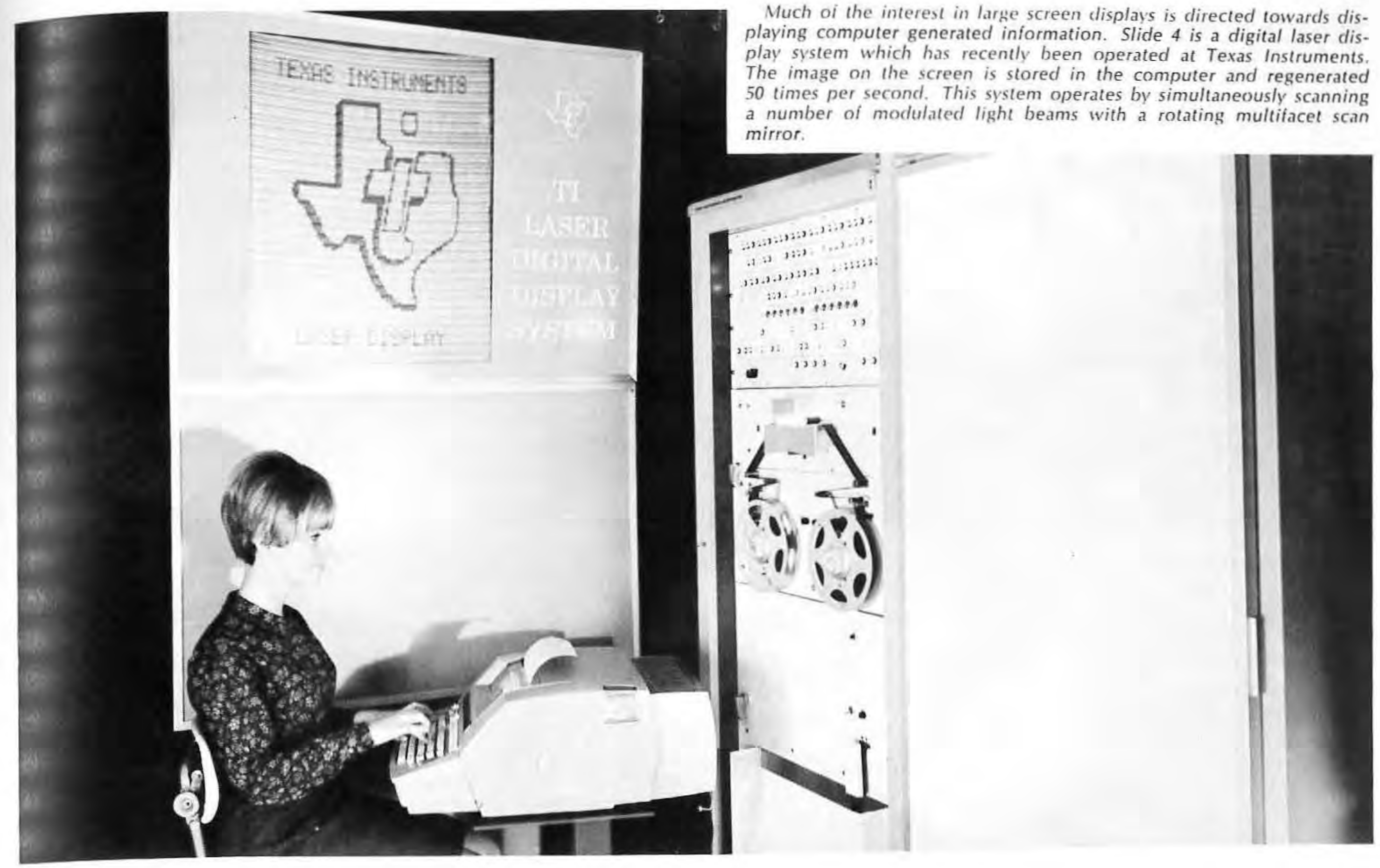
Since laser efficiency increases with output power level and many large screen display requirements cannot be satisfied with present technology, this area appears to hold more immediate promise. For many large screen display applications the dynamic characteristics of a CRT-like display would be highly desirable. In addition, in the usual large screen display installation, power consumption is not a primary consideration.



High frequency, high resolution sinusoidal scanning can be produced by a mirror mounted on an acoustically resonant structure. Slide 2 is a photograph of the system shown in Slide 1. This system uses fiber optics to convert a circular scan produced by an acoustically resonant moving mirror scanner into a linear scan. The fiber optics destroy the coherence of the transmitted light. This makes it necessary to use a projection lens and results in some light loss, but has the desirable effect of eliminating coherent light speckle. Defects in the fiber optic circle-to-line converter result in dark vertical lines in the display image. It has not been possible to completely solve this problem and more recent work has used other means to linearize a sinusoidal scan.



Operation of a full color display was the next step in laser display development. Slide 3 shows a color television laser display in operation at Texas Instruments. Adequate color coverage has been obtained from the blue and green lines of an argon laser and the red line of a near-helium laser. The same scanning and modulation techniques used in the monochrome display were employed in the color display.



Much of the interest in large screen displays is directed towards displaying computer generated information. Slide 4 is a digital laser display system which has recently been operated at Texas Instruments. The image on the screen is stored in the computer and regenerated 50 times per second. This system operates by simultaneously scanning a number of modulated light beams with a rotating multifacet scan mirror.

MR. BEISER: Thank you very much. Vernon Fowler, please.

VERNON FOWLER: Laser display work at General Telephone & Electronics Laboratories is mainly in three areas: (1) modulation and beam deflection techniques; (2) color television projection experiments; and (3) ion laser research. This display work is an outgrowth of earlier activities in optical modulation for communications applications and optical beam steering for use in laser tracking systems. An experiment in 1962 achieved the transmission of television pictures on a microwave-modulated laser beam and provided us with a substantial foundation in electro-optic technology. More recent work on wideband beam steering was directed toward developing, assessing, and comparing both electro-optic and moving mirror methods for accurate high-resolution beam steering. A piezoelectrically-driven mirror device, developed for a NASA launch vehicle tracker, was adapted for use in our first 3-color laser display system.

Our current laser display research is concerned largely with evaluating scanned laser beams as an information display medium. To this end experimental work is under way with the objective of producing large, bright, high-quality color television images by modulating, scanning, and projecting intense blue, green, and red laser beams. Much of this work is being applied toward achieving synchronized raster scanning with rotary mirror devices and developing new methods for improving the efficiency of ion lasers.

Mirror scanning devices are favored for the experimental display system for several reasons: (1) they readily produce large scan angles without the need for magnification; (2) the light loss is very low; (3) they can be used to scan concentric multi-color beams to form perfectly-registered images; and (4) they preserve the remarkable properties of the high coherent TEM_{00q} laser mode in the final image.

A principal method being applied toward improving the efficiency of ion lasers is through the reduction of discharge tube wall losses. About 80 percent of the power applied to a laser discharge is converted to heat through collisions with the beam confining walls (nowadays generally an array of closely spaced graphite, ceramic, or metal discs). Recent experiments at GT&E Laboratories have shown that these losses can be greatly reduced through more optimum use of magnetic plasma confinement, using only a limited number of well-spaced and shaped aperture discs.

Current work, though emphasizing gray scale capabilities and a full color gamut, is relevant to information displays as well as to entertainment applications. In particular, current work on precision wideband beam deflectors may find later use in the formation and positioning of stroke-generated symbols in non-raster-scanned displays.

However, an earlier consideration than the development of any laser display system for practical use is the question of the suitability of high-brightness steered laser beams for display applications. Does instantaneous spot brightness of tens of millions for footlamberts have any deleterious effects on vision, particularly after long periods of using a laser display? Is scintillation distracting and disturbing, and must means be applied to eliminate this effect? Are there serious hazards, as from the effects of looking back into the beam, that must be avoided? Can rear-projection avoid these hazards? Does the absence of persistence in the image produce annoying flicker

The mechanical system has to be re-learned by everybody who practices it—*Vernon Fowler*

at the high brightness levels and large viewing angles that are desired for laser display systems? Answers are being sought to all of these questions in our current laser display experimental research.

Rapid progress is being made on display lasers of greatly increased luminous efficiency and improved scanning devices suitable for synchronous raster scanning. Even with these improvements, however, the laser display is likely to retain many of its present elements of high cost during its early years of commercial development. For this reason it is appropriate to seek ways in which lasers can provide significant and valuable new capabilities and respond to well-defined present needs.

One major display application area where new capabilities are needed is in the presentation of alpha-numerical and graphical information from a computer. A computer display system must perform the functions of symbol generation, positioning, and recording as well as projecting the displayed information. These functions can all be accomplished by conventional means with expensive added components, including mass magnetic core memories, scan converters, stroke character generators, etc. It is highly desirable to avoid the need for such costly components and achieve some of these capabilities as an adjunct to the means used to form the raster-scanned image. Baker[1] has produced a laser display with this sort of capability in which a magnetic drum memory attached to a polygonal mirror scanner provides built-in image storage.

Another important application area is in what might be called precision display applications (computer controlled or otherwise). The military problem of map overlay projection is one example. A difficulty of many volatile display systems is the lack of inherent capabilities for precision positioning of data. An advantage of the rotary polygon optical scanner is its property of constant scan angular velocity. Assuming the ability to achieve synchronism and avoid bearing noises and other jitter, data could be positioned on a laser display screen with a high degree of accuracy by time delay methods.

The laser can also offer other special capabilities applicable to both entertainment and information displays. Since laser light is polarized, it is a simple matter to implement a stereoscopic laser display on a dot, line, or frame-sequential basis. The display could present a view for the left eye in left-handed circularly polarized light and for the right eye in right-handed circular polarization. Special polarizing eye glasses could be used to select the desired polarization for each eye. Going further with this same idea, it is a simple matter to arrange for the laser projector to generate its own video signals, using an unmodulated, scanned beam as a flying-spot scanner. This method was used by Stone[2] for the production of 3-color scanned laser images. Images generated in this fashion can be itensified in brightness, magnified in size, and enhanced in contrast compared with the original object. In addition, the video signal can be transmitted over standard channels for the projection of stereoscopic images on a second laser stereo projector at a remote location.

The use of polarized laser light permits the easy achievement of stereoscopic effects. In addition it can also be used to derive images by phase contrast or strain birefringence. An auxiliary flying spot formed by the optical scanner can be passed through a transparent object, such as a strained piece of glass, and detected through a polarizer arranged to block the light of the original polarization. The resulting video signal, applied to the display beam modulator, will produce a projected image of the sort that would be obtained from an ordinary polariscope, except that it can be magnified, intensified, and enhanced in contrast.

Furthermore, the flying spot of laser light need not be of the same wavelength as the light projected to the viewing screen, although it could come from the same laser. In particular, it could be infrared laser light, and the display system could be made to function in the manner of a projection infrared binocular microscope or a projection infrared polarizing binocular microscope.

Doubtless there are many additional ways in which the unusual properties of laser light and the means available for controlling it can achieve new and useful results. During the next few years as improved laser and electro-optic components become available, there will be an increasing trend toward greater versalitity in laser display systems.

MR. BEISER: Thank you very much, Mr. Fowler.

Dr. Robert Pole, please.

DR. R. V. POLE: As far as displays go, I have been associated with the research in the area of (1) light deflection and (2) the efficient methods of conversion of a phase object into an intensity modulated image.

The effort in the area of light deflection has culminated with a device which we call the "Scanlaser." Fig. 1, conveys schematically its mode of operation. Briefly, it consists of two parts; (1) a highly (transversely) degenerate multimode laser resonator and (2) an electronically controlled, electro-optic mode selector. The resonator is potentially capable of lasing in a large number of spatially distinct modes. The mode selector selects only one or a few of these modes at the time. This selection is accomplished by means of a deflectable electron beam and an electro-optical crystal. The charge deposit-

1. C. E. Baker, "Laser Display Technology," 1968 IEEE Convention Record, p. 107.
2. S. M. Stone, "Experimental Multicolor Real-Time Laser Display System," Proc. 8th Natl. Symposium for Information Display, May, 1967.

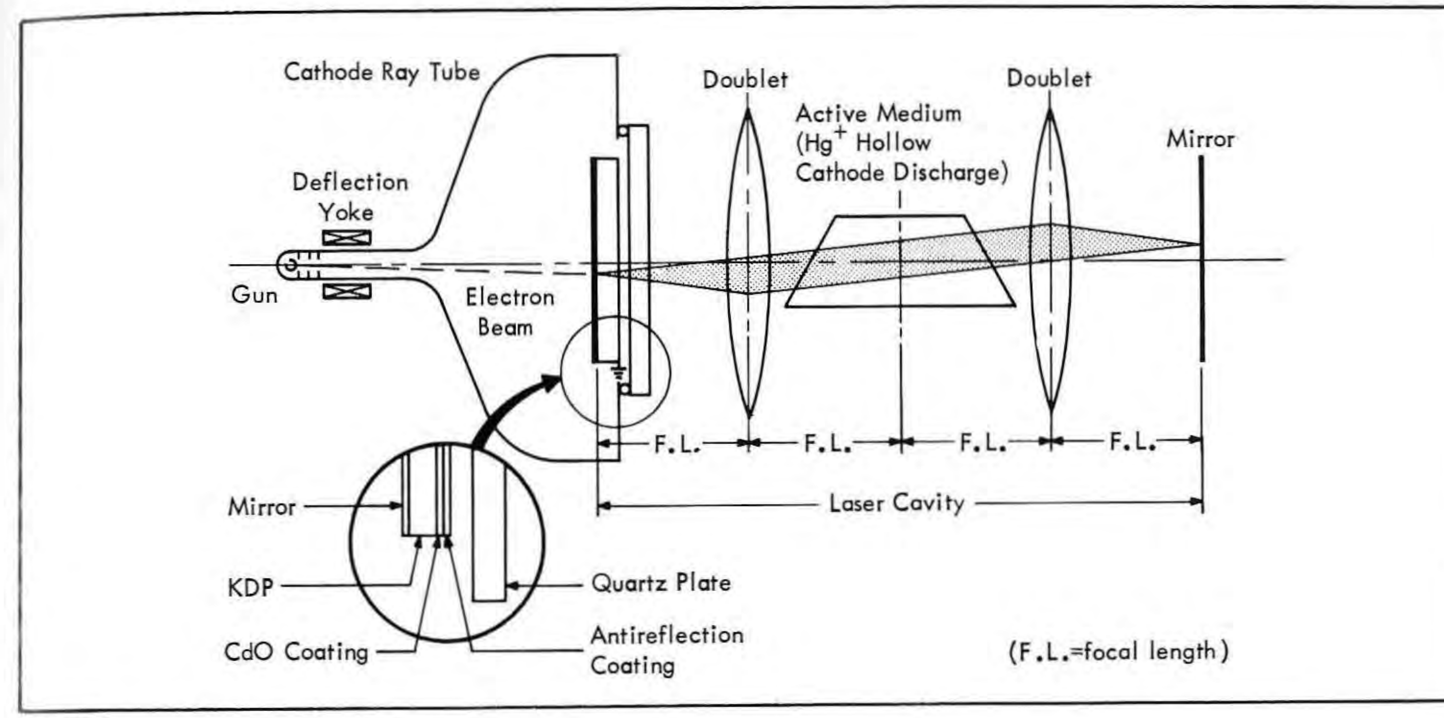


FIGURE 1

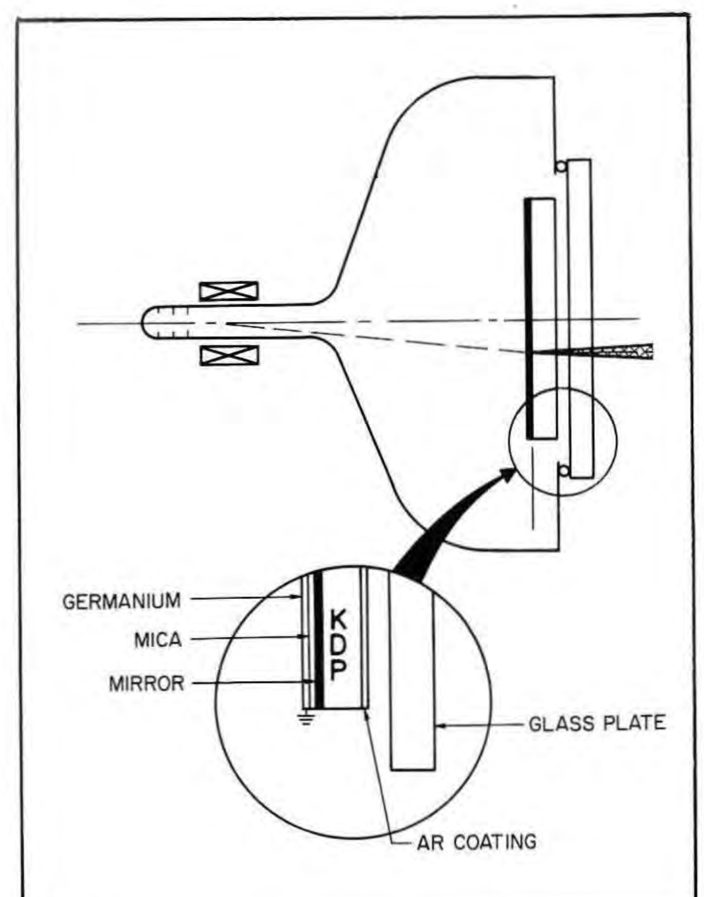


FIGURE 2

A mere substitution of laser devices for incoherent displays doesn't buy us anything—*Robert Pole*

FIGURE 3

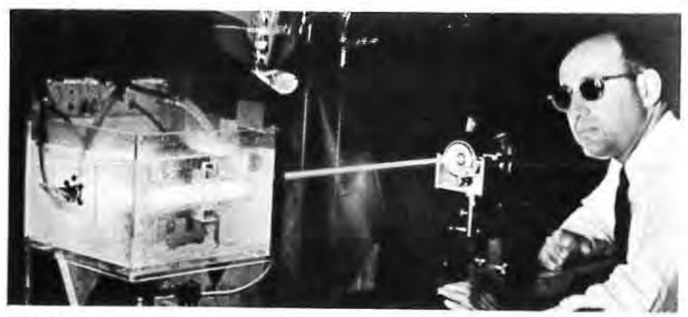


FIGURE 4

ed by the electron beam creates an electric field across the crystal, which, in turn, generates a certain amount of birefringence at the position where the beam has landed. If this birefringence is equal in amount, and opposite in sign to the birefringence introduced uniformly over the field by a biasing phase plate, the laser will have a maximum Q only in that small area. Consequently, only one mode or a few modes corresponding to this position on the mirror will lase. The

FIGURE 6

rest of the lasing field will be Q-spoiled. The deflection of the electron beam to another position opens the Q for another mode while the previous mode decays with the decay of the charge.

The original version of the Scanlaser was plagued by the rather slow charge decay. In its latest version the decay is speeded up (Fig. 2) by a semiconductor layer on the back of the crystal.

Fig. 3, shows the appearance of the experimental device.

A major problem associated with the operation of the Scanlaser is the need for a wide aperture laser; the wide aperture being necessary if a large number of modes and therefore a large number of deflectable spots are required. Fig. 4 shows an experimental 1 cm diameter and 15 cm long argon laser developed by C. B. Zarowin in my group, which is capable of supporting in excess of 10^5 transverse modes.

In the other area of effort, which we refer to as "Reactive Processing" we have demonstrated a rather efficient method of conversion of a phase object into an intensity modulated image. The method resembles the classical Schlieren method (Fig. 5), except that the zero order light is not absorbed but stored in the laser cavity as a basic oscillating mode. In principle, the method is highly efficient because only the useful, side order light is coupled out of the laser.

An intensity modulated image obtained by this method from a phase object, which is a bleached transparency, is shown in Fig. 6.

This method is applicable to any system where the classical Schlieren system is used and where laser illumination is desirable or tolerable.

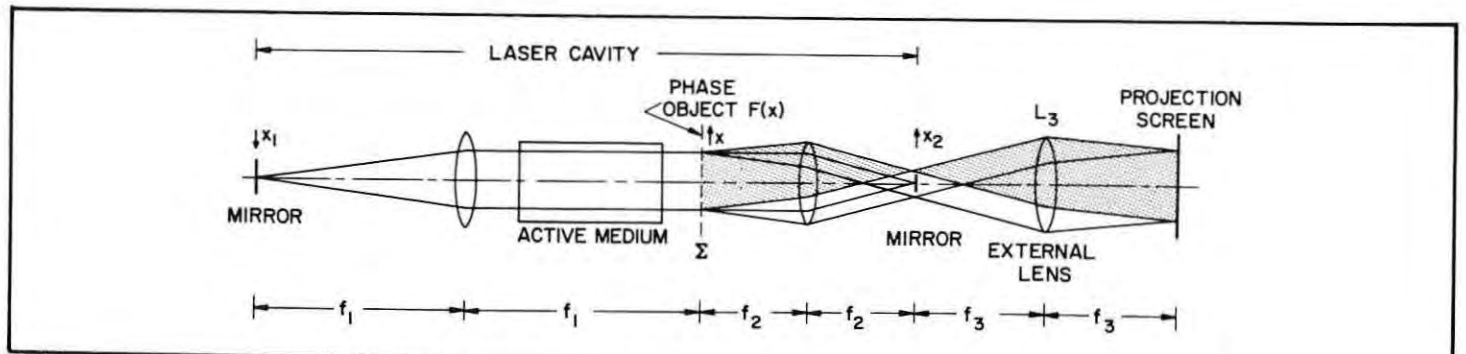


FIGURE 5

MR. BEISER: Thank you very much, Dr. Pole. Professor Bennett, please.

PROF. BENNETT: At the risk of some repetition, I thought what I would do is talk a little bit about the historical development of gas lasers and the current technical situation in relation to the various other subjects that are on the program today.

At the present time there are well over one thousand known gas laser transitions. These extend from the ultraviolet (around two-tenths of a micron) to far out in the infrared (a large fraction of a millimeter). I think we can safely say now that there is no longer a wavelength gap in coherent sources of oscillation between those produced, for example, by harmonics of Klystron radiation and laser oscillation.

The gain coefficients that are available range from a few percent per meter to enormously large values — some in excess of a hundred dB per meter. These transitions occur in a large number of different media and on many wavelengths within the same media. Most of these transitions are Doppler broadened lines in which, the Doppler widths, due to the atoms' thermal velocities are much larger than the "natural widths" from spontaneous radiative decays.

If we make the reasonably-realistic assumption that the cross sections for excitation of the upper laser level are independent of the laser transition wavelength an inherent dependence of the small-signal gain coefficient on the third power of the wavelength occurs. At the same time, the power gain will involve the product of the energy per photon (or the reciprocal of the wavelength) and the excitation rate. Hence, from the same argument, one expects the largest powers to be obtained at shorter wavelengths. Obviously this idealized model of this problem will break down in specific instances. However there is a general tendency of the empirically available data to at least roughly follow these trends.

In 1963 I did a fairly detailed analysis for the Institute for Defense Analyses of the types of power capability and efficiency that one might expect, in principle, out of oscillating gas laser systems. I don't think my opinions have changed greatly since that time.

It is, of course, extremely difficult to predict the properties of specific transitions because there is almost a total lack of information on excitation cross sections and transition probabilities pertinent to most cases of interest.

On the other hand, by taking realistic values for excitation cross sections, the type of electron densities that one can expect to get before serious instabilities develop, it did not seem unreasonable to me that one might expect ultimately to get power densities in gas lasers in the order of ten watts per cubic centimeter. That estimate still seems reasonable to me today.

Furthermore, if one finds the right media, I don't see why efficiencies in the order of 50 percent or so can't be achieved. In 1963, that seemed like a rather bold assertion to make.

At that time, the highest power CW gas laser was the He-Ne laser, which put out in the order of ten to a hundred milliwatts, depending on the size of the device.

On the other hand, the recent developments in infra-red molecular systems tend to indicate that the estimates I made in 1963 are not totally unreasonable things to expect from the future.

The existing CW gas lasers have output power capabilities ranging from the milliwatt level to over several kilowatts. The power densities that have been obtained, in practical devices still tend to be less than a watt per cm^3.

I would like to make a few general comments. Of the 500 or so atomic species for which there is substantial data based on spontaneous emission in the literature, roughly ten percent have been observed in laser oscillation. Because a relatively small fraction of the available atomic species have been observed in oscillation, I think it is dangerous to try to predict what may be obtained and what may not be obtained too specifically. In particular, in the past, most people who have indulged in this predictive game have erred in the direction of pessimism.

I think, in fact, probably one of the most realistic approaches one can make to this predictive game is to treat it somewhat statistically, such as you might treat data from the stock market. Certain basic limitations will, of course, exist based on conservation laws. Beyond this, however, one can do little more than extrapolate from the average slope and value at each point in time.

I have, therefore, prepared two slides. The first of these slides is a plot of the total number of gas laser transitions as a function of time. Its as good a way to look at the problem as any, I think. The ordinate goes up to 1,000 on a $\log_{10}$ scale and three cycles are represented.

The first five gas laser transitions oscillated at 4:15 P.M. on Tues., the 14th of December of 1960 off to the left of the figure. This was followed by a long horizontal period extending until 1962 — at which point the properties of the confocal interferometer with Brewster angle windows began to be exploited. At that point a very steep rise started which persisted for about two years. However, please note that the number of transitions is even now steadily growing at a large

Six years ago, we were wondering when we'd have to throw out all the microwave equipment and replace it with lasers—*W. R. Bennett, Jr.*

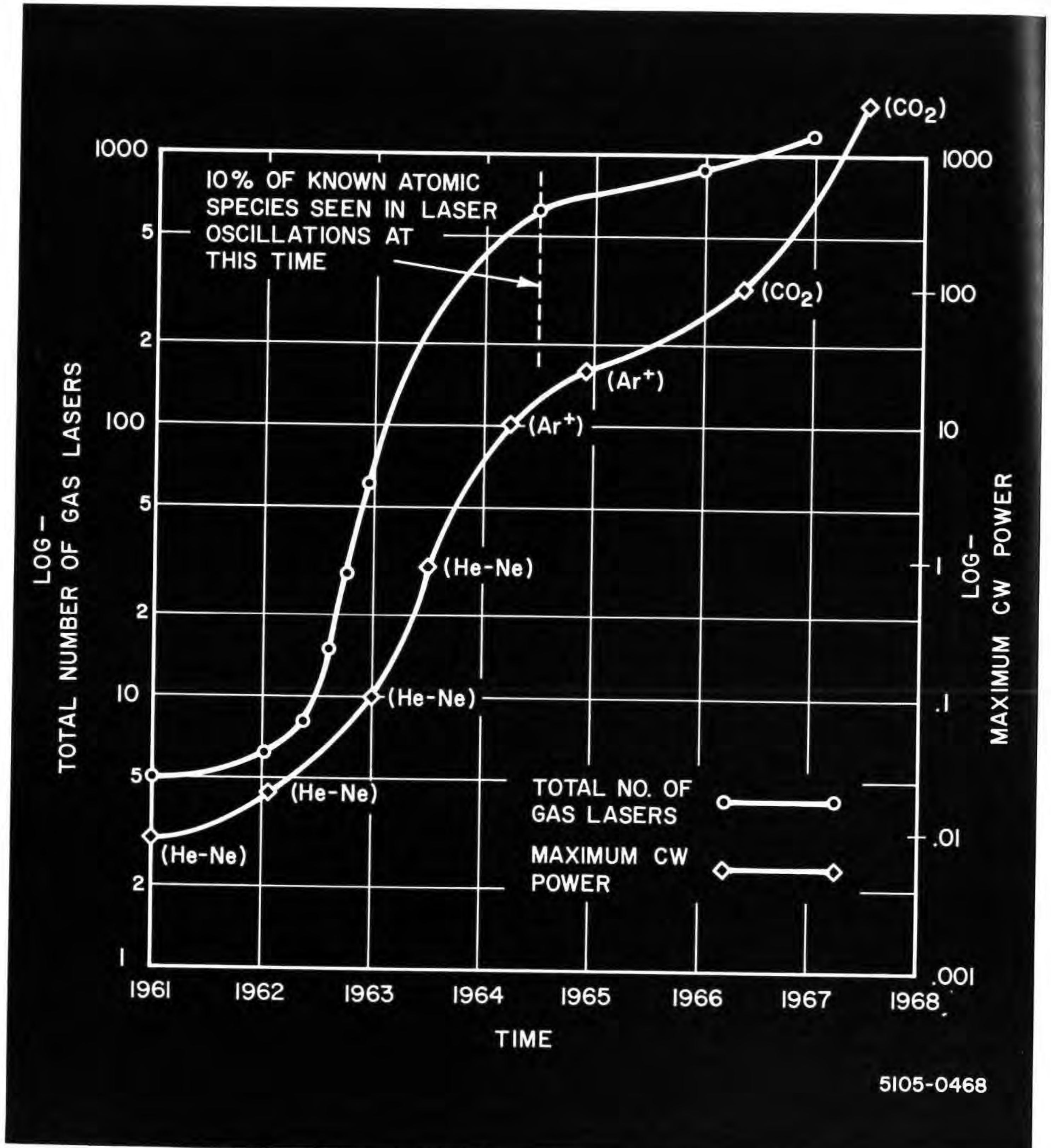


FIGURE 1: Total Number of Gas Lasers (log scale) vs time maximum CW power (log scale) vs time

rate — a fact which is obscured somewhat by the logarithmic nature of the graph.

At the same time, I'd like to call your attention to the fact that the point at which ten percent of the atomic species were seen in oscillation occurred fairly high up in number. And I think it would be a little dangerous to assume that we have run out of new possibilities.

The second curve shown on this graph is a plot of the maximum reported CW laser power. The scale is on the right and it runs from one milliwatt at the bottom to a thousand watts at the top.

For the first couple of years, power levels in the order of a hundred milliwatts were about all that was attainable from a practical size device.

In the neon system, sometime during 1963, some of my friends at the Bell Laboratories built a system which put out about one watt. It's questionable whether you could refer to that as a practical device or not, since it was about 30 feet long.

The next thing that occurred was the development of the argon ion laser which immediately made CW power levels in the order of watts available — perhaps 20 watts depending on how much electrical power facility you have available.

But certainly a number of watts became available in the visible and, of course, with the development of the CO_2 laser in the last few years, power levels in the infrared of about 100 watts are available. In fact power levels in excess of 2,000 watts have been obtained from a CO_2 laser at the Huntsville, Alabama, missile base. That one was about the length of a football field however, and may have had some practical drawbacks for general application.

The second figure is another satistical presentation of data, illustrating the spectral distribution of gas laser transitions. Here the number of observed gas laser transitions per 100 Å interval is shown a function of wavelengths in microns.

The horizontal scale runs from a tenth of a micron to a hundred microns in three decades.

In particular, the small region represented by the visible in this plot is indicated up on the top. And I think we're all rather fortunate that the peak in the distribution occurred here. This, of course, may be no accident in that people working on these things like to see what they are doing.

The result is particularly encouraging in view of inherent difficulty expected initially in getting sufficiently high gain coefficients at short wavelengths to permit oscillation.

As far as predicting the future, I guess you probably can extrapolate these curves as well as I can.

There is one other characteristic that most of the atomic gas laser transitions have exhibited worth noting: namely, they are generally all multi-level systems involving excitation of the outer electron in the atom in a mode in which rapid relaxation of the lower state is dependent upon radiative decay to obtain CW oscillation.

Fig. 3 is meant to represent an idealized model of a large number of atomic and ionic laser systems. We have a ground state of the atom, and some excitation process which gets the atom into the upper laser state which generally involves the outer electron in the atom.

The laser transition occurs between levels 2 and 1 and in particular the requirement that the decay rate of the lower state be large compared to the decay rate on the laser transition — $R_1 > R_2$ (needed in order to obtain a continuous population inversion across the laser transition) is generally provided by radiative relaxation to another excited state of the atom which in itself is very long lived and has sluggish decay rate, R_0.

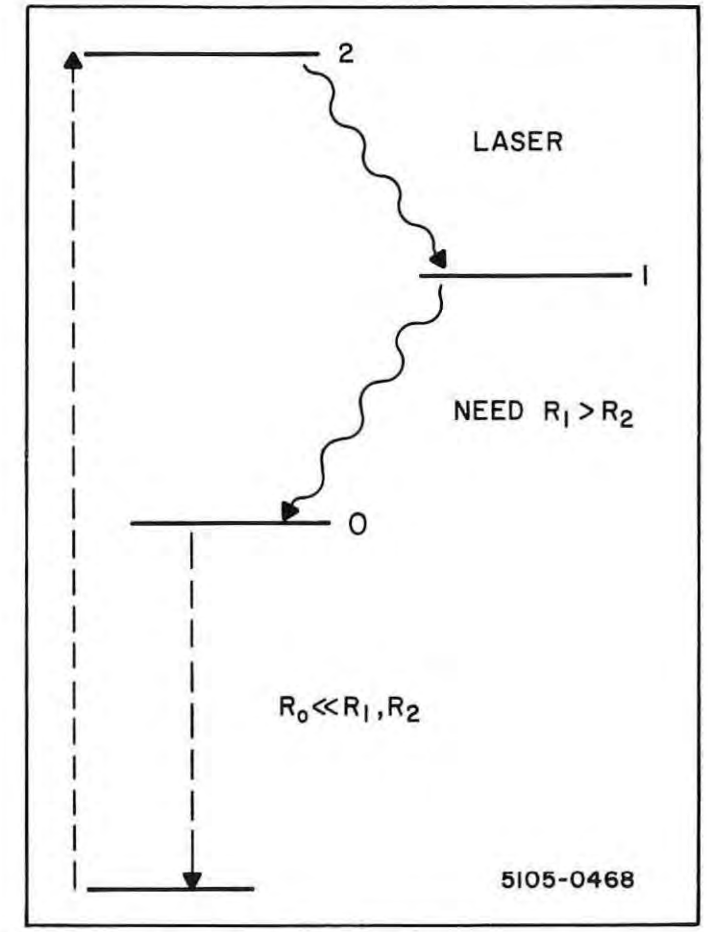


FIGURE 3: Laser transition energy diagram

So, as you try to build up more and more excitation on the upper laser level, the density of level 0 builds up and resonance trapping on the transition from 1 to 0 followed by repeated reabsorption, contributes to an enhanced population of the lower laser state at high excitation levels.

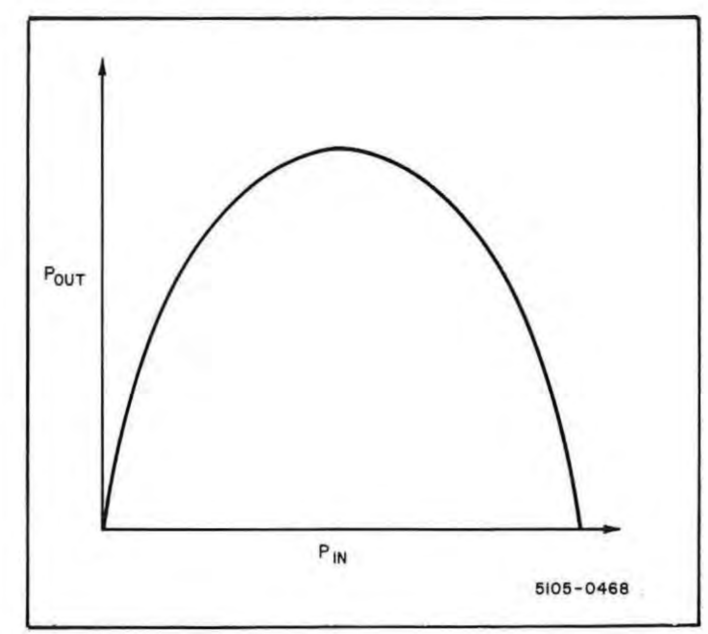


FIGURE 4: Laser output vs input power

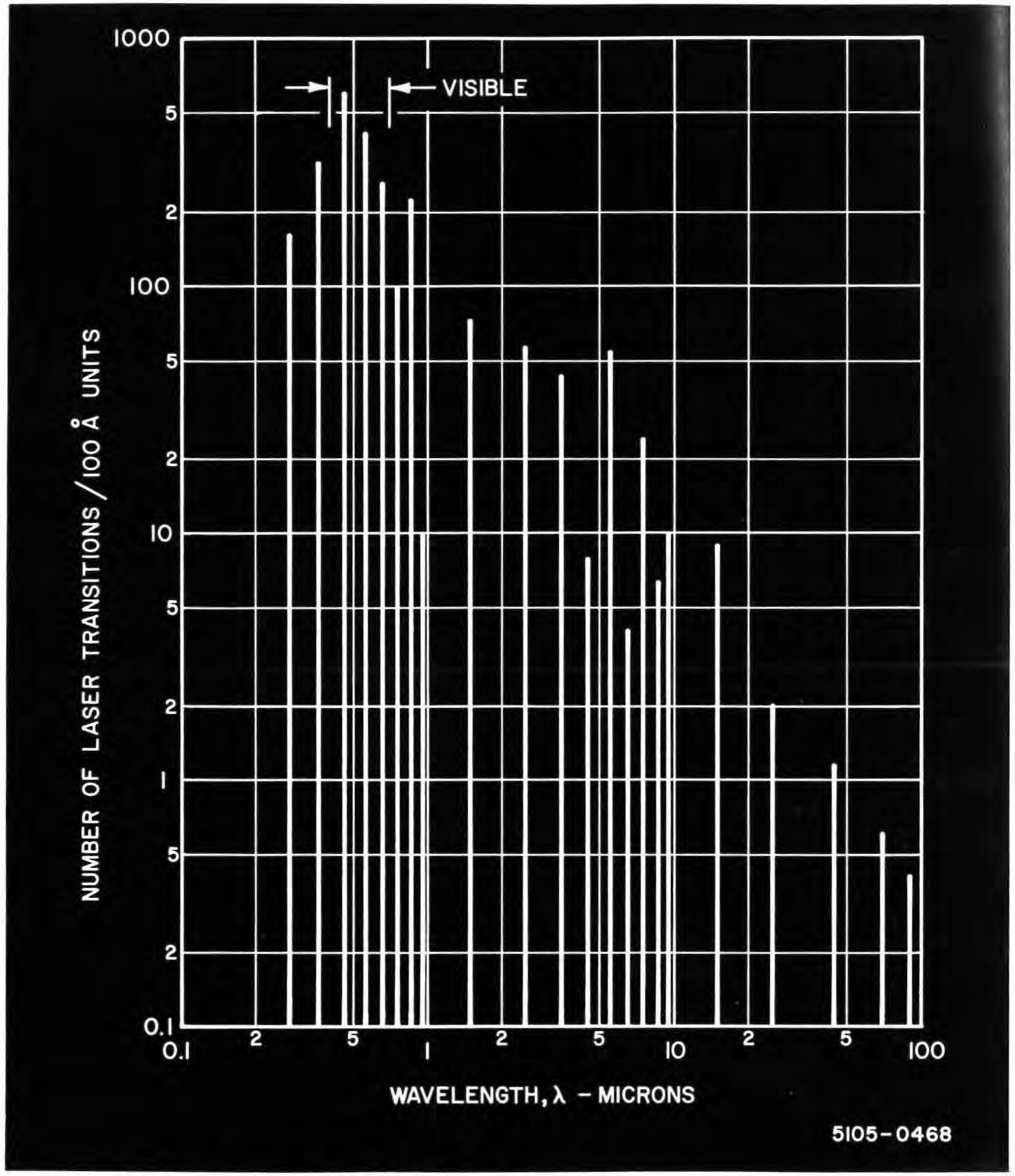


FIGURE 2: Number of laser transitions vs wavelength presently known

In particular, the density of the lower laser state tends to go as the square of the excitation rate, whereas the density of the upper laser level may only go as the first power.

As a result, one gets a very fundamental inherent limitation to the maximum power output that you can get in many of these systems. That is, the obtainable laser power density depends on the population difference and that goes through a quadratic maximum with increasing excitation as illustrated in Fig. 4.

In fact, you can see that one of the important distinctions between the helium neon laser and the argon ion laser is the wave length of the transition 1→0. The cross section for the absorption of the resonance radiation goes roughly as the cube of the wave length.

In the case of the helium neon laser, that wavelength is about 7,000 Å and in the case of the argon ion laser, it's about 700 Å. The ratio of corresponding wavelengths in these two systems is about 10:1. Hence the resonance absorption cross section in the argon ion systems (for the 1→0 transition) is about 1000 times smaller and it is not surprising that one can obtain about 1000 times as much power out of the system.

The inefficiency in many of these systems depends on many factors. One of them is the fact that the energy per quanta is very small, compared to the excitation energy from the ground state. In addition to this, the saturation properties mentioned above limit the efficiency along with the branching ratios associated with the fact that there are many excited states involved.

The hope for getting increased efficiency, I think, will largely rest with going to lower-lying states, and this, of course, is precisely one of the reasons why the CO_2 laser is more efficient. Also systems where one can replace the radiative decay of the lower laser state by collision-induced decay would be desirable and this is again something that is characteristic of the CO_2 systems.

I see no reason in principle why such mechanisms cannot be applied to the visible part of the spectrum. Obviously one doesn't want to predict that next year, we'll be able to get a thousand watts out of a CW visible gas laser.

At the same time, it doesn't seem to me there's any fundamental reason why one can't expect to do that well eventually. I think we can still look forward to a number of pleasant surprises in this area.

MR. BEISER: Thank you very much, Prof. Bennett. That completes our first round by our panelists.

Let me introduce just a few of the things now that might be picked up later, during the audience's opportunity to interchange with the panel. I'll offer some general questions to the panelists, and see if we can establish a platform for further discussion.

Let me ask Bob Adler, first, to "lay down the gauntlet" regarding what major problem areas are in his mind. What are the things that should be attacked in order to promote the development of laser display?

DR. ADLER: As far as a TV type display is concerned, we've got to realize that the laser is a latecomer. The CRT is doing very well. There are thousands of people all over the world trying to invent ways to replace it, not only by means of lasers but by means of all kinds of devices. They are not having very much luck.

So I think first of all we ought to be a little bit humble about what we're trying to do. Having said that much, let me mention this. I had said at the end of my talk that there is no particular trouble getting full resolution.

There is obviously no technological problem preventing a full resolution picture if you don't care how much the equipment costs. You just build three monochrome systems.

The first obvious thing then is you've got to come up with something a little more clever than this. The acoustic system about which I talked suffers from dispersion. So there is a challenge for some clever ideas to use only one set of deflectors in spite of the fact that the light is deflected through different angles depending on its wave length.

On the other hand, electro-optic deflectors discussed by others are not dispersive, so this problem does not arise when you use them.

Generally, you can sum up by saying, work hard on trying to reduce the amount of gadgetry that it takes to make a laser display. But, of course, none of this is going to amount to anything unless the efficiency of the light source goes much higher than where it now is.

The development announced by Bell Laboratories concerning the work on frequency doubling promises to increase efficiency to ten percent. Yet, it's only one color.

I was tremendously impressed by the first reports, but the fact still remains that until we can make a tri-color source of coherent light in mass production for something like $20.00, we should not hold our breath for the general use of laser displays. Maybe that's all I should say at this point.

MR. BEISER: Thank you. Very well spoken. Dennis Gabor, may I ask you please to express yourself on the informational, the bandwidth and resolution aspects of laser displays. Do we see any limitation in this respect?

DR. GABOR: No, not at the moment. I was struck by the fact that some of these devices suffer from laser speckle.

[Laser speckle is subsequently discussed as a separate item—Ed.]

MR. BEISER: I'd like to ask Bill Bennett to offer some comment regarding laser noise, signal-to-noise ratio, and if we may expect this to be a limitation in providing information for human consumption.

PROF. BENNETT: The physically-interesting region to look at laser noise is right near the threshold of oscillation. In this region the output noise undergoes a transformation from Bose to Poisson statistics. At the power levels involved in typical laser oscillation the output is Poisson-distributed and one may estimate the signal-to-noise ratio merely by noting that it will be proportional to the square root of the number of photons detected in the observation time. For example to obtain a 40 db signal-to-noise ratio in a 10 megacycle bandwidth would require about ½ milliwatt power in the visible. This is a power level which is available from most practical CW gas lasers.

I remember having a conversation with Rudy Kompfner about 1962 at Bell Labs about the application of lasers to communication. The big question then was, of course, when is it that we're going to throw out all the microwave equipment and replace it with lasers for communication purposes.

One, of course, encounters the same situation there as you referred to before in the TV displays and other displays. The microwave components have been around for a long time. They're very well-developed.

At the time of the conversation I had with Kompfner six years ago, the magic number was something like this: I think it was estimated that four watts CW at one kilomegacycle modulation bandwidth would give a signal-to-noise ratio competitive with microwave equipment. This seemed like a safe margin at the time, since we were obtaining about one hundredth of that power from CW gas lasers. On the other hand, I notice in the intervening period that the 4 watt capability has become available—maybe not with high efficiency, but it's certainly obtainable. At the same time, I do not see a large scrap heap of microwave communication components developing across the country. I suppose that one of the inevitable things that has happened is the microwave techniques have also improved in the last six years. This type of competitive development will probably continue for some time in both the communication and display areas.

MR. BEISER: Thank you, Bill.

I'd like to ask Vernon Fowler what he considers to be the system power losses in a laser display system. The proliferation of interposing (lossy) components and, therefore, the resulting laser power requirement to provide a particular quality in brightness of laser display.

MR. FOWLER: Let's assume the systematic losses are incurred by all of the lenses that need be added to the system.

The illustration I showed you of our three-color laser system required a large number of optical surfaces to do the job because of the strange way that we generated it. We had transformed means. Something like 30-50 optical surfaces were involved and we lost about half of the light.

You all know that ordinary mirror reflections, (ordinary glass), will give you something like an eight to ten percent reflection loss unless you anti-reflect coat it. If you coat it well you may get down to one or two percent. It mounts up rather rapidly.

One good feature of a maximum coherent system, of the sort that takes the beam from the laser and runs it right through as a gradually converging beam, it that one can do this job with a very small number of surfaces. Certainly, with a smaller number of superfluous surfaces.

There is, of course, good reason to include lenses as an approach to reduce the power requirements for electro-optical modulators. Squeeze the beam down and use the tiny crystal. This is a trade off.

I would rather use barium sodium niobate crystals in my modulator and suffer with a little bit more voltage because the light is still the premium quantity.

Incidentally, you get a lot of it back at the screen if you use an ordinary slide project (type) screen which is obviously applicable to most situations. The directivity of the screen can be a factor of five. You have some advantage, but not an awful lot.

MR. BEISER: Before you sign off, could you just give us an idea, please, of what absolute power level might be required of the laser.

MR. FOWLER: Let's talk about a three by four foot screen. Let me refer to a table I've got with specific numbers. This is a useful piece of information anyhow. How much power do you need to make white light? What does a white laser look like?

Of course the amount of blue that you need and red that you need is large compared to the amount of green that you need. Now my calculations, which may differ from somebody else's who knows how to do it a different way, shows that we need 0.458 watts of blue.

By the way, this is for the helium, neon, argon combination. 0.458 watts of red and .114 watts of green. About equal amounts of blue and red and they're roughly of the order of 40 percent; the other is roughly of the order of 45 percent.

So, this is the composition. Now you've got to convert that into lumens. How many lumens do you have? Well, there are about 60 lumens of blue and about 47 of green and about 70 of red.

And how many lumens do you need to make a nice bright picture? Well, a nice bright picture may be about 40 foot-Lamberts, let's say a three by four screen. That requires about three-quarters of a watt.

If I were building a system to do this, I would say you really should count on having twice that much power from the laser. Or in other words, it's taking an awful lot of trouble to squeeze this down to maybe a watt.

MR. BEISER: We're talking of the one to two watt range roughly.

MR. FOWLER: For that size; just covering a three by four foot picture.

MR. BEISER: Thank you. I think we might go back to Dr. Bennett again for a moment. Is there anything in the near future we can see at the present time which would seem to fit this power requirement?

PROF. BENNETT: Well, it depends on how much power you want to throw away. But as various people have noted, the efficiency would run around ten to the minus four to ten to the minus three. I don't know what power inefficiency may be realistically tolerated.

As far as immediate new prospects in the gas laser area, for example next week, I don't know of any. I know of some promising possibilities that are still a twinkle in the eye of their creators. With this field, however, it's very dangerous to count one's lasers before they're hatched.

I think there may very well be some possibilities for improving efficiency. For example, in the case of ion lasers, one method we're working on at Yale is the possibility of using charge transfer between ground states of ions and neutral atoms to produce excited laser states of impurity ions.

We have found definite evidence that this may be accomplished in certain types of systems and hopefully if one can really make these oscillate, there would be a possibility of greatly-increased-efficiency. Such an improvement would be expected because one can get a high degree of ionization in a gas such as neon or argon, and then hopefully arrange a situation where you transfer this ionization to the upper laser level with a high degree of selectivity.

There's another category which might turn out to be particularly promising in the use of internally scanned lasers. The majority of gas laser transitions (on which the statistical data was presented in the previous figures) occur only in pulsed oscillation. These lasers tend to be inherently limited to pulsed oscillation because of insufficient lower-state relaxation processes.

Since one is really concerned with scanning a spot over a different region of the medium, one could in principle use these transiently-inverted systems to achieve a CW scanning spot, even though each individual element in the active medium might only undergo pulsed oscillation. It's conceivable that some of those cases might also have higher efficiencies in the scanning mode of operation.

MR. BEISER: Larry Anderson, do you have anything to add at this point regarding the trade off between power output and promixity of the diffraction limit in the ND:YAG Laser?

DR. ANDERSON: Well, I think I prefer to make some comments on the efficiency and availability of other wave lengths. I think these are probably the questions we're closest to answering right at the moment.

Although there's nothing new now, there's hope of something in the immediate future, both in terms of increased efficiency, which I mentioned earlier, and in terms of other available colors.

First of all, let's talk about the efficiency for a moment. As I mentionead in the first (Geusic's) work on efficiency in doubling from its 1.06µ to the green, his overall efficiency from an incandescent pump source to green output is something like 10^{-8}.

However, one can by sqeezing the last bit of engineering out of the optical cavity, and the pump system that one uses; this can be pushed up to about one percent if you use an incandescent source and if you correctly choose the color temperature of the source and make sure that every last photon that you generate gets into the laser.

If you want efficiency better than that, and you surely do, then you've got to look for a different kind of pump source. And here I think you take advantage of the fact that if we'd only pump the lines that do some good, we can easily get that efficiency up to ten percent in a practical way.

The immediate thought here is let's use a more or less coherent pumping source instead of an incoherent source and let's try pumping with a solid state source of one sort or another.

Radiation from a gallium arsenide diode unfortunately occurs at the wrong place. However, by mixtures of gallium arsenide and gallium phosphide, you can get radiation in the appropriate pump bands.

So, there is some prospect in the distant future for a combination pump laser that would operate with ten percent efficiency. I think that would get us over the hump. We've already seen that power is there.

[After a brief recess, the meeting reconvened—Ed.]

MR. BEISER: I'd like to pick up where we left off with the panel directly, just to cover a few more general aspects of laser displays, and then we'll open the meeting to audience participation.

I just recently met Stephen Hant of RADC (Rome Air Development Center) who had communicated with me earlier. And one of the things that he brought to mind that I will therefore pose to the panel, and perhaps specifically to Charles Baker, is the utilization of active screen materials rather than passive screen materials to help us overcome some of the power limitations.

Perhaps we can supply the laser power at a wave length which activates the screen material and let the screen reradiate back in a visible range.

In general, I'd like to ask Charles Baker, are there any special optical requirements, chromatic distortion, for example, that should be considered unusual regarding laser displays?

MR. BAKER: As far as the active screens go, the reason usually given for considering these is to move out into the infra-red and thus use higher power, more effective lasers. The power required for generating light in the screen could then be supplied electrically. The principal problem is the resulting loss of resolution. Resolution in a laser display is determined by the smallest effective aperture in the optical system. This is usually the scanner. If you displace wave length, this means that resolution will be halved.

The other problem is that the screen would use the same types of technologies now being used with flat panels or discrete element displays. With a direct laser display, color is also readily available, but with an active screen, three types of phosphors would be required and construction would become complex.

As far as the resolution of the display itself, it would be quite attractive if it did not have the laser operated in its lowest mode since we can obtain more power from a higher or a mode laser. Unfortunately, for example, the PEM_{01} mode expands at several times the rate of the PEM_{00} mode and you have one-fourth the resolution for a given aperture optical system. So the laser just about has to be a lowest order mode device to take advantage of all its potential. Of course, even after you do have the proper laser, you can have aberrations in the light modulator, lenses and mirrors and lose resolution there. It hasn't proven too difficult although we did have some problems; more with the modulator than with any other device there is about four inches of electro-optic material in the light path.

MR. BEISER: Thank you, Charles. I'd like to close the more formal panel part of this meeting with a double question to Bob Adler and Vernon Fowler regarding the laser deflection techniques. I'd like to ask Bob Adler first to generalize or classify the various laser techniques and then I'd like to ask Vernon Fowler to give us a brief status report on this technology.

DR. ADLER: I'm not sure how I should classify the different techniques. Let me take the two techniques that Larry Anderson has put in contra-distinction, the electro-optic and the acousto-optic.

Both techniques are adequate for scanned displays, the electro-optic suffers from having to use too many joules of energy.

The acoustic one needs very little energy if you can either scan slowly or if you can program your scans so that you can predict ahead of time what's going to happen, as is the case in TV. It means too much energy if you have to use digital reflection and don't know where your next position is going to be.

MR. BEISER: Vernon, any further comment?

MR. FOWLER: Only that I would say the status of the acoustical methods is probably much further along towards satisfactory operational results than mechanical systems.

I guess it's because, in part, the mechanical system has to be re-learned by everybody who practices it, and there are difficulties with problems of how to get the speeds that are required and avoid jitter and things of that sort.

Our recent research has been carried to the point where we have been able to produce uniform scans. It's certainly not a first, because this sort of thing is done all the time in video tape recording.

We find that hysteresis synchronous motors driven from sinusoidal oscillators (connected) to television sets do, in fact, produce, synchronous scans, a little bit of jitter, and I think it's a matter of work to remove the jitter.

It was our original impression that more elaborate means might be needed. That doesn't seem to be the case. I don't have enough information from our own experience and I haven't had enough chance to talk to other people using this technique.

But there's an open question as to the life of these machines. To make a device that is intended to spin a mirror at a high rate of speed, particularly in the 30,000 to 100,000 RPM range. How long would it last?

While we're talking about all those considerations, bear in mind that we have to register the scan lines from the individual facets (of the polygon).

The only factor working in our favor is that it can be solved once and for all by making a good enough polygon. But that means the facets have to be in their proper orientations within about a half a minute of arc to establish constant scanning and that is a pretty expensive thing to do.

DR. ADLER: I'd like to make a remark on the rotating mirrors. I think they have no place in this discussion. They may very well be the most plausible and the most useful way of deflecting light, and they ought to be because they're about a hundred years old.

The deflection angles that you can get with the complex, non-mechanical methods are so small that unless you can project an actual diffraction limited spot on the screen, you're not going to get enough spots. And to get such a spot with any intensity at all, you need a laser.

Now in the rotating mirror system, it's quite easy to get an angle of 45 to 180 degrees. People have been doing that since the twenties, when they built the first mechanically operated television systems. There is no difficulty getting enough resolvable spots for TV without using a laser.

Now there is an exception to that. There was a recent news item in the press about a high resolution scanner being developed by RCA for military purposes. It uses coherent light and a rotating mirror. Here we're talking about several thousand elements, and then it makes sense again.

But why use coherent light with rotating mirrors, when all you want is a few hundred elements?

MR. BEISER: Are there many more panelist comments?

DR. GABOR: Dr. Adler has already expressed what I wanted to say. But, of course, it is not sufficient to remember what has been done 30 years ago.

The other thing people forget is the Scophony, one of the very first mechanical systems. It was considerably advanced in that it projected a whole line at a time; a whole scanning television line arrested by a very ingenious technique.

MR. BEISER: Yes, Vernon?

MR. FOWLER: I'd like to make one comment on this. What has to be borne in mind is that if we're producing a laser television device projecting a spot, this is a Scophony system of course, capable of projecting a line system. If you are projecting a spot, then the spot intensity on the screen has to be multiplied many times.

How do you form a light spot of light? You form a little lens and you put it on the screen. To improve resolution, you put a little bit of a pinhole in the aperture near the source.

You finally get it down to a tenth of an inch and you throw out most of your light and the brightness going down is the inverse square of the area. So it's not practical to use incoherent sources for this. You stretch the duty factor on the screen.

But I think I take exception to what was said about the need for a laser in a system of the sort that utilizes a spot of light. And perhaps the laser may even be good for the Scophony system.

DR. ANDERSON: Another way of looking at this is to say you can use an incoherent source if you're prepared to work with f/l optics. If you're prepared to work with f/100 optics, then the laser is fine. f/100 optics are a lot cheaper than f/1.

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[At this point, the meeting was opened for discussion from the audience—Ed.]

MR. LOU BLUM GT&E Laboratories: One of the questions that has not been touched on by the panel is the question of flicker. Certainly a laser in terms of its presentation on the screen provides a system in which there is no storage such as you would have from a cathode ray screen.

I'm wondering, from the standpoint of the viewer and the question of any flickering, the question of the pleasantness of the picture. So I'd like to hear a response from any of the panel members on that one.

DR. ADLER: There was an experimental piece of work done on this particular problem by Joe Markin and Alan Sobel of our laboratory which appeared last July. This was not done with the laser because of the impossibility of getting white light. Rather, they used two cathode ray tubes, with phosphors of very different persistence, and color filters to make the two pictures look alike.

What they were really after, and what was reported in this paper, was the question of reciprocity. There was some question whether the eye might not be overloaded by the high light intensity of the short-persistence phosphor. The answer was negative. There was absolutely no visible difference between the two displays.

While they weren't asking anyone to comment on flicker, you would think that people would mention it had they noticed it. There again the answer was completely negative. There is apparently no way of distinguishing two cathode ray displays in which persistence times differ roughly by 600 to 1.

MR. GARY STARKWEATHER, Xerox Corporation: Two questions. It seems that we're talking about light sources in a laser which has two characteristics. One is the intrinsic radiance is very high because of the very narrow solid angle.

And secondly, the coherence. Would anyone comment on the possibilities of what really are the things to be gained by using coherent light, the gains to be used by the instrinsic radiance?

DR. GABOR: May I say that in these applications, coherence is just a nuisance.

MR. BEISER: We might add that if we're seeking typical resolutions which might be represented by television, then I think that the comment Dr. Gabor made is quite appropriate.

If we're seeking extremely high resolutions, such as 20,000 elements per scan line, then coherence becomes quite important in the ability to focus the light beam and to maintain high power density. Apparently, coherence has to do with the attainable resolution.

DR. ANDERSON: Another comment on this. There are the fundamental differences between the coherent and the incoherent techniques that you might be willing to exploit for scan purposes.

The coherent light is inherently more modulatable since it can be confined to a single mode in the volume of space in which you have to have an interaction for modulation.

And the volume of space that you require in order to deflect it can be less.

Now a point of fact is that most of the deflectors that we heard about today make absolutely no use of this principle. However, when the light is coherent the interaction volume required can be substantially reduced.

DR. POLE: I would like to amplify Professor's Gabor's very brief comments on laser displays and its coherent properties. As I see it, a mere substitution of laser devices or laser displays for incoherent displays does not really buy us anything. Perhaps there are a few advantages that Larry spoke about, but in general we inherit only this advantage; certainly coherent speckles on the screen are just a nuisance.

Therefore, I believe that laser displays may have a future only if we somehow take advantage of the coherence one way or another; either by means of some sort of active screen or any other means that may come up.

MR. GERALD GOLDHAMMER, IDA: It seems to me that one of the best things to look forward to in the laser display, as opposed to a cathode ray display, is the limited dynamic range of the CRT and that if you go to an active screen, you then proceed to throw away this great inherent advantage. Would anyone care to comment on that?

MR. FOWLER: Are you referring to the use of an active screen in conjunction with a laser?

MR. GOLDHAMMER: Yes.

MR. FOWLER: Are you saying this laser (system) has all kinds of capabilities?

MR. GOLDHAMMER: In your modulator, basically you have far more dynamic range potential that you ever do in a phosphor. So that, for example, if you take something like a radar display, it seems to have far more dynamic range—

MR. FOWLER: You mean intensity dynamic range?

MR. BAKER: I agree. Especially the acoustic-optical type has much greater brightness ranges than it can handle. The frequency quoted figure is 15 to 1 contrast range. This is certainly true.

MR. FOWLER: It's not true of electro-optic modulation where you're using cross polarizers. It is not difficult to achieve very large dynamic ranges.

MR. BEISER: Well, I think the point is that it's possible, if I'm interpreting it right, to achieve dynamic ranges by modulating laser beams which exceeds those on a phosphor, for example, on a CRT. And if we go to an active screen, we may throw away what might have been an advantage.

Any other questions from the audience?

MR. WILLIAM GOOD, General Electric: I have two questions. The subject of speckle has been passed over apparently lightly. I would like to hear more about that as far as human beings viewing the screen.

Number two, has anyone noticed any deviation from the usual additive colors regarding spectral purity?

MR. BEISER: Chuck, do you have any comments about speckle?

MR. BAKER: Speckle is relatively easy to get rid of if it really bothers you. Just by moving the screen or by putting a moving diffuser in the optical path speckle is easily removed. Since speckle is much smaller than image detail, it doesn't seem to bother most people. This is especially true for untrained operators.

MR. BEISER: To summarize the speckle problem, or the relief of a problem, the approach is to either move the screen or move yourself. It's easier to move the screen. And this is what has been provided in most cases.

DR. ADLER: Could either Vernon Fowler or Charles Baker comment on the following question? What is the difference between the monochrome and trichrome displays?

MR. FOWLER: This is the comparison of standard color display and the three-color laser display based on argon lasers.

The color gamut is certainly not the same. In some respects, it seems to be a little better and somewhat worse in another respect.

[At this point Fowler refers to the C.I.E. color diagram—Ed.]

Particularly the green appears to be most favorably placed to enlarge the color gamut and the blue is rather unsatisfactorily compared to say 450 inch microns because at that wave length you'd have a much bigger separation between illuminant C which represents white light and the lower line of the triangle. In that area, of course, is where you represent purple.

We will have a less purple display with lasers until we get a shorter wavelength blue line. This isn't a totally bad situation because although this diagram doesn't show it very well, that's a variation of luminous efficiency along the perimeter of this curve.

And with the longer blue wave length, we've got significantly more lumens per watt. You don't frequently run into purple in most objects. I imagine if you look around the room with the lights on, you won't see any purple.

The reds seem to be not too badly placed. There's not much difference between the television red and the laser red. If we had the television red in a somewhat shorter wave lengths, we have better efficiency.

You'll notice there's a desaturation along the points of the curve between the red and the green. I really don't know if it's bad as ordinary color television, but I think it's away from the complete color saturation that might be avoided if there were objects that were very well saturated in the green-yellow region.

On the other hand, there are papers from RCA which I can cite reference which show the color gamut available from ordinary dyes, pigments and so forth. That's all very nicely contained within the color gamut of ordinary color television.

So you don't ordinarily run into well saturated colors in the region above the television color gamut.

MR. BEISER: There's another half of the question that was just asked, I think, and that was regarding the spectral purity. It's the consequence of the very high spectral purity and how it affects our perception. Was that the other half?

MR. GOOD: Yes.

MR. BENNETT SHERMAN: I thought I might answer this because I've looked at the problem. One of the things that is somewhat overlooked is the so-called problem of metameric color. There is a whole host of colors which we see in normal life which are represented, not by three pure colors, but maybe represented by a more complex function of reflectivity throughout the spectrum.

And in general, you find systems involving extremely narrow emissions, highly saturated. They tend to produce irregularities in the metameric color problem where this may not be true in some of color television displays where the emissions are broader to, perhaps, pick up some of the illumination reflected by the subjects.

This is a serious problem, for example, in the reproduction of pastel colors which sometimes are represented by a complex reflectivity function of visible light; skin tones being one of them. This is one of the drawbacks of systems involving extremely well saturated and highly pure primary colored systems.

MR. BEISER: Thank you very much. I'd like to identify what appears to be a very sensitive point raised at this discussion, and that is the ability to cover the gamut in tone throughout the range of the tri-stimuli indicated on that system (C.I.E. color diagram).

I wonder if any one of you could, or anyone else who has had experience in attempting to reproduce pastel-like or skin-like tones with these highly saturated colors. Any comment on that?

Speaking: Dr. Dennis Gabor. L to R: Leo Beiser, Dr. Adler, Dr. Anderson; Mr. Baker, Mr. Fowler, Dr. Pole, Prof. Bennett

MR. FOWLER: Very brief comment. The answer for us is no, but that's one of the things we intend to do.

MR. BAKER: The color television system we've operated did operate with standard color television broadcasts and standards. We've done very well as far as for untrained observers in reproducing flesh tones. Very acceptable displays were possible.

One rather curious aspect, though. We've had great difficulty in photographing the color displays produced by a laser display. The emulsions in conventional color film don't match up with the lines of the argon and helium lasers.

In fact, if you looked very closely in some of the slides of the color systems, the blue and green lines are quite difficult to tell apart. You have no difficulty at all when you actually look at the argon laser; in fact, the green line in the laser is almost yellowish.

I suspect there's some sort of Land phenomena here, following Land's concepts of the eye forming a long and short wave records of the scene. You can tell a color scheme very easily.

MR. BEISER: I have some comment on that. I have recently investigated the exposure of photographic emulsions to specific laser lines and became involved in the investigation of almost all color emulsion spectral characteristics. The problem appears to be the spectral sensitivity of the emulsion; some blue and green sensitized layers overlap with almost equal sensitivity to 4880 Å; sometimes with inadequate separations with respect to the spectral lines that are being used to expose the film.

So that the emulsion, not knowing what is happening, responds to its proportionate sensitization, and therefore you get this blending of color in the photography of the laser light which is not really apparent to the human eye.

One must select the emulsions very carefully in order to photograph the laser with color film.

PROF. BENNETT: It seem to me with kodachrome if you over-expose it, it turns yellow in practically any color.

MR. BAKER: In the field of color, we probably know less about color than we did 50 years ago.

MR. BEISER: I have a question over there.

MR. BLUM: I think we shouldn't lose the opportunity to ask Dr. Gabor what he sees in the future in an area which has just been touched over lightly, and that's holographic display, perhaps three-dimensional and three-color photographic displays. Would you care to comment on that?

DR. GABOR: What do you mean by display?

MR. BLUM: A means providing presentation for us in the same way we might be looking through a window or be able to observe information which is being put at us.

DR. GABOR: Looking at the real time scenes?

MR. BLUM: No.

DR. GABOR: Looking at pictures. What we need, in order to make it perfect, is the photographic material to be perfect. What you need for recording a color picture is a good combination of laser color and photographic material.

Then with regards to the second question which is one we'll discuss in more detail, regarding photographic image transmissions. Here we have a terrific handicap because we start with something like a factor of 10,000 times too much information. There is a wealth of information (which is not being used in normal viewing).

MR. STEPHEN HANT (RADC): I was wondering if someone on the panel might be willing to comment on the photochromics; something of this type where you would write on it with a laser and project through it. Also about a group of U.V. lasers.

MR. BEISER: Perhaps we could ask Professor Bennett to answer the second part. Then we'll get back to the first part.

PROF. BENNETT: There are large numbers of pulsed laser transitions that have been observed in gases, extending down to, perhaps, 2300 Angstroms. The CW cases are much less copious, however. Of the presently-known CW cases the ionized neon transitions at about 3300 to 3400 Å are the most powerful.

MR. BEISER: The problem is that photochromics are rather insensitive, and their peak spectral sensitivity is somewhere in the 3500 Å range. Is that part of what you were looking for?

MR. HANT: Right. And also the reason I brought this up is one of the obvious things that comes to mind here is the fact that photochromics do have some storage. So you might be able to make use of this which would cut down your scanning rate.

I'm wondering is there anything available in the way of photochromics for this application now? Do you foresee any progress in this area?

MR. BEISER: Would you like to take that?

DR. ANDERSON: One or two comments on that. First, most photochromics write the information in the form of an absorption band which is induced in the material. If you want to write a hologram and then read it out this way, this is catastrophic, because absorption holograms are inherently of lower efficiency. The efficiencies are less than a few percent.

So in order to get a hologram with an efficiency of 50 percent or greater, it's necessary to get a material in which you make only a phased perturbation. There are materials in which this has been done. And it's a very attractive field right now.

There are also a variety of materials where instead of inducing an index change directly within the bulk of the material, you etch or otherwise deform the surface, thereby getting a substantial change in the phase of either the reflected or a transmitted wave.

So my only comment here is that you must look for materials of that sort if you you're looking for a high efficiency holographic display device.

MR. BEISER: There may be a further comment regarding the use of photochromics, or equivalent, in that, in general, they are much less sensitive than silver halides and therefore require far more excitation energy to provide the transition in density.

So, back we go again to the laser power; it's somewhat of a vicious circle, although it's not inappropriate to seek such less sensitive materials and their application.

There is some progress in dry silver, incidentally, which I'm sure you're aware of. It is a siver halide which is processed by a non-liquid method which is far more sensitive than photochromics, and may be sensitized in a specific spectral region. This would be a real-time storage and access capability.

MR. WALTER LUCIW, UNIVAC: I would like to direct to the panel a general question about deflectors, and how they can be used in the computer type of information gathering.

Let's assume that it's a thousand by a thousand spots. I would like to know what type, in other words, what material I could presently use now or in the future. Or is it possible at all?

MR. FOWLER: We, of course, considered the relevance of electro-optic deflectors for this aplication. You're really dealing with two functions. The stroke generation of character and the positions of the character.

It seems you'd use two devices in tandem. Start with light from the laser and run it through an electro-optic or some other device of similar speed capabilities device that has enough resolution capability to accommodate the format.

That would be 20 by 20, for example. Then pass that beam through a high resolution device for positioning the spots.

It turns out—this is an unpublished theory—but writing speed for stroke character generation can be shown to be equal to the bandwidth.

In other words, the number of spots per second, in generating a character, is about equal to the bandwidth of the deflector in cycles per second.

Now that's just for the actions of writing the character. The positioning of the character is another thing. You have two kinds of transients involved. In writing a character, you're generally dealing with combinations of ramp functions.

And the transient dies down to give you a finite area after a time. And that finite area does not affect the character.

In positioning, you're not writing. You wait until you get in position. And that generally is a step function type of thing with a pretty tremendous transient.

But when the step function is over and when you wait for things to slow down, you're in a rather fortunate position. It doesn't make any difference what trajectory the spot took to get into its next position. As long as you're prepared to wait for it to get there.

I think you can arrange for the positioning time for some applications to be comparable to the time it takes to draw a typical character of say something like 30 separate spots. That means then that you could probably do, in some applications, as well as writing speed, about a half or a third of what you would take if all you had to do was draw the characters.

In other words, you figure it out for yourself. You do a pretty nice job with 20 kilocycles, in fact.

DR. ANDERSON: Could I add just one comment on that. I think the answer to your question which Vernon has really given is that if you want to have a very high speed deflector which has a resolution of a thousand by a thousand, it can't be done that way.

So you've got to use some tricks. And Vernon mentioned one particular trick for getting a large number of resolution elements which apparently do for a lower capacity speed product.

In the sort of optical memory applications that we've looked at, we use another trick which is to use a high speed deflector of limited capabilities but multiply it in a different fashion.

Using a holographic technique, we were able to store many bits of information at each address and then use electronic separation to get at the different bits.

MR. JAMES LIPP, IBM: There was a discusion by Pierce Siglin of the Fort Monmouth Signal Corps about a year ago in terms of displays. That work was done by our group. I'd like to comment just a little in answer to what was raised here in terms of speed and access and electro-optic deflection systems.

Several years ago, IBM developed and delivered electro-optic digital deflection systems that had capabilities of a thousand by a thousand spots. And there were diffraction-limited spots in which the actual spot size was measured to be about 40 microns in terms of resolution.

Since then we've also done a lot of work on the electronics and we're able to deflect these at rates of up to 100 KHz with 3 μsec access times.

I think Larry Anderson has seen some of this work up in Poughkeepsie. I'm surprised he hasn't mentioned some of this in digital deflection systems. It's well published.

I just want to end it with that. You can look this up at the library. It seems to me that a lot of stress has been put on acousto-optics.

MR. BEISER: I'm glad you brought that to our attention. Many of us are aware of that. I'm glad you pointed it out to the audience.

DR. ANDERSON: I certainly didn't want to ignore digital light deflector. I think I pointed out that that's one of the two operating systems. About the work that the IBM has done, the only reason I said that in answer to that last question, (why 1,000 by 1,000 couldn't be done) was that I was thinking of access times in the one micro second region or less.

I believe it's still fair to say that that hasn't been done by anybody, although the electro-optics is the closest one.

MR. LIPP: I'd like to point out we haven't reached one, but we've reached five μsec access time.

MR. BEISER: Microseconds per spot?

MR. LIPP: That's right. I'd like to also point out one other thing. And that is that there were certain ways of forming characters on the screen. It's possible to have a mask with all the symbols and characters that are required in any alphabet, including a Chinese alphabet.

Instead of trying to get a memory to store all that information, you have the information already stored in characters which can be accessed, this screen displaced on a large or small screen.

MR. BEISER: Before we leave this digital deflection situation, I think it's only fair to point out that of the efficiencies that Vernon Fowler was speaking, (regarding the 50% losses of a typical system) it must be indicated that the digital deflection system, which IBM developed very effectively, has high resolution but suffers from severe optical transmission losses. Perhaps you might want to make a comment about that.

MR. LIPP: Well, that's in direct proportion to the number of spots you have because the losses depend on the number of deflector cells which you have in the path of the beam

In general, the cells that have been built today have an optical transmission efficiency of about 97 or 98 percent. So that if you go to a system of 2 to 12 or a million spots, it's possible to have attenuation of 80 or 90 percent throughout the system. That's one of the benefits of using a laser. Even if you throw away 80 or 90 percent, you still have enough energy left for whatever you want to do with it.

MR. BEISER: However, I think we really canot ignore this power thing as easy as that, as far as display applications are concerned.

MR. LIPP: It depends on the size of the screen.

MR. LEROY JOHN, Eastman Kodak Company: I recently read a summary of an article which was on a spherical cavity, reflector cavity, rather than the cylindrical one. And it was said that this spherical cavity was much more efficient than the cylindrical one.

I wanted to ask anyone on the panel if they could tell me if they had been exposed to the use of a spherical cavity, about the thermal distribution within a rod, over a sustained period, particularly when you wanted to apply this in a continuous synchronized mode. Would the thermal distributions be concentrated basically in the center of the rod and thereby increase the light intensity?

MR. BEISER: I think I'm interpreting you correctly. Is this the Westinghouse development that you speak of?

MR. JOHN: I believe this is. I'm not certain.

MR. BEISER: If this was a pumping technique that Westinghouse developed, the pumping source was located adjacent to the center of a spherical mirror. Is that the system?

MR. JOHN: Yes.

Speaking: Dr. Adler. L to R: Mr. Beiser, Dr. Gabor, Dr. Anderson, Mr. Baker, Mr. Fowler, Dr. Pole, Prof. Bennett

MR. AIL: I have two questions which are somewhat fundamental. I think the first one has been reasonably covered but I wonder if I can get any additional elucidation.

In addition to the hologram and aside from the advantages that we have which have already been covered by Dr. Pole regarding coherence, does the panel foresee any additional applications which make use of the coherence of the laser beam?

DR. POLE: This is the work that was done by Charles Church of Westinghouse. But I wouldn't be able to answer the question as specifically as you ask.

MR. BEISER: This is an optical pumping technique rather than a resonator which it might have been interpreted to be at first. Bob Pole has investigated resonators of that particular type. But, I think that spherical mirror was for optical pumping only. Any other questions?

MR. BEN ACKERMAN, CBS Laboratories: To return for a minute to electro-optic deflectors, especially in regard to coherent light, I'd like to ask if any of the panel would like to mention whether or not such a deflector, presuming that it operates on a change, a spacial change, can be truly coherent, can a light beam deflector through such a beam remain actually coherent? I think there was some work done, and I don't know what the results were, that if you have a spatial variation in the index refraction, can you maintain coherence?

MR. BEISER: The consensus, I think, is that coherence (to the extent that we require coherence) is for all practical purposes unaffected, so long as the change in refractive index is gradual and continuous.

However, if you measure the quality of the light traversing the gradient deflector in terms of the aberrations, (the geometrical distortions which may be inserted in the wavefront) then there are problems which do develop. And this was analyzed and was published*, in terms of the limiting number of achievable spots per scan.

The second question which I address to Professor Bennett has to do with the status of the theory in terms of being able to predict what their powers will be and what frequencies. Why is there so much difficulty in determining what's going to happen?

DR. POLE: I'd like to make just one comment in response to this question. One of the possible future applications of such deflecting devices, which is being seriously considered, could be the application to scanning radars.

MR. BEISER: Before we go through the question about the difficulty in predicting laser lines, which I hope Professor Bennett can help us out on, another consideration regarding coherence is, again, super-resolution; an area in which we don't normally get involved for real-time display.

But, by virtue, of the high spectral purity of the laser and its coherence, it may be focused to a very, very fine spot, and this spot is diffraction-limited. This is another case where the coherence and the laser light is now being utilized.

Now from Dr. Bennett, about the difficulties in establishing laser lines.

PROF. BENNETT: The first part of the second question dealt with the status of the theory. I think on the whole it's pretty good. There are various aspects to this problem and they have been worked out in considerable detail, particularly regarding the interaction of radiation with a limited number of states—particularly the small-signal and intermediate field limits. There are some problems that still require additional understanding, particularly aspects of the problem involved in the nature of broadening processes in certain cases.

So, why can't we just sit down and predict everything in advance? I think the basic answer to that question is that there is an enormous complexity to real systems in that there are many levels involved. Also, in order to give a complete description of a real system you generally need an enormous amount of data, oscillator strengths and probability data for both the laser transitions and the other transitions involved in the atom. In point of fact, there are very little of these data available. If one goes through a standard course in atomic physics or quantum mechanics, you spend most of

*L. Beiser, "Generalized Gradient Deflector and Consequences of Scan of Convergent Light", J.O.S.A., Vol. 57, No. 7, 923-931, July 1967.

the time discussing the hydrogen atom. You then go out into the world thinking that everything can be solved—but you probably never come across the hydrogen atom again.

The hydrogen atom is very well understood. Helium is almost in as good a shape. Frequently in real life, however, you are interested in things like argon or ionized neon or highly excited states of these atoms and ions.

In fact, there has been almost a total lack of existence of data for excitation cross sections for electron collisions with excited states of neutral or ionized atoms.

I think we are just beginning to enter into an age where it will be realistic to calculate many of these things using digital computers. In fact, this is an area where there's considerable activity going on now in the Soviet Union.

One additional problem aside from the lack of data, occurs in the question of how to handle the data (even if you had it). Obviously one would need to write computer programs to work out the properties of real systems. The only specific cases that I recall in detail along these lines have been ones that really did not lead to particularly useful results. In fact, there's a certain validity to the notion that one really should investigate many of these things with analogue computers. In particular, an analogue computer made up from a pair of mirrors separated by the medium in question is a most useful way to investigate the problem.

DR. POLE: I want to add something. I just wanted to say that as far the various deflection systems go some are good for some applications and some are good for others.

Furthermore, it has been indicated here that there are limitations on the response time in the various deflection systems. I happen to believe that we are going to have fairly fast deflection systems in the near future.

However, this still does not necessarily say that the deflection of coherent light will give us something useful in the area of displays until and unless we solve some other problems such as the problem of how to take an advantage of the coherent light.

MR. BEISER: I want to thank the panel for their very precious time and very important contribution to our knowledge and understanding. I hope that we all have benefited from this meeting.

I wish to acknowledge my sincere gratitude to the following people, who gave so much of their time and service to make the Laser Display Seminar a success: *Robert C. Klein,* Kollsman Instrument Corp.; Business Manager *Thomas Maloney,* Burroughs Corp.; Facilities Chairman *Leon Weissman,* The Computer Exchange, Inc.; Publicity Chairman *Martin Waldman, Information Display Publications;* Local Publications Chairman *Gordon Burroughs,* Burroughs Engineering; *Bennett Sherman,* General Telephone & Electronics, President of the Greater New York Section OSA.

Also, sincere appreciation to: *Jim Ogle,* Burroughs Corp., Facilities Services; *Mrs. Leslie Conron,* CBS Labs Office Manager and Hostess; *Mrs. Rose Bianchi,* General Telephone & Electronics Hostess; *Albert Fournier* and *Calvin Yee,* CBS Labs, Editorial Assistants. Also to *Mr. John Acuff,* executive Director of the Society of Photographic Scientists and Engineers for welcome cooperation in his nationwide distribution of our program announcement through the S.P.S.E. mail facilities.

Photograph on page 36 courtesy of Technical Operations West Inc., Mountain View, Calif.

ROBERT ADLER was born in 1913 at Vienna, Austria. He received the Ph.D. degree in physics in 1937 from the University of Vienna. The following year, he was assistant to a patent attorney in that city. From 1939 to 1940, he worked in the laboratory of Scientific Acoustics, Ltd., in London, England.

After one year with Associated Research, Inc., in Chicago, he joined the research group of Zenith Radio Corporation in Chicago in 1941; he became Zenith's Associate Director of Research in 1952 and Director of Research in 1963.

Dr. Adler has been active in two fields—electron beam tubes and ultrasonic devices. His work in the vacuum tube field includes the phasitron modulator used in early FM transmitters, receiving tubes for FM detection and color demodulation, transverse-field traveling wave tubes, and the electron beam parameter amplifier. In the ultrasonics field, his work includes an electro-mechanical I.F. filter at an early date (1943) and, later, the development of ultrasonic remote control devices for television receivers. In recent years he has been active in the field of acousto-optic interaction.

Dr. Adler has been a Fellow of the IEEE since 1951.

WILLIAM R. BENNETT, JR., did his undergraduate work in physics at Princeton University (B.A. in 1951) and obtained his Ph.D. in physics from Columbia University in 1957. He was an Instructor in physics at Yale University from 1957 - 1959 where he worked on inelastic collision processes and resonance experiments in gases.

From 1959-1962 he was a Member of the Technical Staff at Bell Telephone Laboratories where he collaborated in research leading to development of the first several dozen gas lasers. In 1962 he returned to Yale University where he is presently located, as Professor of Physics and Applied Science and Director of Research in gas laser physics.

He is co-author on the basic patents on the first several gas lasers and has published more than 50 papers on laser problems. He was awarded the Morris Liebmann Prize of the IEEE in 1965 for basic contribution to the theory and realization of laser oscillators. He was an Alfred P. Sloan Foundation Fellow from 1963-1965, and a John S. Guggenheim Foundation Fellow in 1966. He is a Fellow of the American Physical Society, a Fellow of the Optical Society of America and a Senior Member of the IEEE. He is also a member of the Editorial Advisory Board to Journal of Applied Physics, Applied Physical Letters and Journal of Quantum Electronics.

LEO BEISER, Staff Physicist, Intelligence Systems Department of CBS Laboratories, is responsible for research and new development in image and information technology.

Mr. Beiser completed his Masters and Bachelor Degrees in Physics at Hofstra University, Hempstead, New York. In 1948, he graduated with honors the E. E. Course of RCA Institute, and in 1958, the Business Administration Course of Alexander Hamilton Institute.

Prior to joining CBS Laboratories in 1963, Mr. Beiser served as Staff Research Specialist with The Autometric Corporation, Division of Raytheon; as Research Manager at Telechrome Manufacturing Corporation, Long Island; and as Staff Consultant with the Radio Receptor Company, Hicksville, Long Island.

His many patents and disclosures relate to laser scanning, electronics, mechanics, microwave, character generation, and display. In addition to Chairmanship of the *SID* Mid Atlantic Chapter, Mr. Beiser is a member of the A.P.S., the O.S.A., the S.M.P.T.E., and the S.P.S.E.

L. K. ANDERSON was born in Toronto, Canada, on October 2, 1935. He received the B. Eng. degree in engineering physics from McGill University, Montreal, Canada, in 1957 and the Ph.D. degree in electrical engineering from Stanford University, Stanford, California, in 1962.

In 1961 he joined Bell Telephone Laboratories, Murray Hill, New Jersey, where he worked on magneto-optical interactions, microwave ferrite devices and high-speed semi-conductor photodetectors. Presently, he heads a department, in the Solid State Device Laboratory, engaged in exploratory work on ultrasonic devices and optical memory components. Dr. Anderson is a member of the IEEE.

VERNON J. FOWLER received the B.S. degree in electrical engineering from the Milwaukee School of Engineering, Wisconsin, in 1949, and the M.S. degree in electrical engineering from the University of Illinois, Urbana, Illinois, in 1951.

Upon graduation, he was employed by the University of Illinois as a Research Assistant working on broadband amplifiers and delay line structures. Since 1956 he has been a member of the Research Staff of the General Telephone & Electronics Laboratories where is currently Manager of the Optical Devices and Display Group. His research has included studies of backward-wave magnetrons, hot carrier effects at millimeter wave frequencies, ceramic traveling-wave tubes, the electro-optic effect in crystals at microwave frequencies, gas lasers, optical modulators, and beam deflectors.

Mr. Fowler is a member of Sigma Xi, Pi Mu Epsilon, IEEE, *SID*, and OSA.

CHARLES E. BAKER received his B.S. degree from Oklahoma State University and his M.S. degree from Washington University, both in electrical engineering. He is Manager of the Optoelectronic Systems Branch at Texas Instruments where he directs a group that is applying coherent optics technology to signal processing and display problems. He is also a consultant to the Department of Defense.

Mr. Baker has been closely associated with development of the laser display concept, his work having resulted in a laser generated image being produced from a television broadcast in 1964. He has also been active in the development and application of coherent optical data processing techniques to communications, radar, sonar and seismic signal processing problems. Mr. Baker is a member of *SID*.

DR. DENNIS GABOR, who produced the world's first hologram 20 years ago by reconstructing objects in three-dimensions onto a photographic plate through interference patterns, formerly was professor of Physics with the Imperial College of Science and Technology, London. He is now Professor Emeritus of that institution.

As senior staff scientist for CBS Laboratories, he will direct development efforts in holography and serve as an advisor on research programs.

Dr. Gabor is well-known throughout the science community for his pioneering contributions in the mathematical theory of communication and electron optics, which have led to practical applications in such areas as frequency compression and color television. In 1967, he received the Christopher Columbus Prize .The international prize is awarded annually to outstanding men of science who have contributed most to the progress of navigation, communication and telecommunication.

He is one of the first in his field to be made a Fellow of the Royal Society, Britain's oldest scientific society. He is also a Fellow of the Institute of Physics, a Fellow of the Television Society, and a Fellow of the Institute of Electrical Engineers.

Dr. Gabor is the author of numerous papers on communication theory, which have been published on a worldwide basis. His book on social problems, entitled, *"Inventing the Future"* has appeared in seven languages.

ROBERT V. POLE was born in Yugoslavia and graduated in 1953 from the University of Zagreb with the Yugoslavian equivalent of DEE. He has also studied Physics at Syracuse University. He is currently the Manager of the Optical Physics group at the IBM Thomas J. Watson Research Center in Yorktown Heights, New York. He is the author of eighteen technical papers and numerous oral papers in the field of displays, lasers, light deflection and holography. He is a member of the OSA and IEEE.

President's annual report 1968

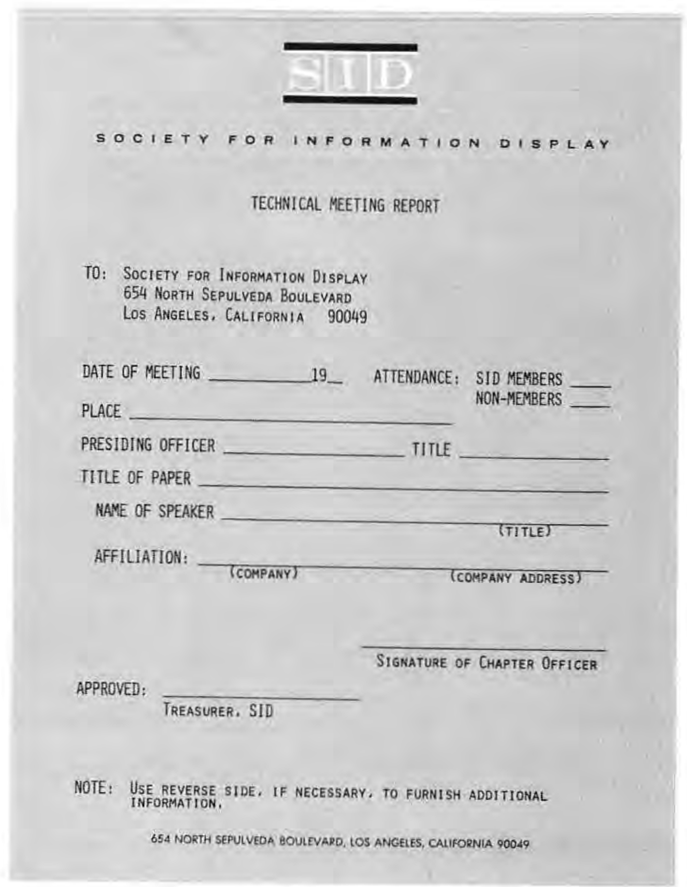
by
WILLIAM P. BETHKE,
President, Society for Information Display

The *SID* is now a *going* organization. From an idea, it has grown and developed into a realization. And, as with any composite body, it is a synthesis of many ideas and suggestions; a working entity of many motivations and plans. To survive beyond the embryo phase and *go*, it must have direction. It must know *where* it is going. Basic to any organization on the move *forward* are *goals*. A reliable measuring device for ascertaining the validity of an organization is a re-assessment and analysis of its goals. Let's consider *SID's*:

> *To conduct these activities and achieve these objectives without pecuniary profit to its directors, officers or members; any balance of money or assets remaining after the full payment of corporate obligations of all and any kinds shall be devoted solely to the above stated purposes of the society.*

Last year we reported the establishment of a central office. At that time, we were furnishing it, setting up procedures, and formulating office policy. These efforts are now accomplishments. Approximately 300 telephone calls and 350 letters are handled each month, and the rate is increasing. The cost of operating the office is about $1400 per month. No small expenditure, granted; but the service rendered certainly justified the cost.

We were concerned about assisting individual Chapters in carrying out their technical programs and assuring good attendance at meetings. We therefore inaugurated a system of paying additional funds ($15) to each Chapter, commensurate with the number of technical meetings it conducts annually. Each Chapter is entitled to an additional base of $50 per year, in addition to basic, per-member rebate (see Figure 1).



SID

SOCIETY FOR INFORMATION DISPLAY

TECHNICAL MEETING REPORT

TO: SOCIETY FOR INFORMATION DISPLAY
654 NORTH SEPULVEDA BOULEVARD
LOS ANGELES, CALIFORNIA 90049

DATE OF MEETING ________ 19__ ATTENDANCE: SID MEMBERS ____
NON-MEMBERS ____

PLACE ________

PRESIDING OFFICER ________ TITLE ________

TITLE OF PAPER ________

NAME OF SPEAKER ________
(TITLE)

AFFILIATION: ________ (COMPANY) ________ (COMPANY ADDRESS)

____
SIGNATURE OF CHAPTER OFFICER

APPROVED: ________
TREASURER, SID

NOTE: USE REVERSE SIDE, IF NECESSARY, TO FURNISH ADDITIONAL INFORMATION.

654 NORTH SEPULVEDA BOULEVARD, LOS ANGELES, CALIFORNIA 90049

All in all, in studying the financial report (see Figure 2), we note that although expenses have increased over previous years, our general fund balance has also increased significantly. *Our first objective is met. I consider the Society in excellent financial condition, and I believe we will maintain this favorable status.*

	YEAR ENDED JANUARY 31 1968	1967
INCOME:		
Dues	$29,982	$14,946
Profit from sales of journal	9,281	5,974
Net profit (loss) from symposiums	2,487	(2,868)
Sale of *SID* reports	1,137	—
Interest on savings account	1,040	702
Sale of pins	277	—
Total income	44,204	18,754
EXPENSES:		
Office salary	5,700	—
Chapter operations	4,561	1,973
Stationery, printing and office supplies	4,414	148
Rent	1,800	—
Professional fees	1,373	750
Postage and mailing	910	1,489
Printing of directory	745	512
Election expenses	597	762
Telephone and telegraph	501	—
Travel and entertainment	455	619
Insurance	431	385
Payroll taxes	357	—
Awards	305	—
Typing services	286	—
Office management	250	3,173
Maintenance	131	—
Depreciation	108	—
Label pins and tie tacks	—	467
Total expenses	22,924	10,278
EXCESS of income over expenses	21,280	8,476
GENERAL FUND BALANCE at beginning of year	27,755	19,279
GENERAL FUND BALANCE at end of year	$49,035	$27,755

FIGURE 2: STATEMENT OF INCOME AND EXPENSES

> *To promulgate definitions and standards pertaining to the field of information display.*

As reported last year, the Standards and Definitions Committee is comprised of one member from each Chapter, who, in turn, is Chairman of his Chapter Standards and Definitions Committee. Assignments which had been made to the Chapters were to formulate and prepare definitions in the areas of (1) Resolution, (2) Colorimetry and (3) Luminance and Luminance Discrimination. The definitions in each of these areas placed emphasis upon those terms which define measurements of significant display parameters.

To date, four Chapters (Washington, Los Angeles, San Diego, Northeastern) have completed their assignments and have provided initial drafts of proposed definitions in the areas of resolution and luminance. Copies of these drafts have been provided to each Chapter committee and they are currently involved in critiquing and reviewing the work of the other Chapters. It is planned that the resultant material will be reviewed at a meeting of the National Committee prior to the preparation of a final recommended draft for submission to the membership.

The objective of maintaining a central depository has always been a basic one since the origin of the Society. However, beyond the rather meager beginning last year (establishment of a permuted index), very little work has been done in this area. *The Society is not meeting its objectives in this area and must; therefore, reassess the approach and, if necessary, provide financial assistance to give more impetus to the program.*

> *To encourage the scientific, literary and educational advancement of information display and its allied arts and sciences, including, but not limited to, the disciplines of display theory, display devices and systems development, and the psychological and physiological effects of these display systems on the human senses.*

During the past year, the new Philadelphia-Delaware Chapter has been added, with representation to the National Committee, and is at work with the rest of the Chapters in performing the technical review mentioned above.

It has been extremely difficult to get this program underway. People talk excitingly about it but can't get enough people together at one time in one place to work something out. Perhaps we, being engineers, might be acting too conservatively in not announcing some standards and definitions for fear of criticism. *Perhaps we should set up "straw-men" and let them be picked to pieces and perchance something constructive may come of it.*

> *To provide forums, by establishment of a journal and regular conferences, for the exchange and dissemination of ideas relating to the field of information display.*

One of the major functions of any Society is the exchange and dissemination of ideas relating to its field. In this regard, our symposium in San Francisco provided an excellent forum for such an exchange. Both the facilities and technical program were of the highest caliber. Further, the technical meetings held by the Chapters throughout the country, have also been extremely well chosen and appropriate to our field. Each Chapter has been invited to participate in national activities by suggesting appropriate dates for hosting either the annual symposium or the technical meetings. The schedule to date follows:

	Symposium (Spring)	*Technical Meeting (Fall)*
1968	Los Angeles	New York
1969	Washington	San Francisco
1970	Minneapolis	———
1971	Delaware Valley	———
1972	San Francisco	———

In addition to the normal *SID*-sponsored symposium, the Society structured a session at the Fall Joint Computer Conference of AFIPS which was extremely well attended (standing room only). It appears that we will become a regular part of that program since we expect to participate in the next Fall Joint Computer Conference (December 1968). *The Society is meeting its objectives in this area.*

> *To maintain a central repository for data relating to information display and its allied fields which shall be accessible to all qualified members of the society for research pur-*

The management and advancement of information display and its allied arts and sciences is probably the greatest goal we strive for. Our direction has been, first, to achieve a high level of membership who, as "disciples," could spread the "word." Since the last report our membership has increased by approximately 200, for a present total of 1,500. Memberships denote an international representation (See Figure 3). In addition, three new Chapters have been formed in the Society in St. Paul, Minnesota; in the Southwest at Dallas; and in the Delaware Valley at Philadelphia.

Our membership directory has been revised and forwarded to all members. I think you will notice significant improvements in the directory which make it more usable.

The increase in membership and number of Chapters have forced us to reassess our method of operation. It was felt that the Chapters ought to have representation on the Board of Directors. As a result of a petition, followed by intensive study, new by-laws were prepared and voted upon and accepted by the membership. The implementation plans for the change will begin this year. It will allow for each Chapter to have, ultimately, direct representation on the Board of Directors. In addition, it will call for Regional Directors in those areas where there are few or no Chapters.

To further encourage the advance of the Society, and recognize individual worth, the Society has elected a number of outstanding engineers and scientists in our field to the status of Fellow:

FORDYCE M. BROWN, "for outstanding and significant contribution, as an officer of *SID*, and as an active member at the local level. Fordyce Brown has furthered the objectives of *SID* significantly."

ROBERT C. CARPENTER, "for outstanding and significant contribution. An active member of *SID* at the local level, and as a representative of the Department of Defense, Mr. Carpenter has contributed to the display field and to the objectives of *SID* through his personal support of various development activities and through his efficient counsel to both government and industry."

PHILLIP DAMON, "for outstanding and significant contribution, as an officer of *SID* and as a regional director, and national committee chairman. Mr. Damon's activities at the national and local levels have furthered the objectives of *SID* significantly."

Progress is good but expansion of efforts are still required. In summary, and in retrospect, the Society is now a stable and "going" organization. It must therefore, take its place in our technical world and begin to contribute its technical "know-how" for the advancement of our objectives as well as that of society in general. In pursuit of this objective, *SID* is now affiliated with the American Federation of Information Processing Societies (AFIPS). Through this association we hope to advance the field of information display and its allied arts and sciences.

A re-examination of our position further indicates that, where in the past, we had concentrated on organization, we must now concern ourselves with furthering our technical objectives. In this regard, all the past presidents and other directors were queried as to the direction our Society should move, and to set some goals for the future. In summary, the group reported as follows:

1. A Data Central (repository) is needed and should be established.
2. Effort should be made to develop a better rapport with the Universities to the extent that we would encourage the idea of information display as a separate discipline and that a curriculum be established leading to a degree in information display.
3. More effort be applied to standards and definitions. Here we can make significant contributions.
4. Expand our activities and affiliate, co-sponsor, etc., with other technical societies.
5. Develop short term courses specifically sponsored by *SID*.
6. Expand the membership.

In this report I have tried to convey a concise, yet comprehensive picture of *SID*'s progress during the past year. Some of our goals were met; some were almost met. All indicated that *SID* is on the move. Which is good. Any organization, to endure, must always have somewhere to go. All in all it's been a good year!

Distribution of SID Membership – April, 1968

A "solid-state" electron tube for the PICTUREPHONE set

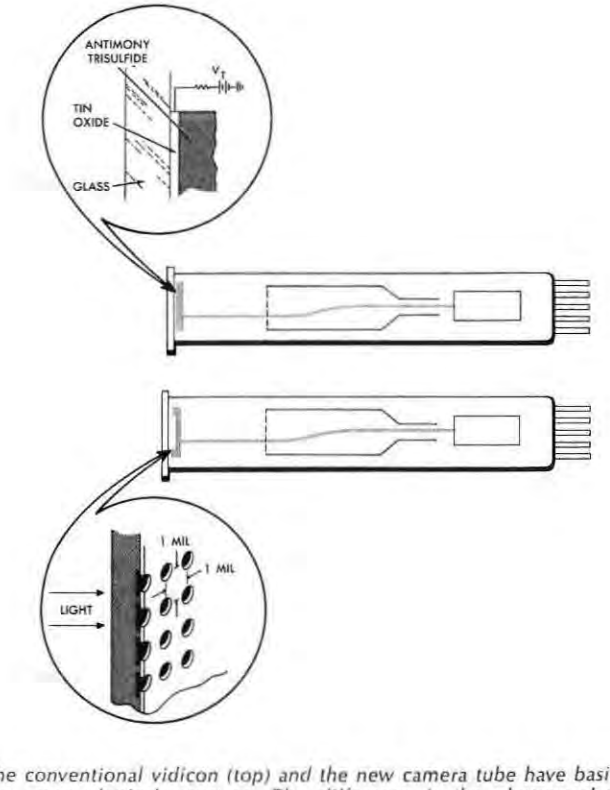
E. I. GORDON
Bell Telephone Laboratories
Murray Hill, N.J.

A new camera tube for the PICTUREPHONE® visual telephone combines some of the best features of the "old" and the "new" arts of electron device design. From electron tube technology it takes the low cost and simplicity of electron beam scanning; from integrated circuit technology, the reliability and sensitivity of a silicon photodiode array. The result is a camera that will operate reliably over an extremely wide range of light levels including exposure to direct sunlight.

Of various camera tubes in use, the small, simple, potentially low cost vidicon is most suitable for *Picturephone* service. It is used, in fact, in the experimental version. Unfortunately, the vidicon is susceptible to several phenomena collectively called "burn-in," which lower its reliability and preclude electronic control of the camera's field of view.

To understand the deficiencies of the vidicon in the *Picturephone* application and how these are overcome in the new camera tube, it is appropriate to begin by describing the operation of the vidicon. A conventional lens forms an image on a photoconducting target which performs the image sensing function. Scanning is accomplished by an electron beam which is focused and deflected in a manner similar to that used in television picture tubes, except that the scanned area is a half-inch square.

The electron beam scans the target



The conventional vidicon (top) and the new camera tube have basically the same physical structure. The difference is the photoconducting target. The target of the vidicon is an evaporated film of antimony trisulfide (or a similar material) about one ten-thousandth of an inch thick which is supported by the face plate of the tube. The target of the new tube is a self-supported silicon wafer about the diameter of a nickel and about eight ten-thousandths of an inch thick in the area of light sensitivity. This area contains an array of about 300,000 diodes formed on the wafer by integrated circuit techniques. Up to 700,000, can now be formed on an area about a half-inch square.

Formation of the conventional interlaced raster. Circular boundary of the illustration encloses the image the camera lens forms on the target of the tube. The rectangular area of horizontal lines—the raster—defines the transmitted image. Each field of the raster is scanned in a sixtieth of a second, the two scannings comprising a frame. Frame rate of 30 per second assures normal animation in the displayed picture. Field rate of 60 per second precludes broad area flicker.

along a pattern of lines called a raster. A complete scan of a raster takes one-thirtieth of a second, a period known as a frame interval. The scanning operation generates a video signal which is proportional to the image intensity at the position of the scanning beam.

In the vidicon, the target consists of a glass substrate which is usually the tube window, a transparent conducting tin oxide film and a photoconducting film less than 0.001 inch thick. Antimony trisulfide is one of the commonly used photoconducting film materials. In the dark the film is a fairly good insulator; when exposed to light, it is a conductor.

In operation the conducting tin oxide layer is held several tens of volts positive with respect to the electron beam cathode. The landing energy of the beam electrons is sufficiently low that fewer electrons than are incident leave the surface by secondary emission. In the area of electron impact (or site) the surface of the film accumulates a negative electronic charge until its potential approximates that of the cathode and additional electrons are prevented from landing. The area of a site, about 0.001 inch in diameter, corresponds to the beam diameter and approximates the smallest resolvable picture element.

It is convenient to consider that each site behaves like a small capacitor. One plate of this capacitor is the conducting tin oxide film opposite the site. The other plate is the surface of the photoconducting film. Since the potential of this surface is established at cathode (ground) potential by the electron beams, the voltage across the film site capacitor equals the voltage applied to the tin oxide film. In the dark this voltage can be maintained for many seconds since the film is a good insulator.

Light enhances the leakage current through the film, causing the film site capacitor to discharge between successive scans of the site by the electron beam. Reduction of the capacitor voltage by the discharge process increases the surface potential since the potential of the tin oxide film is held virtually constant. The degree of discharge, and hence the increase in surface potential, depends on the intensity of the light at the site position. Thus, the surface potential of the photoconducting film exhibits variations corresponding to intensity variations in the image. Since the capacity of the surface relative to ground is negligibly small, discharge of the film site capacitor produces no current in the external circuit containing the target resistor.

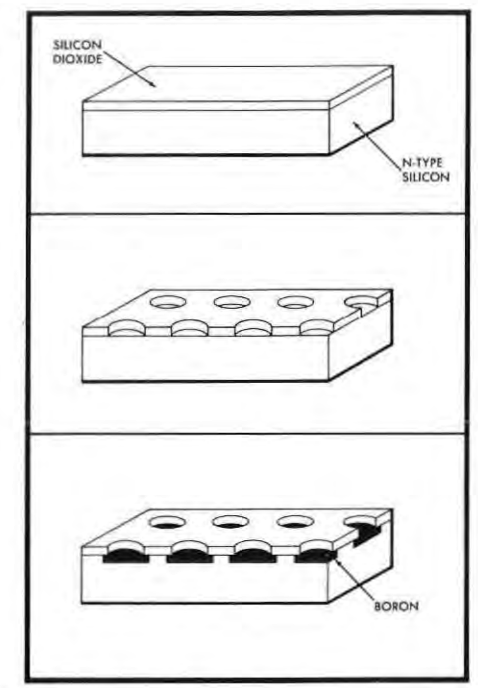
When the scanning beam returns to a given site it quickly replaces all the negative charge dissipated by leakage in the preceding frame interval, thus returning the site to cathode potential. The replacement charge repels an equivalent negative charge from the film-tin oxide interface which flows back to the cathode through the target resistor and ground. Voltage variations produced across the target resistor in this way represent light variations and are uniquely related to the instantaneous position of the scanning spot. This constitutes the video signal.

To sum up the process: the scanning beam sequentially makes electrical connection to each target site capacitor bringing the surface plate almost instantly to ground potential, and recharging the capacitor. The associated charging current constitutes the video signal. As the beam goes on to access all the other sites, the capacitor slowly discharges under the action of the incident light, however, producing no current in the external circuit. The process is repeated and the capacitor is recharged when the beam returns to the site. In general, the resulting video signal does not increase linearly as the intensity of the light increases, but rather more slowly. For example, doubling the intensity of the light increases the video signal by a factor of 1.5. The lack of linearity is related to the manner in which photocurrent is excited in a highly insulating film.

Under normal conditions only a small part of the video signal results from leakage current not produced by the light. Commonly called the dark current of the target, this can degrade the displayed picture if it is not uniform over the target area or if it is too large and discharges the film voltage too rapidly. In the latter case light sensitivity is reduced since the electric field within the film is reduced. Also, charge may spread laterally from one site to the next impairing the resolution.

The burn-in phenomenon, which impairs the usefulness of the vidicon for the Picturephone camera, is associated with damage to the photoconducting film caused by high light levels or electron beam bombardment. If the camera "stares" at an electric light for any length of time, damage to the film may accumulate. The damage shows up as local variations in the dark leakage current and light sensitivity. The viewer sees ghost images in the picture. If the light is from a photographer's flash gun, for instance, burn-in may be instantaneous, completely destroying the usefulness of the tube.

The scanning beam may cause a similar type of damage called raster burn-in. Light sensitivity and dark current differ considerably from the normally scanned to previously unscanned areas of the raster. Therefore, if the size of the raster is increased or its position is changed, the edges of the previous raster are clearly visible in the displayed picture. If it were not for raster burn-in, zooming and centering—which can be accomplished by changing the size and position of the raster to permit transmission of only part of the image formed by the lens—could be done merely by changing voltages associated with the beam focusing and deflection structure.



Major processing steps (sequentially top to bottom) in the fabrication of the diode array. It starts as a silicon wafer several thousandths of an inch thick. An oxide layer about 25 millionths of an inck thick is then grown on the surface of the silicon. Photo-lithographic techniques are used to generate an array of holes in the oxide. Boron is diffused into the silicon through the holes forming the p-type islands. In this step the remaining oxide serves as a diffusion mask.

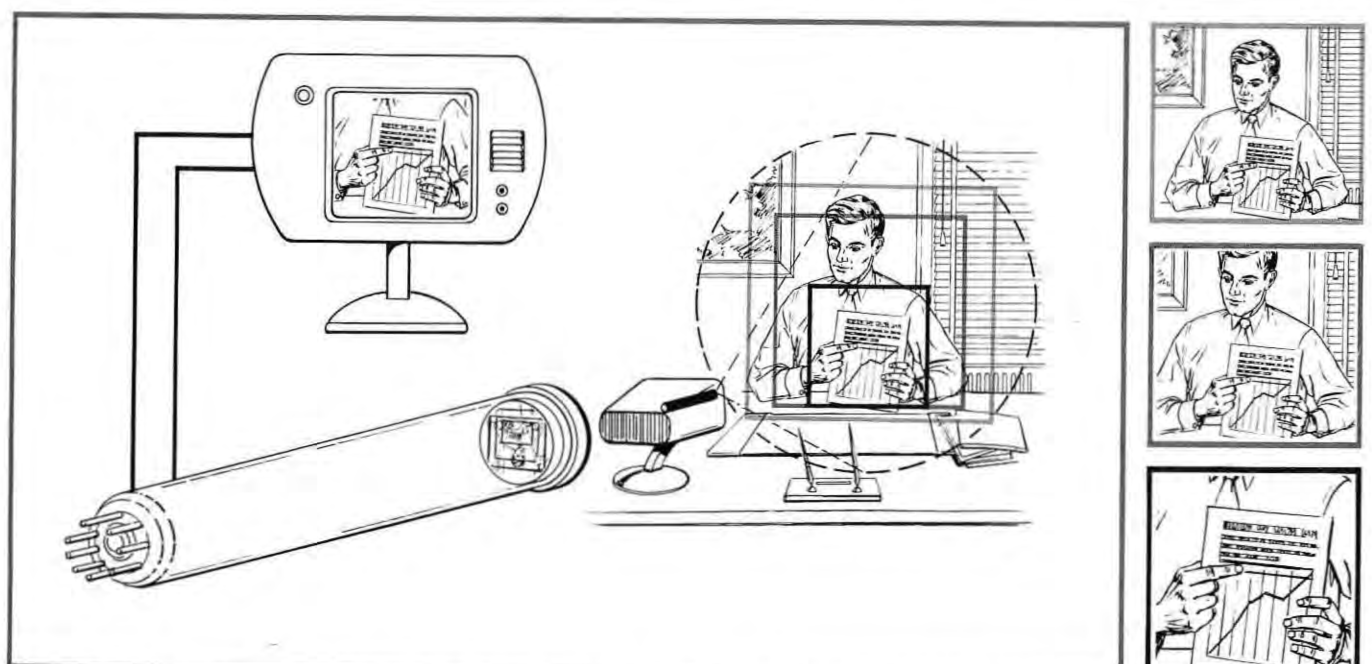
Burn-in damage in the vidicon arises from the intrinsic properties of the photoconducting target film. The film requires extremely low conductivity in the dark and good photoconductivity response to visible light. All known materials suitable for the vidicon and satisfying these requirements are subject to burn-in. Although the precise nature of the damage is not understood it is associated with the fact that these are compound semiconductors in an amorphous state.

Reverse biased silicon diodes have been used as photodetectors and show good sensitivity while being completely free from burn-in. Attempts have been made to construct arrays of such diodes to function as video image-sensing devices. To date these have required extremely complex access circuitry and have posed economic and technological problems which are as yet unsolved.

The design of the new camera tube for the *Picturephone* station set retains the best elements of the vidicon while incorporating the advantages of the array of silicon photodiodes. The electron beam scanning structure is identical to that of the vidicon. Its target structure, however, is an array of reverse-biased diodes on a silicon wafer about the size of a nickel. A typical array, fabricated using integrated circuit techniques, contains close to 700,000 individual diodes in an area about one-half inch square. The extreme simplicity of the array allows fabrication of exceptionally uniform diodes with virtually no defects.

The photodiodes face the electron beam. During operation, the electron charges the surface of the silicon to cathode potential, reverse biasing the diodes. The *n* type substrate maintains a uniform potential (equivalent to the conductive tin-oxide layer in the vidicon) except for a space charge region surrounding each diode. Leakage current per diode is sufficiently small (less than 10^{-14} amperes) that reverse-bias voltage can be maintained for many seconds in the dark. Since the scanning beam is larger than the diode spacing, the discrete nature of the array does not significantly limit the resolution of the tube, and registration of the beam with the rows of diodes in the array is unnecessary. In many respects a diode is analogous to the target site capacitor of the vidicon.

An image is formed on the surface of the light target opposite to the array. The incident light penetrates the silicon substrate and is absorbed, creating hole-electron pairs. Holes are minority carriers in the *n* type material of the substrate. A fraction of them diffuse into the space charge region where the space charge field immediately sweeps them across the junction into the *p* type region or island, thus discharging the photodiodes. This process occurs during the thirtieth of a second between successive scans of the beam. The video signal is created as the scanning electron beam recharges successive diodes along the scanning path. The signal is directly proportional to the number of holes discharging the diode which, in turn, is directly proportional to the light intensity.



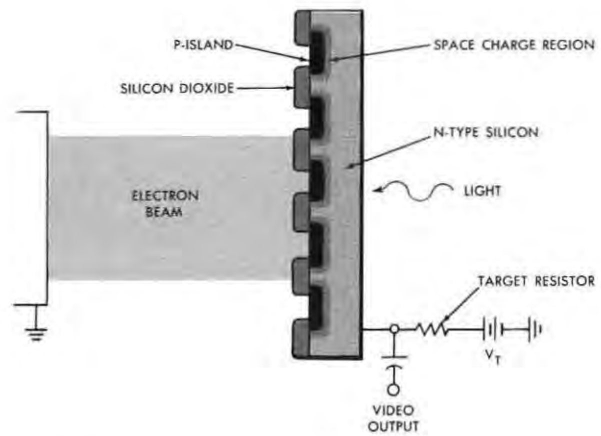
The new camera tube electronically controls the field of view of the displayed image by changing the size and position of the scanned area on the target. The camera lens produces a fixed-size image. The displayed image is defined by the raster which can be varied by varying the beam accelerating voltage or bias current in the deflection coils. At the display unit, the syncronizing information controls only the time of the raster sweeps, not the length or spacing of the lines. Changing the raster size varies the magnification of the scene. Wide angle, normal, and telephoto fields of view are shown at right side.

A number of the holes created in the *n* type region recombine there with electrons and are lost. This reduces what is called the collection efficiency — the number of holes reaching the space charge region per incident photon—and has a direct bearing on the sensitivity of the camera. The greater the collection efficiency, the greater the sensitivity.

Controlling the collection efficiency is a matter of controlling the bulk minority carrier lifetime and the surface recombination velocity which characterize the recombination process. Long lifetimes and low recombination velocities increase efficiency. Moreover, if virtually all the incident light is absorbed in the substrate and if the carrier lifetime, and the surface recombination velocity are fixed, collection efficiency increases as the target is made thinner. As the holes diffuse toward the diode space charge region, they also diffuse laterally reducing the target resolution. The thinner the target, the greater the resolution. The target of the new tube is made as thin as possible—about 0.0005 to 0.0008-inch thick—in the sensitive region. The thicker outer rim provides structural strength. Increasing the target voltage, which increases the reverse-bias voltage, increases the width of the space charge region of each diode. This also increases the sensitivity and resolution. However, the diode leakage current also increases with increase in reverse-bias voltage and only a limited degree of improvement can be achieved in this manner.

Collection efficiency is greater for infrared than for visible light since short wavelength photons are absorbed closer to the surface of the silicon substrate away from the diodes. Visible light (0.4 to 0.7 microns) is absorbed within about 0.0001-inch of the surface. Near-infrared light penetates somewhat further. Holes created deeper in the substrate by near infrared wavelength light have a smaller probability of recombining with electrons before reaching the space charge region. For wavelengths of light greater than about 1.1 microns the target is virtually transparent and the collection efficiency is extremely low.

Early versions of the new tube were markedly more sensitive in the near-infrared than in the visible part of the spectrum. However, improved fabrication techniques have increased the minority carrier lifetimes and decreased the surface recombination velocities. Collection efficiency in recent models of the tube exceeds 40 per cent over wavelengths of 0.4 to 1 micron and it is believed that further improvement is possible. The spectral response is much broader and flatter than that of the vidicon. As a result, it is possible to tailor the spectral response to a specifc requirement by the use of suitable filters. For example, if it is desirable to match the spectral response of the eye, a filter approximating this response can be inserted in front of the tube window. In the Picturephone set application it is necessary to eliminate the infrared response above 0.8 microns since the relative gray scale balance of most scenes is distorted when viewed in infrared light.



Geometry of the new camera tube. The silicon substrate is held at a potential of about 10 volts relative to the electron beam cathode. As the beam scans the diode array, it charges the p-type silicon islands down to cathode potential, leaving the diodes in a reverse-bias condition. A space charge region forms around each island, serving as the collection area for photo excited holes generated in the substrate. The holes are swept across the space charge region partially discharging the diodes. At the next scanning the diodes are recharged, the islands returning to cathode potential. Recharging current flows through the target resistor back to the cathode, creating a video output signal, which is felt across the condenser.

In contrast to the vidicon the signal output is directly proportional to the incident light intensity. For these reasons a direct comparison of sensitivity is not possible. However, under normal operating conditions for the *Picturephone* camera the new camera tube requires only about one fifth the illumination level required for the vidicon. Also, the dark current is several times less than that of the vidicon.

In the vidicon the photocurrent lasts for several frame times, producing image persistence or lag. Lag is eliminted in the new tube because the minority carriers diffuse out of the silicon substrate within a few microseconds—about one ten thousandth of a frame time.

Exploiting the properties of silicon in the new camera tube, has led to other advantages over the vidicon. First, the high thermal conductivity and chemical stability of silicon liberates the new tube from any possibility of burn-in. This leads to the wide range of light levels under which the tube can operate and permits electronically controlled zooming and centering. Second, in contrast to the antimony tri-sulfide used for the photoconducting film of the vidicon, silicon can be baked at high temperatures. Thus contaminating substances can be eliminated from the tube during vacuum processing without damaging the target structure. This increases the life and reliability of the cathode.

The final result is a vidicon-type of camera tube far more sensitive than any now being used and with a potential lifetime several times greater than that of its conventional predecessors.

The author wishes to acknowledge thanks to Messrs. M. H. Crowell, E. F. Labuda, T. M. Buck, J. V. Dalton, and E. J. Walsh, who were involved in the work described. Information Display is grateful to the Bell Laboratories RECORD for permission to reprint this article

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Generation of statistically-controlled keyboard data

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INTRODUCTION

Tests requiring a large number of entries of keyboard data often need to have the entries simulated. This is particularly true if the test involves a number of operators using keyboards over a considerable period of time.

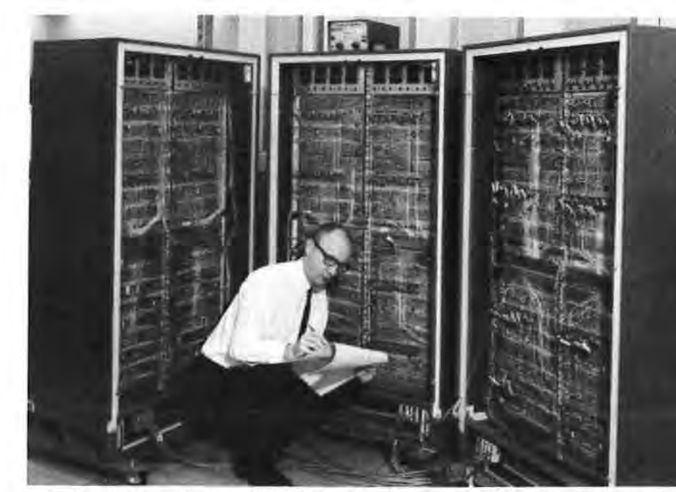
However, no two persons operate a keyboard in the same manner, or generate identical data, because of such variables as intercharacter time, burst rate, and average character rate — to name a few. Another problem is that completely predictable data is needed for testing and computer analysis of a keyboard device. Otherwise, operator errors can mask the errors of the device being tested.

An experimental simulator has been built and used by IBM Corporation at its laboratory in Kingston, N.Y. to simulate the entries of 24 keyboard operators. Although designed to simulate display keyboard operation, it can be used to simulate any keyboard or other device having a variable distribution obtained randomly.

In one test — if actual operators had been used — 24 operators would have had to transmit, simultaneously, approximately 5,000,000 characters each. At an average rate of three characters a second, this would have required five weeks, working an eight-hour day with time out for breaks, lunch, and coordination. An additional week would have been needed for set-up and instruction, and approximately three weeks for initial calibration and measurement of operators.

Using simulated channels, no keyboard operators were required and the 5,000,000 characters were entered into the graphic units in three days. Even though a prototype simulator had been designed and built, major cost savings were made.

The 24-channel keyboard data entry simulator, housed in three frames. The single-shot timing capacitors are externally attached to provide flexibility. The record-length counters are located across the top of the frames.



A typical test configuration of 12 IBM 2915 airline display terminals. The keyboard simulator can simulate twice the amount of data entered from these displays.

Distribution and Intercharacter Generation

The time between the keystrokes of a typical operator can range from approximately 40 to 1700 ms because of the varied locations of the keys on the keyboard, the use of special keys such as the space bar and "carriage return," and individual operator variations. If the percentage of the total number of characters entered is plotted against intercharacter times, a curve is obtained which shows percentage of characters for all intercharacter times between 40 and 1700 ms. Operator distribution curves will vary with operators and the type of data.

The purpose of the distribution generator is to duplicate these percentage-intercharacter-time curves. It was designed by dividing the distribution curve of a typical operator into 20 segments, and using a ring of 20 single-shot circuits whose timings are proportional to the percentage of characters requiring a particular intercharacter time. The timings can be varied by a screwdriver adjustment to fit any distribution curve.

The ring of single shots are fired continuously in sequence, with a 500-nanosecond delay between them to prevent overlapping. The complete ring cycle is 100 μsec. A single shot is selected by a random gate pulse. The probability that any single shot is selected is proportional to its on time which, in turn, equals the percentage of characters with that particular intercharacter time.

The distribution generator, then, simulates the frequency that characters are selected. Each single shot in the ring is gated to another single-shot whose timing equals the corresponding inter-character time.

Since there is a 500-ns delay between the single shots in the distribution ring, the 300-ns gate pulse may not find any of them on. However, a hunt circuit which is activated for each selection of a 20-ns character, keeps sending gate pulses until an active single shot is found. The need for extra gate pulses has a negligible effect on circuit operation since the delays and gate pulses are of only nanosecondus duration while the single-shot timings are in milliseconds — a ratio of 1,000,000 to 1.

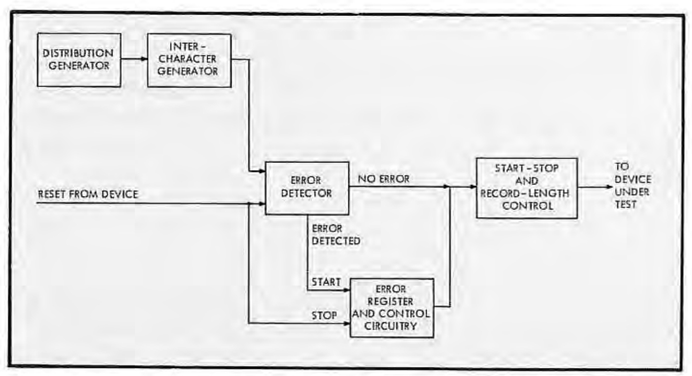


FIGURE 1: The simulator includes a distribution generator for simulating the varied intercharacter time of 24 different operators, as well as 24 programmable record lengths. Error detection circuitry simulates locked keyboard conditions on any of the channels. Special circuitry times the lengths of such conditions and maintains a record of them.

The distribution curve is semi-random because generation is, theoretically, predictable. However, there are so many variables that prediction becomes extremely difficult, if not impossible. Among these variables are starting and stopping sequences, varying record lengths, the delays caused by operator errors, and the ±5% tolerance of the single shots. For all practical purposes, generation is random.

An engineering model of the distribution generator duplicated an original distribution to ±1% with a sample size of 10,000 characters.

Two single shots were used for each intercharacter time to provide for the occasions when an intercharacter time is selected a second time before the single shot has had time to recover. All the intercharacter single shots are connected together through an OR circuit to control one single shot which provides a 20-ms pulse to write the character.

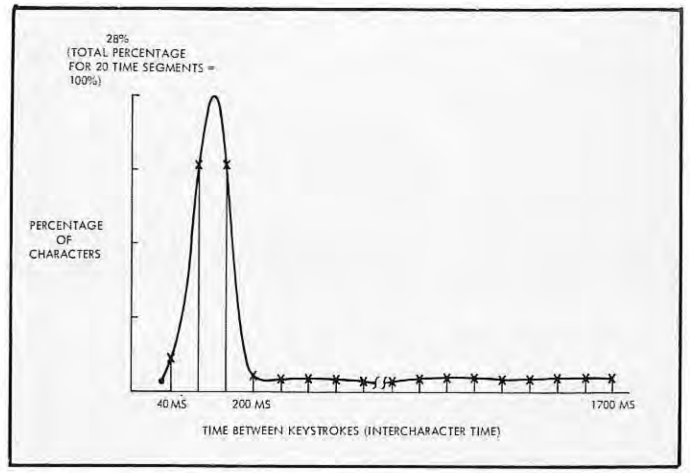


FIGURE 2: Different characters require different intercharacter times because of their different locations on the keyboard, use of special keys as space, shift and backspace, and individual operator variations. The intercharacter times were found to vary from 40 to 1700 ms. Operator distribution curves, which show the percentage of characters sent for different ranges of intercharacter time, was arbitrarily divided into 20 segments for simulation.

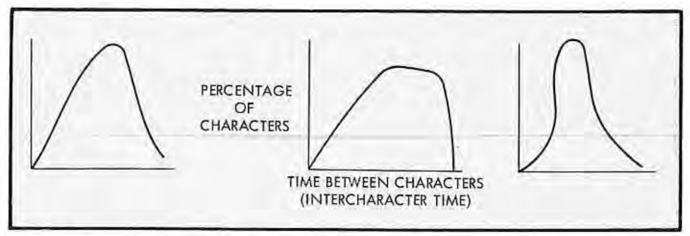


FIGURE 3: The speed and uniformity of key entry will vary from operator to operator, giving different distribution curves of intercharacter times versus percentage of characters sent. Each of the 24 channels of the keyboard-entry simulator can be adjusted to simulate a different type of operator. In addition, record lengths can be varied from channel to channel so that all of the channels, together, can simulate almost any type of data-entry job.

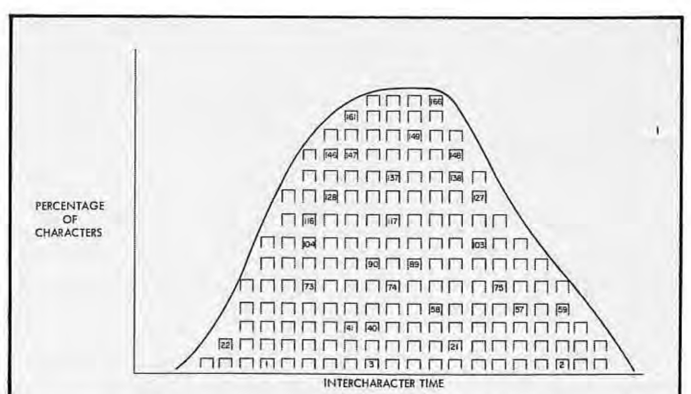


FIGURE 4: Since the continually-firing single shots in the distribution generator are selected randomly, the distribution of intercharacter times is also built up randomly. Although theoretically predictable, there are so many variables that the distribution is, for all practical purposes, random.

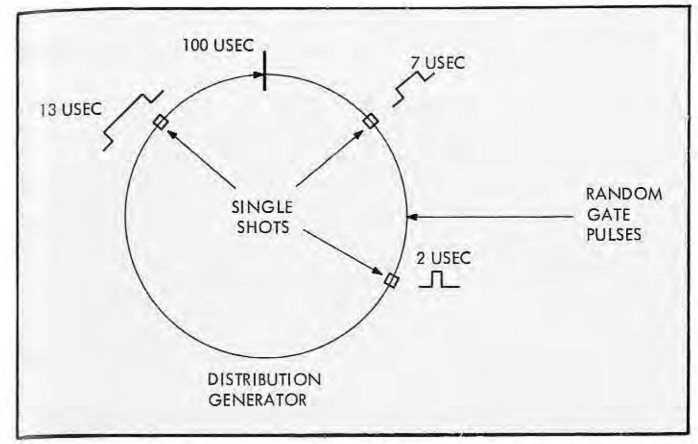


FIGURE 5: Distribution ring showing three of the 20 single shots. The probability that any single shot will be selected by the random gate pulse is directly proportional to the length of time that the single shot is on. The single shot timings can be adjusted to reproduce any type of probability curve.

Operation

A 10-bit code is simulated. Independent control of the type of character and of record length is provided for each of the 24 channels (operators). Any distribution of time between characters can be programmed into any channel.

Communication between the simulator and a control unit or other external device under test is by demand-response; i.e., after each character is sent, a control signal representing a keyboard reset is sent to the simulator.

Normally, the simulator channels operate continuously and can be terminated only by a stop signal. Since the characters come at rates within their programmed distribution, a check of the reset line back from the device under test is monitored for an error condition. As the channel delivers each character, the reset must return before its next character is delivered. If the reset is delayed (simulating the condition when the device is too busy to handle this particular channel), long enough that it coincides with the next character out, an error condition exists and must be recorded. The delayed time is also recorded and entered as part of the data following the error.

Controls

Indicators are used in each channel on the key latches and triggers to monitor the status should any unexpected condition hang up the channel. Preset counters allow setting record lengths from 2 to 99,998 characters. During the ending sequence of each record, this counter is reset before the next record. Character variation is achieved through switch control of coded bits representing characters. The entire simulator was built from solid-state components except for the electro-mechanical preset counters. These have presettable thumb wheels for setting the desired record length. Because of the speed required for minimum intercharacter time (40MS), it is necessary to count every other character in order to obtain the 200-ms step pulse required to drive the counter (40 ms to step and 160 ms for coil-field collapse, and settling of mechanical parts).

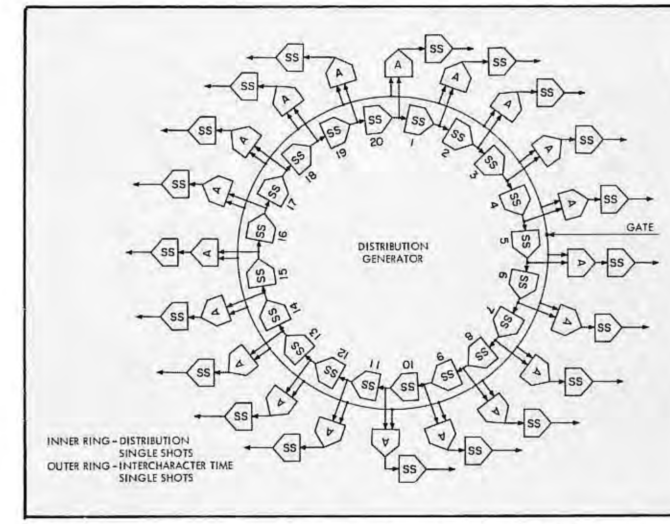


FIGURE 6: The inner ring of single shots forms a distribution generator, determining the frequency at which different intercharacter times are selected. The and circuits select the intercharacter time associated with a single percentage distribution.

Performance and Results

Use of the simulator detected some problems which would not have been found if operators had been used. Because

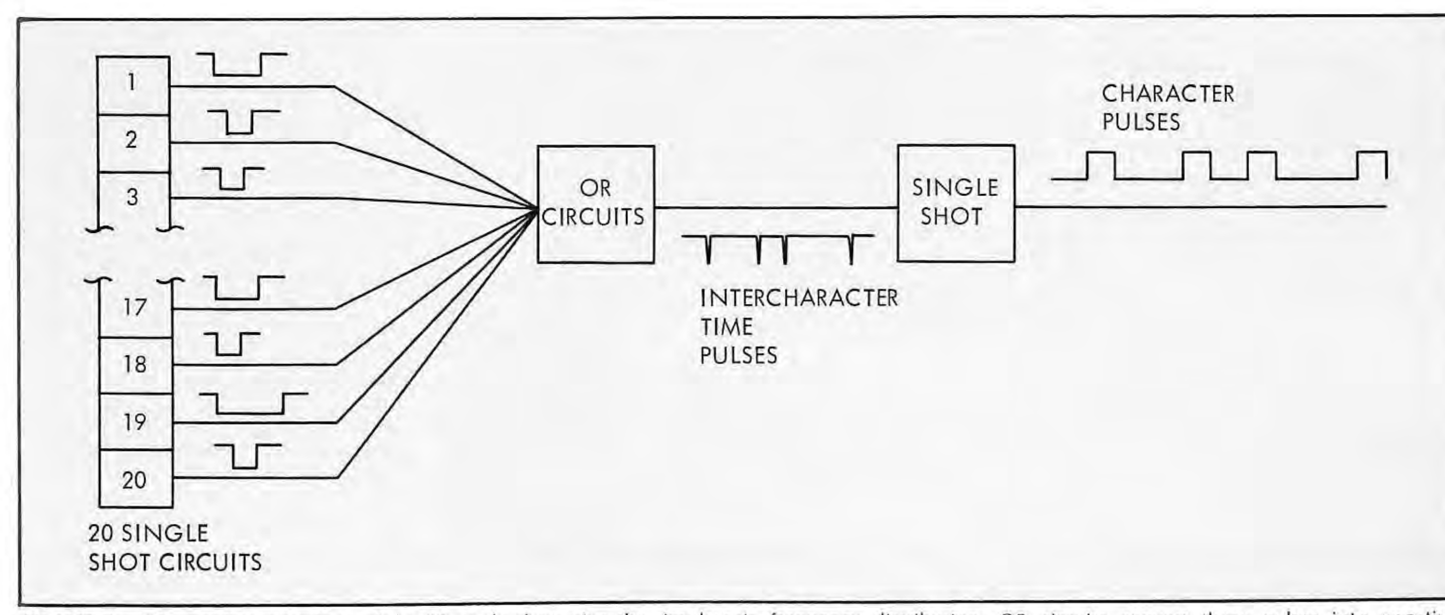


FIGURE 7: The on-time durations of the 20 single shots give the simulator's frequency distribution. OR circuits convert these pulses into negative 300-, 600-, or 900-nanosecond spikes, depending on how many 300-nanosecond random gate pulses are needed to select an intercharacter time. The negative spikes trigger a single shot whose output pulses are a constant 20 miliseconds, at varying intercharacter times.

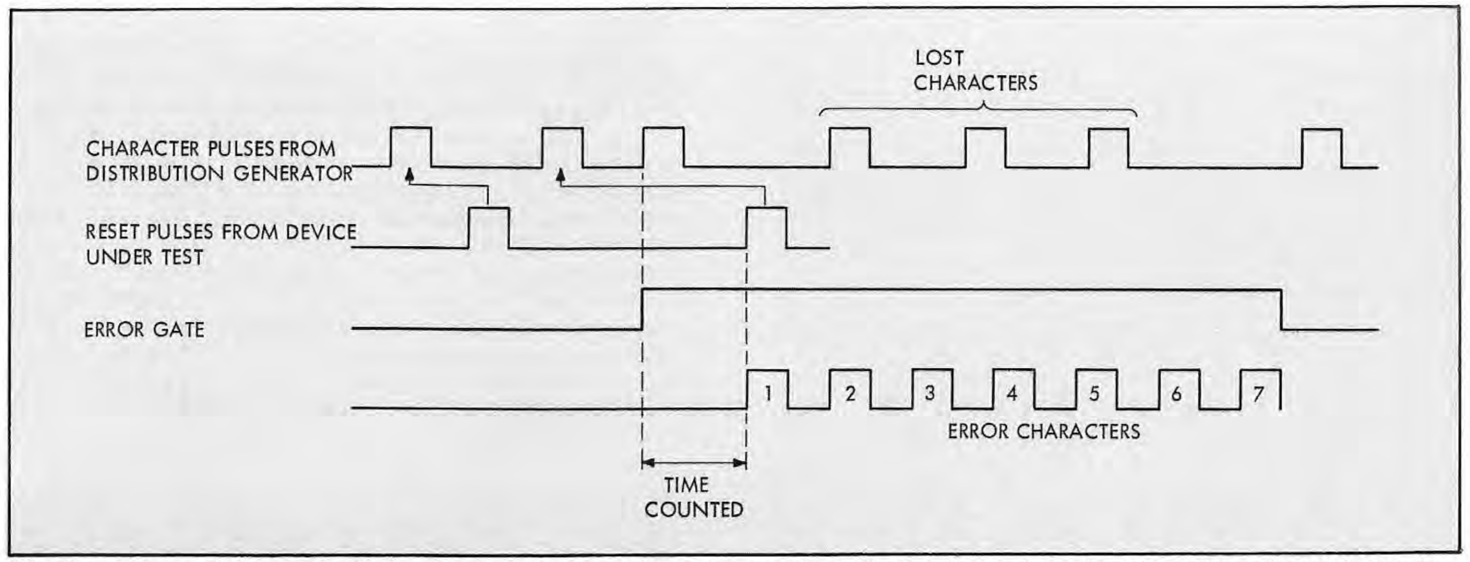


FIGURE 8: After each character pulse, a reset pulse (approximately 7 ms) must be received by the simulator from the device under test before the next character can be sent. The absence of the reset pulse simulates a locked-up keyboard caused by the system's inability to service all 24 keyboards simultaneously. Each occurrence of this condition is timed, and seven error characters are sent. These seven error bits are the output of a binary register whose decimal value is equivalent to the time that the "keyboard is locked up" in miliseconds. Characters generated during this time are lost, but these few characters — typically three or four out of thousands, have negligible effect on the distribution.

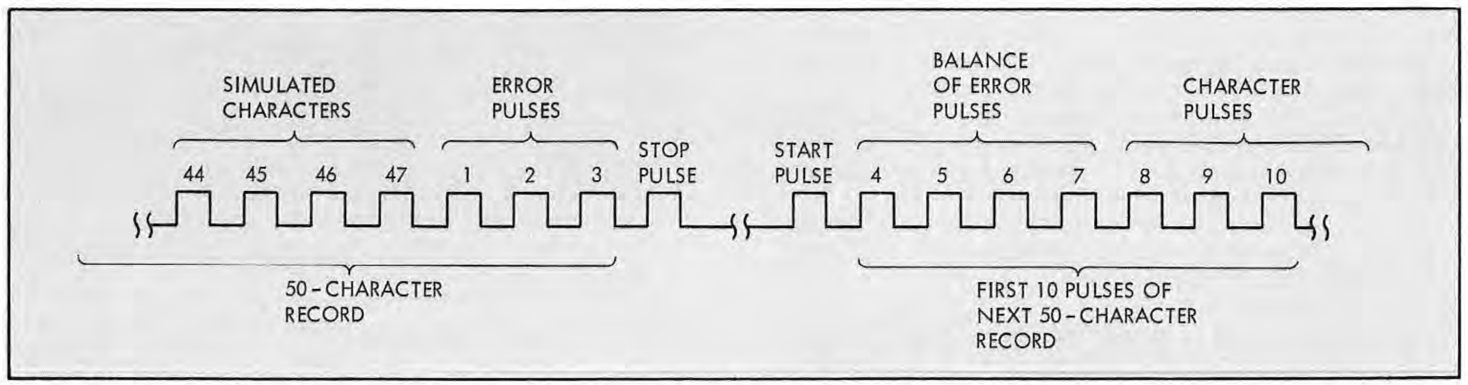


FIGURE 9: Various key-entry situations are simulated by adjusting record lengths on each channel with preset counters. These record lengths are always maintained by splitting the error message if necessary. If the error message cannot be inserted into the remainder of a record being sent at the time, then any remainder must be sent as leading characters of the next record.

of the constant, unending flow of data to the device under test, error conditions which occur as infrequently as once every three or four hours are detected and corrected. What was projected as worst case (all 24 channels operating at maximum average character rate) condition operated error free. It is the variable record lengths and the combined cyclic action of the total data output of these 24 channels which creates an error condition. The worst-case combinations of variables occurred as infrequently as once every three or four hours. With manual testing, these combinations would occur much less frequently — if at all — and would be more difficult to detect.

Since the data is predetermined, more data checking is made available in the control program. If operators had been used, character and record-length errors would have been unavoidable. Every such error would have caused an error printout which would have halted testing.

It was also discovered during the test that characters from one channel were being mixed intermittently with characters from another channel. If the data had not been generated by a simulator, it would have taken considerable time to prove that the trouble was being caused by a defect rather than by an operating error.

Another advantage which saved valuable testing time was the capability to continue through successive shifts. Since it took hours of operation to obtain the cyclic errors, entire runs would have been terminated or lost prematurely because of shift changes if operators had been used. This feature, alone, accounted for a saving in testing time of 25 percent.

The most important advantage of the simulator is that it is fatigue-free and practically error-free, providing controlled, predictable data. Since there are so many variables in testing, the dependability of data and record lengths from the simulator improve the reliability of large-scale key-entry testing.

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JON E. THORSON is an engineer in the Product Test technology department at IBM Corporation, Kingston, N.Y. His assignments have included the design and building of special hardware monitors and simulators for reservation, communication, and display systems. He is currently investigating measurement techniques for advanced circuits and system monitors for advanced computers. He also serves as an instrumentation engineer designing special test measurement systems.

Mr. Thorson has a BSEE from Worcester Polytechnic Institute.

Info 68 convenes in Los Angeles

More than 1,000 delegates will participate in INFO 68, *SID's* 9th Annual Symposium, convening May 22-24 at the Ambassador Hotel in Los Angeles. Included in the five technical sessions are papers from Japan and The Netherlands; the Session of Civil Applications studies in depth, for the first time, the display art in this field. Symposium General Chairman *Louis M. Seeberger*, of Hughes Aircraft, states that . . . "the Society has grown and matured through eight previous national symposia and today represents a significant force in the emerging display industry. INFO '68 has been carefully planned to reflect the stature of a well defined discipline. The technical program is broad in scope, providing a current view of five distinct areas of display interest. Complementing this comprehensive technical exposure is an exhibit grouping exceeding any previous symposia in scope."

TECHNICAL SESSIONS

Erv Ulbrich, Papers Chairman, has outlined five sessions: Civil Applications, Business Applications, Military Applications, Educational Techniques and Applications, and Advanced Techniques. Abstracts on the Japanese papers and the two from The Netherlands follow:

MULTI CHANNEL COLORED OSCILLOSCOPE

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Nagoya Institute of Technology
Nagoya, Japan
and
Hiroshi Furuta
Kobe Industries Corp.
Kobe, Japan

ABSTRACT

One of the authors has been studying the multi-channel oscilloscope of electronic switching system and found that it is very important to discriminate each phenomenal wave when many phenomena are displayed on surface of a small-size cathode ray tube. After having attempted several means in order to find the best resolution, the author came to the conclusion that the best means was to color each displayed wave respectively. Following to this conclusion, a multi-channel colored oscilloscope described hereinafter has been developed and it owes the remarkable progress of the color cathode ray tube for TV use. However, because the color tube available today has large caliber and is fabricated as electro-magnetic deflection, it has several technical problems in the performance for oscilloscope use.

This paper describes an outline of the multi-channel colored oscilloscope using a single electron gun tube, "color-netron" developed by Kobe Industries Corp., Japan.

AN EXPERIMENTAL 4000 PICTURE-ELEMENT GASDISCHARGE TV DISPLAY PANEL

Th. J. de Boer
Philips Research Laboratories
N. V. Philips' Gloeilampenfabrieken
Eindhoven-Netherlands

ABSTRACT

In order to study the possibilities of the use of gasdischarges in the display field, a complete 4000 element gasdischarge matrix display has been constructed together with the necessary circuitry.

The switching properties of the neon glowdischarge, used here, are good enough for TV purposes. The switch-on time is about 5 μs. Therefore if line-scan is used brightness modulation can be obtained by modulating the time during which the discharge is switched on.

Circuits have been developed for converting the height of the video signal into an appropriate pulse length. This pulse length determines the time the discharge is switched on. The display has 40 lines of 100 elements each, therefore 100 of such circuits are needed and the video signal has to be sampled into 100 parts. The horizontal and vertical scanning circuitry is made up of I.C.'s. The driving circuitry, which still uses discrete components, derives its input signals from a TV camera which operates at normal TV frequency.

The 4000 gasdischarge cells of the panel are formed by an insulating plate between two wire grids, perpendicular to each other, with holes at the intersections of these two wire grids. In these holes the glowdischarges can be ignited. The panel is filled with neon gas. Life expectancy, with the geometries here used, is several thousand of hours.

The system produces images in real time with a mean brightness of 170 to 200 nit (50-60 ft. L.). Moving of the images does not give any problem. The brightness modulation of an individual picture-element is better than 10 to 1, but due to inequalities of the gas cells this brightness modulation in the image as a whole is somewhat poorer.

SOME NOTES ON STEREOSCOPIC DISPLAY, AND AN ISOCHROMIC ANAGLYPH C.R.T.

E. T. Ferguson
Philips Research Laboratories
N. V. Philips' Gloeilampenfabrieken
Eindhoven-Netherlands

ABSTRACT

In stereoscopy we must distinguish wavefront reconstruction, giving a full stereoscopic reproduction, from two-channel stereoscopy, and which gives a much poorer approximation of reality. Only the latter form is suited for electronically driven displays. The many factors contributing to the impression of depth are summarized. Stereoscopic displays are shown to have only a limited field of application.

A cathode ray tube is described, on which a pair of stereoscopic images can be displayed in anaglyph form. The spectral distributions of the phosphors are so chosen that, when observed through the corresponding filters, the two images have the same color, and each eye only sees light from one of the images. This eliminates the eye fatigue inherent in the usual red-green anaglyphs.

SPEAKERS

Keynote Speaker Harry I. Davis is Deputy Assistant Secretary Air Force (R&D) (Special Programs). From 1945-1951 he served as Chief, Navigation Laboratory at Watson Laboratory, Red Bank, N.J., and in 1955 was Visiting Professor at Columbia University, N.Y., where he taught a graduate course in Electrical Engineering. From 1952-59 he was Technical Director, Rome Air Development Center. He has held his present position since 1965. His Awards and Fellowships include Sigma Xi; Collier Award; Fellow, IEEE; Commendation for Meritorius Civilian Service by Commander, Air Research and Development Command; Exceptional Civilian Service Award by the Secretary of the Air Force, and the DOD Distinguished Civilian Service Award.

John Whitney, designer of motion graphics, has recently embarked upon an extensive study of creative problems re-

lated to the use of the 360 IBM computer in motion design, under a 20-month grant by IBM. In 1949, Mr. Whitney's abstract film-making won first prize in the Belgium Film Festival. Early in the 1950's he experimented with the production of 16mm films for television, and in 1952 wrote, produced and directed engineering films on guided missile projects for Douglas Aircraft. Mr. Whitney was named Fellow of the Graham Foundation for Advanced Study in the Fine Arts in 1962, two years after he founded Motion Graphics, Inc.

Luncheon Speaker Dr. Eric Von Hogerstrom is a West German scientific consultant who has worked with DOD, Siemens AG and AEG Telefunken. He provides a provocative and controversial discussion of scientific and engineering trends in information display.

H. R. Luxenberg has been active in the information display field since 1958, when, as Manager of the Systems Develop-

ment Department and then as Manager of the Display Department at the Ramo-Wooldridge Corporation, he was responsible for the development of two large-screen, full-color, film-based projection display systems and a series of cathode-ray-tube display consoles. Later at the Houston-Fearless Corporation, he was responsible for the development of advanced photographic processing, interpretation, instrumentation, and storage and retrieval systems. Currently a Consultant in Information Systems, Dr. Luxenberg is involved in graphic arts applications as well as displays and computers. He is also Executive Secretary and a Charter Member of the *Society for Information Display.*

Banquet Speaker Peter C. Goldmark, president of CBS Laboratories, joined CBS in 1936 as Chief Television Engineer, later becoming Director of the Research & Development Division. The first practical color TV system was developed under his direction, and in 1940 the first color broadcast in history was made from the CBS transmitter in New York.

Dr. Goldmark is a Fellow of the Society of Motion Picture and Television Engineers, the Institute of Electrical and Electronics Engineers, the Audio Engineering Society, and the British Television Society. He is also a member of the American Physical Society. In 1954, Dr. Goldmark was awarded the Television Broadcasters Association medal for his color television pioneering work. Dr. Goldmark is the only member of the IEEE to hold both the Morris Liebmann Memorial Prize for electronics research, received in 1946, and the Vladimir K. Zworykin Television Prize, awarded to him in 1961. In 1960, Dr. Goldmark was given the Achievement Award by the IEEE's Professional Group on Audio.

Dr. Goldmark is a visiting Professor for Medical Electronics at the University of Pennsylvania Medical School, a member of the Connecticut Research Commission, and of the National Academy of Engineering.

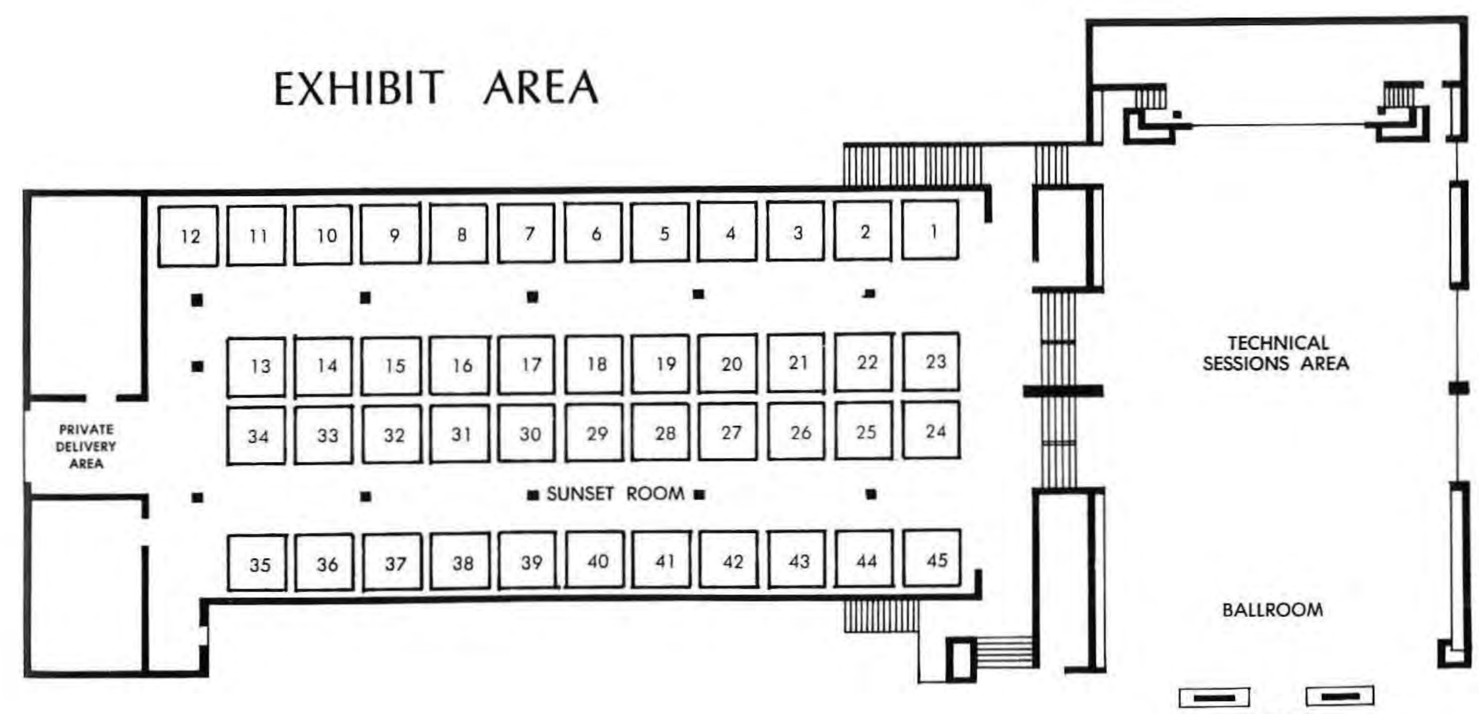
DISPLAY TECHNIQUES UTILIZED

Audio-Visual Chairman *Dave Morgan,* RCA, reports an innovation in the use of a novel message and information system utilizing the very components of information display technology. A Model 990 Videograph Display Control Unit and a Model 995 Videograph Keyboard have been loaned to the Society by the A. B. Dick Company, Chicago. Television monitors are located in strategic areas, with the title of the paper in presentation appearing at the top of the screen. The remainder of the screen displays messages, which are typed on the Keyboard and instantly displayed by the Control Unit, thus enabling any delegate to know at once which particular paper is being presented, and allowing him to pick up his messages. The screen will be activated in the Papers Presentation Room only between speakers, so as not to distract from the presentations.

LADIES PROGRAM

An entertaining Ladies Program has been planned by Chairman *Sharon Satterfield* and her committee. A tour, "A Day in Beverly Hills", consists of a bus tour of the city, a guided tour of the MGM Studios and a poolside luncheon at the Beverly Hills Hotel. On Thursday morning *Dr. H. R. Luxenberg* speaks to the ladies on *"SID—*In One Easy Lesson." Two trips are planned for Friday: one to the Farmer's market, the other a tour of Los Angeles' new Music Center, with luncheon in the Pavillion Restaurant overlooking the city.

EXHIBIT AREA



INFO 68 EXHIBITORS

The following companies are exhibiting:

Ball Brothers Research Corporation
Booth No. 42

Beta Instrument Corp.
Booth No. 31 and 32

CELCO, Pacific Division
Booth No. 5 and 6

Conrac Division, Conrac Corporation
Booth No. 38 and 39

Datanetics Corporation
Booth No. 7

A. B. Dick Company
Booth No. 41

Dumont Electron Tubes
Division of Fairchild Camera & Inst. Corp.
Booth No. 8

Electron Tube Division of Litton Industries
Booth No. 35

Ferranti Electric, Inc.
Booth No. 20

Gamma Scientific, Incorporated
Booth No. 4

General Atronics Corporation
Booth No. 2

H F Image Systems, Inc.
Booth No. 15

Hughes Aircraft Company
Vacuum Tube Products Division
Booth No. 18

Isomet Corporation
Booth No. 27

Magnetic Shield Division of
Perfection Mica Company
Booth No. 3

Polaroid Corporation
Booth No. 44 and 45

Radio Corporation of America
Booth No. 1

Raytheon Company
Booth No. 43

Sylvania Electric Products Inc.
Booth No. 28

Thomas Electronics, Inc.
Booth No. 22

Transistor Electronics Corporation
Booth No. 23 and 24

USECO Division of Litton Industries
Booth No. 13 and 34

Video Color Corp.
Booth No. 25

Wagner Electric Corp.
Tung-Sol Division
Booth No. 19

Westinghouse Electric Corporation
Electronic Tube Division
Booth No. 10 and 11

Bendix Corporation
Masaic Fabrications Division
Booth No. 14

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Sharon Satterfield,
Ladies Program Chairman

A. Byron Perkins,
Exhibit Management

ID Readout

AUTOMATIC DRAFTING WITH PRE-ENGINEERED OFF-THE-SHELF HARDWARE/SOFTWARE

A concept in automatic drafting technology that separates hardware and software into pre-engineered standard modules has been introduced by the Universal Drafting Machine Corporation (UDM), Cleveland, Ohio.

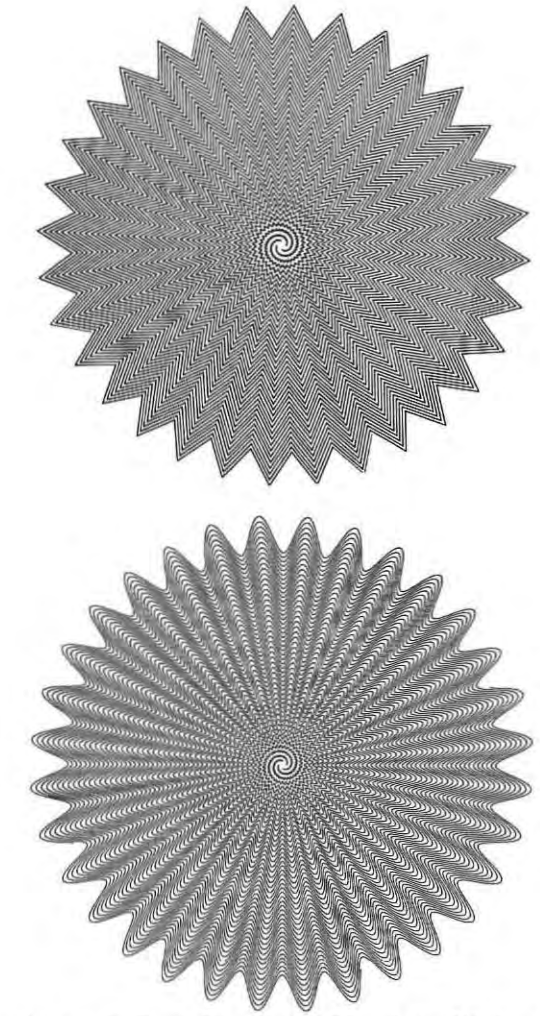
The equipment, called the Orthomat Mark II Graphic System 5000, was designed by joining standard components into specific hardware and software packages that are said to meet 90 percent of the requirements for any automatic drafting system.

Cutler-Hammer's AIL Division, Deer Park, New York, has been associated with UDM in this effort since 1965. AIL has developed and is building the computer controls and the software programs that UDM will use in this new pre-engineered automatic drafting machine system.

EYE MOVEMENT CAMERA

A precision optical device to study and record the eye movement or reaction of the eyes to changing visual stimuli has been produced by NAC Incorporated of Japan. Experiments have been conducted in recent years in Japan to produce a lightweight device that can be worn by a person without abnormally encumbering his movement, and which would provide a view and a photographic record of his eye reactions. NAC's new device, called the NAC Eye Mark Recorder, is worn on the subject's head, and offers visual observation, recording on 16mm movie film, or videotape, or monitoring on a TV screen, depending on the requirements of the discipline. It shows the subject's eyemark as a spot super-imposed on the entire field of view being observed or recorded. Because of the ability to record on film or videotape, the following quantitative analyses can be developed: a time history of the eyemark, the timing or period of eye fixation, the direction and distance of eye movement under various stimuli, the relative motion between the eye and head, the distribution of the eye fixation distance and the three-dimensional ranging of the eyemark.

A fibre optic is employed to permit full adaptation to cameras, analyzers or videotape recorders.



Archimedes spirals (from the equation $R = A + B\theta$) drawn 1-to-1 scale, 32 cycles per revolution, by a Baldwin-Kongsberg automated drafting machine. Drawing time: 2 hours (each). Software, run on an IBM 7094 computer, was created by Information Processing Laboratories, Pasadena. The sine wave (bottom) represents curve fitting to the nearest .001 inch.

ELECTRONIC EQUIPMENT CHARTS INVESTMENT DATA

Electronic equipment similar to that being used to track satellites and missiles now provides investment analysts with up-to-date charts of financial data. Waddell and Reed, Inc., mutual fund investment corp., has installed a Milgo DPS-6 Digital Plotting System to provide them with graphs of the financial data handled by their two IBM 360 computers. The Kansas City firm uses their DPS-6 Plotting System to produce fast, accurate graphs of comparative financial data for more than 600 companies, plus information on a number of basic industries. The graphs show stock trends and performance by company and by industry, as well as comparisons of factors such as relative earnings and price/earnings ratios.

Current investment data for Waddell and Reed is provided by their Continental Research Division, using the most advanced computer techniques. With the addition of the Milgo DPS-6, graphic data as current as the information fed into the computers is available for evaluation and analysis. The Milgo digital plotting system is similar in design to the 14 Milgo plotters tracking data received from spacecraft used in exploration of the moon at Jet Propulsion Laboratory, Pasadena, Calif.

SPEEDY PLOTTING

A high speed map plotter, said to be so fast that Pentagon officials could view military maps of tactical situations two minutes after transmission by American field commanders, has been developed by the Western Development Laboratories Division of Philco-Ford Corporation.

Called an "Isographic Plotter," the device is computer or teleprinter driven to draw maps, symbols, vectors and alphanumerics at a rate of 1,400 inches per second or 500 characters per second. Depending upon the quality of the transmission media, 1,200 or 2,400 bits per second are used over normal transmission lines with restricted bandwidths of 300 to 3400 Hz.

Compared with other plotters, or devices such as facsimile, the new plotter is said to provide a ten to one reduction of required transmission time, according to WDL engineers.

The plotter is like a small darkroom for developing pictures. It generates a negative map image on the face of a cathode ray tube in accordance with the message it receives. The image is projected onto photographic paper which is automatically processed within the machine and delivered as a positive copy of black lines on white paper.

WDL engineers point out that in addition to uses by the military and meteorologists, the plotter can be used for semiconductor masking, chart and graph production, automated drafting, computer readout, slide production, or any application which can make use of stored standard symbols in graphic output form.

AIRLINE USES CRT VISUAL DISPLAY FOR SPACE CONTROL

An expanded automated electronic reservations system, utilizing CRT visual display terminals, is now providing faster passenger reservations for Braniff International. The new system was designed and built by Bunker-Ramo Corp., Stamford, Conn. Braniff thus becomes the first airline to use the terminal devices as an integral part of a flight reservation system. The system enables reservations personnel to make a sale, buy the seat and receive a confirmation, all in less than two seconds. Three other airlines, Central, Southern and Trans-Texas, share the system, and are connected directly to the processor at the headquarters in the Braniff International operations base in Dallas. Frontier Airlines will join the system when the merger of Frontier and Central is effective. Frontier will be the surviving airline following the merger.

The Bunker-Ramo Model 204's are located at strategic Braniff sites and sites of the other participating airlines. Each of these CRT units has a 10-in. screen with an electronic keyboard. Besides the reservation function these devices also provide hotel reservations, reservations on 28 connecting airlines, management information on airline mileage, sets sold by flight or segment, flight information, routes, flight conditions, inventory levels and other information required by management.

ONE-GUN, MULTI-COLOR DISPLAY SYSTEM

Sylvania Electrical Products Inc. has demonstrated a multi-color information data display system for commercial, industrial, and military applications. The system displays data in four separate colors—red, green, yellow, and orange. The heart of the computer-driven system is a 19-inch one-gun tube produced by Sylvania's Electronic Tube Division.

The one-gun tube has two phosphor layers which are separated by a barrier material. When the voltage is switched at high speed, the tube produces a multi-color.

The multi-color system is applicable for air traffic control systems; military identification systems; bio-medical equipment; stock market quotations units; teaching machines; electronic test equipment, and airline and transportation status boards.

FINGERPRINTS BY COMPUTER

A computer system to read fingerprints is being developed for the Federal Bureau of Investigation by Cornell Aeronautical Laboratory, Inc., Buffalo.

Under an $89,000 FBI research contract, CAL will develop, demonstrate and evaluate a laboratory device for identifying and locating certain fingerprint characteristics with a computer. In addition to the demonstration of techniques with the laboratory model, CAL will develop plans for a prototype reader capable of analyzing a single fingerprint in one-half a second and having the potential for ultimately reading a fingerprint in one-tenth of a second.

Cornell Lab proposes to develop a system which will allow a computer to examine a fingerprint and identify and locate fingerprint "minutiae" consisting of ridge endings and bifurcations. Should the techniques employed in the system prove successful, the project could lead to the development of a high-speed computer analyzer for fingerprints.

In general, the system under development involves three stages of operation; the scanning of fingerprints with a light-sensitive device, the filtering and conversion of the scanner data to digital information, and the detection and location of minutiae through the processing of the digital information with an appropriately programmed digital computer.

Most of the experimental techniques considered for the system have been studied by CAL in various forms on other projects. For example, computer scientists at Cornell Lab have been performing research in image processing using computers for many years, and have developed successful methods enabling a computer to identify characteristics of images. They have also performed extensive research on the means for converting an image, such as a photograph or drawing, to digital or numerical data which a computer can process.

COMPUTER TESTS COMPUTERS

The single most valuable tool for computer test technicians in the IBM plant in Poughkeepsie, N.Y., is a computer.

These technicians, whose job it is to test computers before shipment to customers, use one of the plant's own products, a System/360 Model 40 in their work. The technicians use an information system of 32 TV-like terminals that link the centrally located computer to test cells which occupy almost a quarter of a mile of manufacturing floor space in the company's plant. The system is called STMIS for Systems Test Manufacturing Information System.

System/360s are tailored to specific customer requirements so that virtually no two are alike. Therefore each must have an individual testing routine.

When a test technician begins his testing procedures, STMIS provides him a check list of tasks which takes into consideration all the computer's special features.

Since each of the testing routines is timed, and the target date for shipment is entered into the system before it reaches final test, the system can make a comparison between the time necessary to complete the remaining tests and the time left to shipment. Thus a technician knows if he is on schedule. Furthermore, management can, at any time, obtain from the central computer the exact test status of any machine in final test.

In addition to the added efficiency during the test procedure, the computerized testing system has other benefits. It provides an automatic way to keep labor records for the testing area, and it compiles an historical record of the tests and adjustments made on each machine.

3 NATO COUNTRIES UNVEIL NEW AIR DEFENSE CENTER

A three-nation air defense programming and training center has been unveiled in Belgium as the first operational link in NADGE—called the largest and most complex electronic undertaking in Europe, according to Hughes Aircraft Co., designer and manufacturer.

NATO Bunker—This main operations room of a NATO bunker on the Belgian-Netherlands frontier is one of four custom-tailored air defense "nerve centers" to be installed in the countries of Belgium, West Germany and The Netherlands to provide each nation with integrated, split-second, computerized protection against aerial attack.

Dr. Nicholas A. Begovich, a Hughes-Fullerton vice president, said the underground center will be operated jointly by Belguim, The Netherlands and West Germany. The center will be used in conjunction with command and reporting centers to be built in each country by Hughes.

The unveiling marks the successful conclusion of a 10-year effort by the three nations, which banded together in 1957 as an International Planning Group (IPG) to develop mutual air defense ground environment (ADGE) system.

Eventually, he said, the system will be phased into the $300-million NADGE (NATO Air Defense Ground Environment) project being built in Western Europe from Norway to Turkey.

The entire job will be completed under individual contracts to the three nations, Dr. Begovich said. They will use the center to train operators, maintenance personnel, and computer programmers who will man the over-all system when it is activated later this year.

"The system will give each country, for the first time, an integrated, split-second, computerized air defense capability," he said.

"It is designed to provide electronic umbrella protection against aerial attack over the three countries by detecting, tracking and identifying airborne targets automatically. The system also will rapidly evaluate and compile incoming data and control defensive weapons."

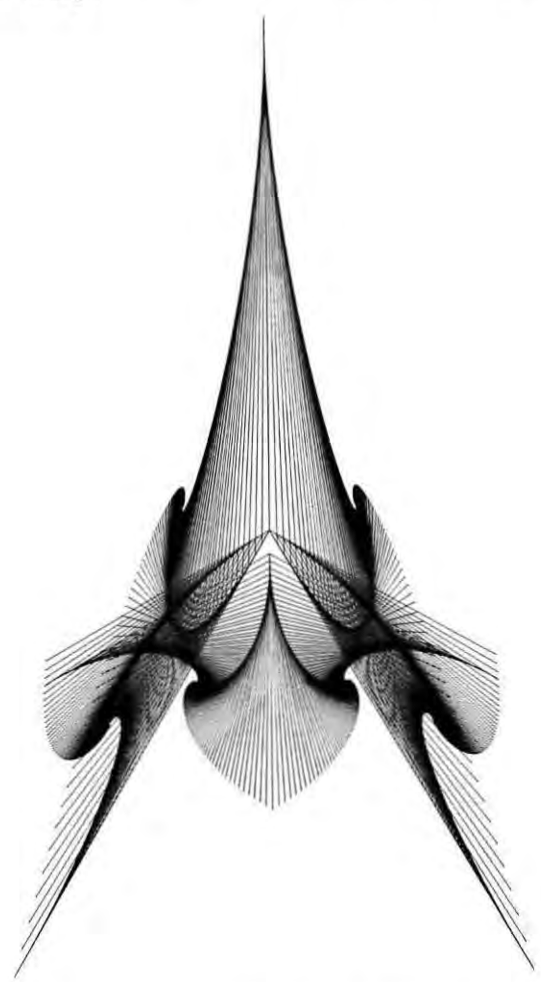
The new center includes a high-speed general-purpose computer, nucleus of the system; and a variety of electronic data-display units, which make it possible to train personnel without interrupting continuing air defense operations.

Existing height and surveillance radars are being modernized to accommodate the new control and reporting centers near the towns of Glons in Belgium, Nieuw Milligen in The Netherlands, and Brockzetel and Udem in Germany.

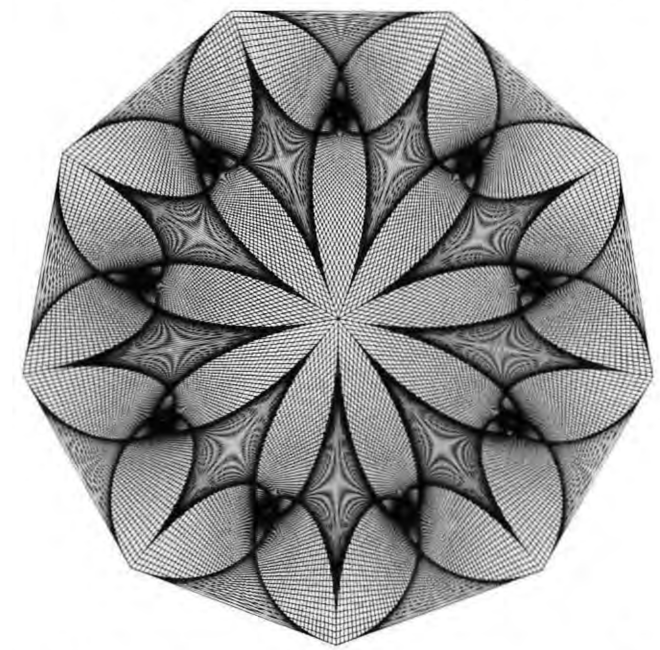
The sites will include data-display consoles; data-processing systems, including a high-speed digital computer; and an integrated communications data link network that will provide rapid voice and digital communications between the installations.

TRADITIONAL? SURREALISM? AVANT GARDE?

For lack of a better word, it's called computer/plotter art, a little known art form which was demonstrated recently at an informal showing held at the New York room of the Statler Hilton, Los Angeles. Around the walls were hung approximately a dozen framed drawings in color and black and white, both original drawings and reproductions of masterpieces, the products of a collaboration between computers, a California Computer Products, Inc., Plotter, and, of course, human beings.



The showing was held in conjunction with the announcement by CalComp that it is sponsoring an international "computer/plotter art" competition by offering scholarships of $5000, $3000 and $2000 to accredited colleges or universities named by the winners, plus cash awards of $500, $300, and $200 with additional awards of $50 each to 50 runners-up.



Judging the contest, which will end on November 1, are Anthony La Rotonda, art director of Parade Magazine, Arnold C. Holywell, acting art director of Time-Life Books, and Peter Fingesten, editor of the Pace College (New York City) art department. Winning entries will be exhibited at leading art galleries and museums throughout the country.

In each case the pictures exhibited at the showing were the product of countless mathematical computations fed into computers and then placed on tape which was run through a CalComp Plotter and created visually into a work of art.

Among the drawings exhibited were "The Fisherman", "The Snail", "Humming Bird", and others.

Although angles and curves are shown in the drawings they are actually straight lines.

Computer/plotting art has been hitherto little known except within the technical world. Increasing refinements, however, have produced beautiful pictures, so much that the drawings, both originals and reproductions, are now being sought by collectors.

BUSINESSMEN'S COURSE ON THE COMPUTER

Management And Computer Services, Inc., has announced the development of a course, "The Computer And You, the Businessman." It is designed to give businessmen a basic understanding of the computer, its uses, capibilities and limitations.

In his announcement, Howard F. Ferguson, MACS Vice President—Educational Services Division, calls the program a "thorough but uncomplicated look at the computer, intended for businessmen who find the computer on all fringes of their daily activities."

Ferguson reports that, to his knowledge, MACS' course is the only one of its kind offered in the Delaware Valley area, and was formulated in response to numerous inquiries from client firms.

FIRST HOME STUDY COURSE IN SYSTEMS AND PROCEDURES

The North American Institute of Systems and Procedures of Newport Beach, California, has announced the introduction of a home-study course in the field of Systems and Procedures. According to the Institute, it will be the first of its kind in the correspondence field. The course is sponsored by the Systems and Procedures Association of Cleveland, Ohio. Comprised of 50 lessons, the new Master Course in Systems and Procedures will offer a comprehensive study of a wide range of subjects including: Systems Studies, Organization, Responsibilities and Functions of a Systems Department, Basic Business Organization, Charting, Report Writing, Procedure Writing, Forms Design, Office Layout, Work Simplification, Work Measurement, Forms Control, Records Management, Automatic Data Processing, Keyboard Accounting Machines, Punchboard Equipment, Electronic Data Processing, Digital Equipment, PERT, Information Retrieval and Systems Planning.

Author of the course is Richard C Rawlings, Coordinating Director of the Institute and a member of its advisory faculty. Rawlings is Systems Specialist with the Information Systems Group of Northrop Nortronics of Anaheim, California. He is responsible for systems analysis and data processing studies relating to military intelligence at Northrop.

Executive Director of the Institute is Harold G. Rider, CPA, and Vice President of National Systems Corporation. Eugene C. Auerbach, Ph.D., and Vice President of National Systems Corporation, is the Director of Education for the Institute.

DELCO-REMY DIV. of GENERAL MOTORS, Anderson, Indiana, has ordered a digital drafting system to provide computerized drawings for use in an optical milling machine that cuts cams for electrical ignition systems. The system was introduced last year by the GRAPHIC SYSTEMS DIV. of COMPUTER INDUSTRIES INC., in Van Nuys . . . KOLLSMAN INSTRUMENT CORP., Syosset, N.Y., has won two contracts totalling $900,00 for flight instruments for the Royal Canadian and Royal Netherlands Air Force CF-5 jet fighters. The instruments, AVU-9/A, are combination air speed, Mach number and maximum allowable air speed indicators, which are scheduled for installation in the CF-5 "Freedom Fighter" aircraft being built at Montreal by Canadair, Ltd.

TELE-DYNAMICS DIV. of AMERICAN BOSCH ARMA CORP., Philadelphia, has entered the digital communications field with the introduction of its Type 7210A Digital Line Level Converter. System is said to provide complete facilities for digital/digital signal level conversion in both directions, and digital/FSK conversion in both directions . . . The Navy has awarded a $423,000 contract to MILGO ELECTRONIC CORP., Miami. Milgo will design, manufacture and install electronic equipment at Roosevelt Roads Naval Base, Puerto Rico, which will automate the presently manually controlled Drone Control System, being operated by the Atlantic Fleet Weapons Range . . . in two moves designed to lead off a major expansion of the division, HOUSTON INSTRUMENT DIV., of BAUSCH & LOMB, has introduced the Complot graphic plotter line and formation of the Computer Graphics Group. General sales manager L. C. Bower was named head of the Group, whose purpose will be to . . . "provide total service for on-line and off-line graphic recording for the computing industry."

MAGNETIC RADIATION LABORATORIES moved to a new plant early this month in the Industrial Park area of Elk Grove Village in Illinois. Al Clap, president of the firm, states the new plant provides approximately 300 per cent greater production capabilities than the former plant . . . BUNKER-RAMO'S DEFENSE SYSTEMS DIV., Canoga Park, has introduced an information system designated the BR-700. E. E. Bolles, div. vice president, says the system introduces a new element in the display equipment spectrum "by providing a self-contained system that is an economical solution to the problems of source data automation and local data management and control."

Under a $300,000 contract with the Foreign Agricultural Service of the Department of Agriculture, INFORMATICS INC., Sherman Oaks, Calif., is performing system design, program design and implementation of an information management system. The work is being done in the Washington, D.C. office under direction of Stewart L. Lane, Project Manager . . . CALIFORNIA COMPUTER PRODUCTS INC., Anaheim, has formed a new division to provide computerized pattern grading for the apparel industry. President Lester L. Kilpatrick said the service is the outgrowth of a pilot operation which has supplied computer-generated patterns for apparel manufacturers on an experimental basis for two years.

COMPUTER COMMUNICATIONS INC., has announced the opening of CCI Systems Center-Federal, headquartered in Washington, D.C. Director of operations is E. L. Smith, previously manager of Washington Operations for Logicon Inc. . . . FERRANTI-PACKARD ELECTRICAL LTD., Toronto, has won a contract from TRANS-LUX CORP., N.Y., to produce the Trans-Lux Jet, a ten-foot long electronic stock quotation display designed and marketed by Trans-Lux. The agreement calls for production of 500 units of the high visibility display which reports stock and commodity transactions instantaneously from any exchange . . . FAIRCHILD DU MONT ELECTRON TUBES, Clifton, N.J., has been awarded a contract from the BENDIX CORP. to deliver 400 units of an improved Fairchild developed, direct view storage tube. The tubes will be used for RDR-1 radar systems produced by the Bendix Avionics Div. in its new facilities in Ft. Lauderdale, Fla.

PERFECTION MICA CO., and its MAGNETIC SHIELD DIV., Chicago, have appointed Engineering Service Co. to handle all its lines of Netic and Co-Netic magnetic shielding components in Missouri, Kansas, Iowa and Nebraska . . . A new firm, RICCA DATA SYSTEMS INC., has been formed in Santa Ana, Calif., by Joseph A. Ricca, former general manager of Raytheon Computer. The firm is in the special purpose computer and data systems business, and will concentrate on commercial and industrial applications . . . LTV Electrosystems announced a $3 million building program in Greenville, Texas to continue facility expansion nearing completion in a $2 million program. The facility is leased from the City of Greenville and construction is financed through municipal bond issues, amortized through lease payments.

PERSPECTIVE INC., Seattle, has shipped a computer-directed drawing machine to London for TELEKONSULT INC., Stockholm, marking Perspective's entry into the European market. The Illustromat, which draws three-dimisional illustrations from blueprints, will be on display in the London office of Induscom International, Perspective's distributor for the U.K., before being shipped to Sweden . . . the DISPLAY DIV., DATA DISC INC., Palo Alto, has delivered a Digital/Video/Disc Memory Model FPD-16 to Illinois Institute of Technology Research Lab in Chicago. Unit will provide buffer storage for IITR's display system to be used in the DOD's Electro-Magnetic Capability Analysis Center . . . Delivery of the first altitude depth sonar display system to OCEAN RESEARCH EQUIPMENT CO. for the Navy Deep Submergence Rescue Vehicle Program was recently announced by ALDEN ELECTRONICS and its subsidiary, OCEAN SONICS INC.

SID Sustaining Members

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AEROSPACE CORPORATION
San Bernardino, California

GRAPHIC SYSTEMS DIVISION
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Van Nuys, California 91401

BUNKER-RAMO CORPORATION
Canoga Park, California

BURROUGHS CORPORATION
Defense, Space & Special Systems Group,
Paoli, Pennsylvania

CELCO
(Constantine Engineering Labs. Co.)
Mahwah, New Jersey

COMMUNICATIONS & ELECTRONICS DIV.
Philco-Ford Corporation
A Subsidiary of Ford Motor Company
Willow Grove, Pennsylvania

CONRAC DIVISION
Conrac Corporation
600 North Rimsdale Ave.
Covina, California 91722

ELECTRONIC COMPONENTS GROUP
Div., Sylvania Electronic Products Inc.
Seneca Falls, New York 13080

GENERAL ATRONICS CORPORATION
Electronic Tube Division
1200 East Mermaid Lane
Philadelphia, Pennsylvania 19118

HUGHES AIRCRAFT COMPANY
Culver City, California 90230

HUGHES AIRCRAFT COMPANY
Vacuum Tube Products Div.
Oceanside, California

IBM CORPORATION
Armonk, N.Y.

NAC INCORPORATED
7 - 1 Ginzanishi
Chuo-Ku, Tokyo, Japan

RADIATION INC.
Melbourne, Florida

STROMBERG CARLSON CORP.
Data Products, San Diego, California

SYNTRONIC INSTRUMENTS INC.
100 Industrial Road, Addison, Illinois

TRANSISTOR ELECTRONICS CORPORATION
Minneapolis, Minnesota

SID Membership

Membership is open to all who can benefit from the Society and wish to further its goals. Both individuals and companies are welcome to apply. Members receive free the bi-monthly Society Journal, *Information Display*, the published proceedings of symposia, a directory, and news of National and Local Chapter activities. They may attend, at member rates, the symposia and other technical meetings. Participation in the local chapter's regular meetings and other activies is encouraged. To apply, complete the Member Application reply card in this issue and mail to the Society.

Sustaining Membership

The *Society for Information Display* is pleased to invite a limited number of sustaining memberships from corporations or other business organizations interested in contributing to the advancement of display technology. Sustaining members need not complete the education or experience sections of the reply card in this issue. Merely supply: (1) the listing desired. This will be printed in each issue of the journal, *Information Display*, Symposia Proceedings and other Society publications. (2) the billing address. Sustaining members may either remit payment with application or request bliling. An address is needed for later use. (3) five mailing addresses. These five locations or individuals will receive the journal, *Information Display*, Symposia Proceedings and other Society publications.

(Tear out SID Application Form on pg. 108)

on the move

JACK JONES has ben appointed sales manager of display products and systems for the Philco Houston Operations of Philco-Ford Corp.'s WDL Division. ROBERT T. BENWARE, director of Philco Houston Operations, made the announcement. Jones will be responsible for selling the D-series of computer terminal products for use with standard data processing equipment.

Spatial Data Systems has made announcement of a network of local-area sales representatives throughout the states. PETER POHL COMPANY will represent SDS in Southern California; Donegan-Ross Company on the Eastern Seaboard; Hobart Associates Inc., for the New England States; Eastronics for Md., Va., and the greater Washington D.C. sector; Data Processors Supply Company for the Southern states; and Industrial Sciences Inc., for the Midwestern states.

ALAN G. BINNIE has become Chairman of the Board and JOSEPH J. LANGFORD is president of Gap Instrument Corp., Westbury, L.I., N.Y. Binnie, who has been the firm's president since 1962, continues as Chief Executive Officer. Langford comes to Gap from Kollsman Instrument Corp., where he was general manager of the Avionics Division.


LANGFORD


JOHNSTON

DONALD L. JOHNSTON has been appointed vice president of corporate marketing for Data Disc Inc., Palo Alto. He will have full responsibility for marketing the complete magnetic disc memories manufactured by the Standard Products Div. and the precision discs manufactured by the Disc Div.

GILBERT M. EDELMAN, formerly assistant to the president at Kollsman Instrument Corp., Syosset, N.Y., is now director of Research and Development Programs. Edelman joined the firm in 1963 as associate director of the Corporate Technology Center, the engineering research group of the company.


EDELMAN


GOLDSTEIN

ROBERT L. GOLDSTEIN has been named president of Crystalab Products Corp., Rochelle Park, N.J. He was formerly manager of engineering sales for the firm, which manufactures crystals and electro-optic instrumentation for the laser industry.

A new corporation, TRI-DATA, has been formed in Mountain View, Calif., by JAMES D. BOWLES and JACK F. SWEENEY, two of the founders of Datamec Corp. Bowles says the firm will develop, manufacture and market business data-acquisition sub systems and peripheral equipment for data processing and communication. JOHN S. CRAVER, formerly with Tally Corp., heads the company's marketing activities.


BOWLES


SWEENEY

ROBERT J. SPINRAD has joined SDS, Los Angeles, as vice president, Programming, according to MAX PALEVSKY, president. Dr. Spinrad has been at Brookhaven National Laboratory, Upton, N.Y., for 13 years, where he was Senior Scientist and head of the Computer Systems Group.

ROBERT G. TOMPSON has been elected vice president of TNT Communications Inc. NATHAN L. HALPERN, president of TNT, made the announcement. Thompson joined TNT in 1962 after a long career at CBS, where he was director of technical operations for the CBS Network.

General Atronics Corp., Philadelphia, has appointed IRVING B. BRAGER manager, Equipment Manufacturing. Announcement was made by ALFRED STAPLER, general manager for the firm. Brager has managerial responsibility for the manufacturing of the firm's line of electronic equipments, including oscilloscopes and radar and communications equipment. He was formerly vice president, manufacturing, for EMTECH Co., a subsidiary of the American Electronics Laboratories Inc.

DR. RAYMOND D. EGAN has been elected vice president of research of Granger Associates. In making the announcement, DR. J. V. N. GRANGER, president and chairman of the board, said, "Among the many important contributions Dr. Egan has made to the company is his work on ionosphere sounders." Egan joined Granger in 1962.

LUTHER HARR has been elected senior vice president of Trans-Lux Corp. Harr was formerly executive vice president and a director of The Bunker-Ramo Corp.

WALTER T. JONES, president of Computer Sharing Inc., Bala Cynwyd, Pa., recently announced the names of the Board of Directors of the newly-organized firm. They are ROBERT K. STERN, president, Mauchly Associates Inc.; DONALD R. WOOD, president, Mauchly-Wood Inc.; BEREL H. STERNTHAL, vice president and general manager of CSI; JOHN I. McMAHON, secretary-treasurer of CSI; JULIUS HONIG, president, Honig-Time-Sharing Inc., and Jones. The firm has $2 million worth of computers in its City Line offices, use of which can be leased.

Three divisions of Westinghouse Electric Corp. have been grouped under one head, according to FRANK E. SPINDLER, group vice president, Electronic Components and Specialty Products Group. Named to the newly created post of general manager, Electronic Components Divisions, is STEPHAN N. DONAHOE, who was previously general manager of the Electronic Tube Div. EDWARD F. DICK has been appointed general manager of the Electronic Tube Div., while JOHN C. MAROUS is general manager of the Semi-Conductor Division.

Applied Devices Corp., N.Y., recently announced that DAVID B. LEARNER, former vice president and Director of Research at Batten, Barton, Durstine and Osborn Inc., has joined the firm as vice president. According to president ROLLAND O. BAUM, Dr. Learner will be responsible for all advanced planning, research, development and new product and marketing activities.

Librascope Group of General Precision Systems Inc., Glendale, has announced two new recent appointments. J. D. "BOB" HANNAM is now director of marketing for the Group's products division and is responsible for directing the sales force activities within the scope of divisional policies and objectives. ARTHUR M. ANGEL joined the firm as manager of Rotating Memory Engineering for the Products Division. Angel has a 17 year background in engineering management on rotating memories, tape memories, and peripheral computer equipment.


ANGEL


KENNY

Milgo Electronic Corp., Miami, has announced appointment of MATTHEW A. KENNY as marketing manager, Data Communications products. JACK B. GERBER, formerly holding the post, is now marketing manager, data communications systems. Kenny is responsible for establishing a field marketing organization for the firm's data modem line.

STEPHEN J. LACOMMARE is now production manager of the Display Division of Data Disc Inc., Palo Alto. The newly-created position carries responsibility for production engineering and manufacturing of the division's line of digital video disc memory systems. He joined Data Disc in 1964 and was one of the original group who formed the Display Division from within the company in 1967.

Appointment of RICHARD RUDE as sales manager for Electronic Measuring Apparatus, Philips Electronic Instruments, Mt. Vernon, N.Y., was recently announced by JOHN P. O'CONNOR, marketing director. The new line is the outcome of a five year program of R&D; line includes oscilloscopes, meters, pulse generators, transistor curve tracer and low frequency measuring equipment.

Computer Industrics Inc./Graphic Systems Division, has named JOHN GELB chief mechanical engineer, according to KENNETH M. MILLER SR., vice president of CI and general manager of the division. Dr. Gelb has had wide experience as consultant and staff member in technical positions at firms including TRW, Marquardt, and Fairchild


GELB


BROPHY

Sylvania, N.Y., recently announced appointment of JOHN J. BROPHY as manager, Marketing Manpower Development for the Photolamp Div. He will coordinate all phases of sales training for the division's marketing group and will be located at headquarters in N.Y.

Appointed to the newly created position of marketing manager for digital readout, display, and ASW programs at the Chicago Center of Motorola's government electronics division, will be ROBERT CZAJKOWSKI. In his new assignment, Czajkowski will be responsible for the planning and implementation of activities required for the acquistion of new business.

WILLIAM F. WEST is now Western Regional sales manager for Adage Inc., Boston. The appointment was announced by I. R. SCHWARTZ, vice president of marketing. West will work out of the office in Los Angeles.

ROBERT K. BURTNER has joined Computer Logic Corp. as director of marketing. Prior to joining Computer Logic, Burtner was vice president, marketing for Autocycle Corp., Fullerton, Calif.

ROBERT W. LANDEE, div. g/m of Hoffman Electronics Corp., announced that GEORGE F. GRODIN has joined the Military Products Div. of Hoffman. For the past five yrs., Grodin, as manager of Computer Engineering and Information Management Systems for RCA's West Coast Div. in Van Nuys, Calif. was responsible for the design and installation of the Aircon computer switching systems for United Air Lines.

DR. MILTON E. MOHR, pres. Bunker-Ramo Corp., Canoga Park, Calif., announced the appointment of FRANK C. CASILLAS to Director of Corporate Development. At Bunker-Ramo, Casillas will be responsible for the development of new business opportunities, including merger and acquisition investigations designed to contribute to long-range plans.

ROBERT N. VENDELAND has been named general manager of Conrac Div. of Conrac Corp., Covina, Calif., according to WILLIAM J. MORELAND, vice president and Communications Group manager. Vendeland previously was assistant general manager, and prior to that was Conrac's general sales manager for four years.

SEYMOUR R. CRAY, vice president of Control Data Corp.'s Advanced Computer Development Laboratory, Chippewa Falls, Wis., was awarded the annual W. W. McDowell Award for outstanding contributions to the computer field. Cray received the award at the SJCC for his "continuing technical contributions to computer development ranging from device and circuit development through design automation and system definition."


CRAY


MORRIS

LEWIS C. MORRIS is now director of research and new product development at Technical Research Group Division of Control Data Corp., Minneapolis. HARRY J. WATTERS, vice president and general manager of the div., made the announcement. Morris was formerly with RCA, where he was manager of the Applied Physics Section.

Two regional managers have been named for Sanders Associates Inc., Nashua, New Hampshire. DUDLEY M. MEYER was named Southeast regional sales manager and DANER A. TOWNSEND was appointed Northeast Regional sales Manager.

ID Products

Hard-Copy CRT Printer

A hard copy CRT printer from Beta Instrument Corp., Newton Upper Falls, Mass., produces 8½ x 11 inch prints of computer-generated graphics and alphanumerics in seconds, according to the co. The paper is exposed by images on the high resolution CRT and developed completely dry, no liquids being used. Model HC610 is designed to be interfaced to a computer, coupled to a display controller or slaved to any graphical computer display.

The Betagraphics Printer is a random-access X-Y device said to feature high-speed magnetic deflection, geometry correction and dynamic focus. Full format settling time is less than 12 microseconds, point plotting rate is 500,000 points per second, line-writing rate is 2 microseconds per inch and character-writing bandwidth is greater than 1 megahertz.

Circle Reader Service Card No. 46

Electromechanical Chopper

Electronic Applications Co., El Monte, Calif., has announced Model 600-UC, the commercial version of the Government approved electromechanical chopper. Some features are copper cored header pins that virtually eliminate thermal offset errors; shielding between the contacts and drive coil assembly making possible the handling of signals less than one microvolt, contacts have a special processed hard gold plating which eliminates contact powdering; operates at all the popular drive frequencies 50, 60, 94 Hz. Model 600-UC, with standard seven pin header, is direct replacement for most choppers now in the field, according to the firm.

Circle Reader Service Card No. 47

Profile Bar Display

Higher sensitivity, better stability, and a price advantage of almost 30 per cent are claimed by a solid-state profile bar display instrument announced recently by the Industrial Products division of International Telephone and Telegraph Corp., San Fernando, Calif.

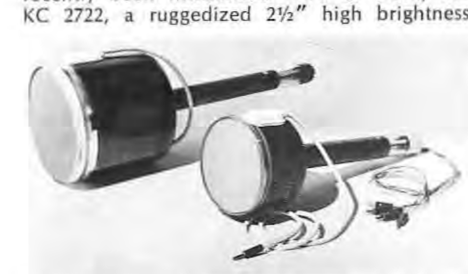
The instrument, the PB-703 Profile Bar Display, uses a 17-inch cathode-ray tube and is said to provide a flicker-free, real-time display of such quantities as temperature, pressure, voltage in convenient bargraph form. Individual channel drift is less than 5 millimeters in 24 hours.

The instrument offers a low-level transducer sensitivity of 500 microvolts per centimeter, a fail-safe alarm circuit that signals when any data exceeds predetermined high or low limits, and display intensification of the channel responsible for an alarm.

Circle Reader Service Card No. 48

Cockpit CRT

Three Fairchild-Du Mont, Clifton, N.J., tubes suitable for airborne cockpit application have recently been introduced. Two of these, the KC 2722, a ruggedized 2½" high brightness



tube for binocular applications and the KC 2672, 5" for cockpit radar projection, represent the head-up display group. The KC 2667 is a lightweight space saver panel mount type developed specifically for use in airborne electronic countermeasure systems.

Circle Reader Service Card No. 49

Trigger Generator

A Trigger Generator designed to trigger most flash tubes has been introduced by the United States Scientific Instruments Inc., Watertown, Mass. This generator is said to eliminate the need to design and fabricate specific circuitry for each individual experiment. The unit, type 3014, is self-contained, all solid state, and can be used for shunt or series injection triggering. Output voltage in excess of 30 KV is available in all operating modes. Operating modes are single shot manual, internal at 60 pps, external up to 400 pps.

Circle Reader Service Card No. 50

New 1.2" Deflection Assembly

The Deflection Components Division of Cleveland Electronics, Inc., Twinsburg, Ohio, has announced a 1.2 deflection assembly for use with current lead oxide television camera pick up tubes. This assembly, Cleveland Electronic part number PYLFA-708, is said to incorporate the latest techniques in deflection yoke manufacturing for color television cameras.

The deflection component contains a yoke, a segmented focus coil and an alignment coil packaged within a completely shielded mu metal housing.

The resolution capabilities of this assembly are said to be in excess of 600 TV lines and geometric distortions have been held within 1 per cent total. In production, this assembly can be furnished in matched sets according to camera design requirements.

Circle Reader Service Card No. 51

IC Driver/Decoders

An IC driver/decoder for driving incandescent lamps in IEE rear-projection readouts, plus other similar applications, has been introduced by Industrial Electronic Engineers, Inc., Van Nuys. According to the firm, use of the latest integrated circuits for gating and coding makes possible a smaller, more reliable instrument. Other advantages are said to include internal data storage for pulsed operations or single line for strobe and re-set, low power consumption (typically 500 mw), same logic voltage as used with IC's and high noise immunity (1.0 v.) which prevents false decimal indication.

All models incorporate forbidden code rejection which eliminates ambiguous displays. Standard 8-4-2-1 BCD code accepted; equivalent decimal output provided.

Circle Reader Service Card No. 53

Graphic Display Unit

A high-performance graphic display unit designed for use with SDS Sigma 5 and Sigma 7 computers has been announced by Scientific Data Systems, Santa Monica.

The SDS Model 7580 Graphic Display can be used to display data from on-going experiments, operate upon static displays to study the efects of design- or test-parameter changes, or visualize data or programs stored in memory to facilitate the development of new programs.

The unit features a 21-inch cathode ray tube, four display generators, a 6-character alphanumeric keyboard, a 16-character function keyboard, four action switches, light pen, and associated electronics.

Solid-state deflection and control circuitry are used in the CRT for accuracy, stability, and speed. Nominal display area is 100 square

inches, accommodating 1024 divisions along both the X and Y axes. Within the 10-inch by 10-inch working area, resolution of a point is 0.01 inch and plotting rates exceed 140,000 points per second.

Circle Reader Service Card No. 54

Video Information Display

The Model 440 Video Information Display has been announced by Data-Vox Corp., Sarasota, Florida. The Display is of modular construction and is designed for use with standard communication circuits as an input/output terminal. As an input terminal, it can be used to assemble and verify message segments prior to transmission. As an output device, it provides a highly legible, on-line CRT display, according to the co.

The Model 440 contains two major assemblies: a buffered character generator and one or more companion video TV monitors for message display. The character generator subsystem includes an input buffer with wired programming for interface with teletype lines, data sets, or other external devices such as manual keyboards or tape readers. Incoming information is assembled into the display format and sequentially converted to an alphanumeric video presentation. A standard display format of 384 characters is provided normally in a 12 line x 32 characters per line presentation. The characters are displayed in a smooth continuous font (not dot patterns or stroke approximations). The use of TV display techniques results in a sharp, well defined presentation. The system produces an output signal fully conforming to the E.I.A. standards for interlaced 525-line Video.

Circle Reader Service Card No. 55

1 H Digital Refresh Memory

A digital refresh memory has been developed by Digital Devices, Inc., Syosset, N.Y., which stores up to 512 bits of digital data to refresh a single horizontal television line, or for use as a high speed scratch pad memory.

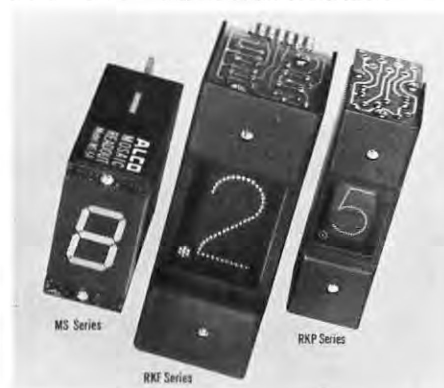
Designated type 457E, the unit uses a glass delay line as the storage element. Integrated circuitry is used to interface the delay line to standard RTL levels, and includes the read and write amplifiers, as well as retiming. Operating from standard DC power supplies, the unit accepts inputs of serial data and system clock, and provides an output of retimed digital data.

The unit is designed to operate in normal commercial environments of +10°C to +60°C. Package size is 4½" x 5" x 1¼". Threaded holes are provided for easy mounting.

Circle Reader Service Card No. 56

Readout Provides Brighter Display

Alco Electronic Products Inc., Lawrence, Mass., offers an improved series of numeral and symbol readouts. Newest addition is called RFK Series and is currently available for immediate delivery. Because of demand, this readout is larger and brighter, and is designed for users who require higher intensity.



The "in-line" design makes use of engraved acrylic plates which are mounted in a tightly packed stack and are individually edge lit by selectively energizing the lamps. Two lamps per plate are used to obtain a higher light output.

This series is available in 6V, 14V or 24V models for both numerals and symbols. Its overall size is 3¼" high, by 1¼" wide, by 1⅜" deep—including the printed circuit board. The display area for the figures, which are formed by a series of engraved dots, is approximately 1-1/6" high, by ⅝" wide.

The unit features a solid aluminum body that acts as a heat sink for the bulbs which are mounted on top and bottom of the unit.

Circle Reader Service Card No. 57

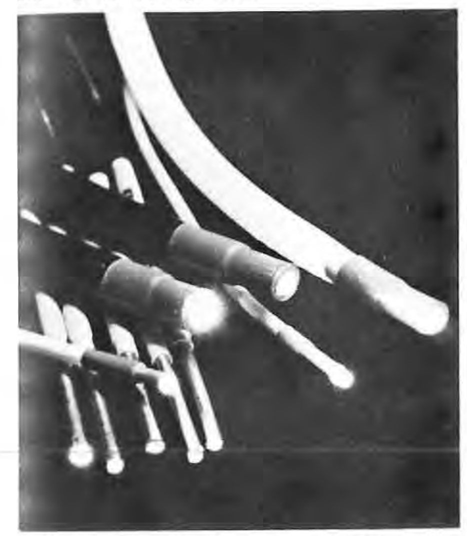
New Photometric Bench Accessories

The HEC Lamp Mounting Unit will accept clear or inside frosted secondary lamp standards up to 1000 watts, and is supplied with the appropriate socket. Location of the socket mounting and dimensions of the diaphragm opening are as specified by the National Bureau of Standards. The socket mount is rotatable. The HEC Opal Glass/Filter Holder Diaphragm provides a convenient method for spring loaded mounting of 2" x 2" filters, or an opal glass on either side of a 1¾" x 1¾" aperture. Available from Hoffman Engineering Corp., Old Greenwich, Conn.

Circle Reader Service Card No. 59

Flexible Fiber Optics Cable

Fiber Optics, Inc., Santa Cruz, announces availability of flexible fiber optics cable (luma-cord) in a wide range of length, diameter, and optical configuration.



With luma-cord, the company claims, controlled intense light, safe for use in explosive atmospheres, can be channeled from one source to one or more end points. Eliminates miniature bulb problems, reduces maintenance, provides greater light intensity than conventional sources. Applications include data processing (optical sensor), industrial controls (counting devices), vending machines, appliances, and other uses where intense, focused or pinpoint light is required.

Circle Reader Service Card No. 60

T-1, T-1-1/4 Bi-Pin Lamps

Two lines of sub-miniature bi-pin lamps with installation and operating cost savings for industrial users were recently introduced by General Electric's Miniature Lamp Department, N.Y.

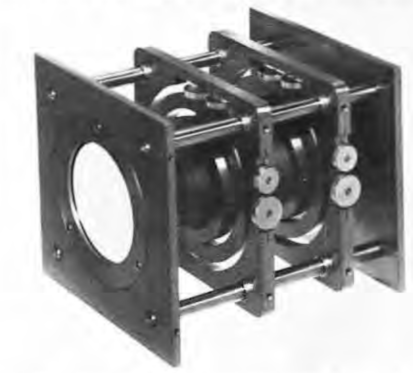
The company's T-1 and T-1¼ lamps feature a plastic base that resists distortion due to heat, thereby eliminating replacement problems. In addition, the lamps have gas vent slots that facilitate automated dip soldering of the lamps on printed circuit boards.

Available in both T-1 and T-1¼ types are three basic lamps: two rated at .06 amperes with design life of more than 100,000 hours, and one 40,000-hour lamp at .115 amperes. Lamp type identification, printed on the base of every GE bi-pin lamp, eliminates chances or delay or error in choice of lamp, according to the co.

Circle Reader Service Card No. 61

Precision Tube and Coil Mounts

Beta Instrument Corp., Newton Upper Falls, Mass., offers Precision Tube and Coil Mounts for the mounting and alignment of cathode-



ray-tubes, direct view storage tubes, single-gun recording storage tubes, dual-gun recording storage tubes, deflection yokes, focus coils and centering and alignment coils.

These units can be adapted to any combination of fixed and moveable yokes and coils. A micropositioning coil mount allows six independent degrees of motion, the adjustments of which can be locked without the slightest movement of final coil position. The bezel ring arrangement allows the tube to be easily removed from the front without disassembly of the frame or movement of the coil mounts.

The mounts are machined from aluminum and stainless steel, completely non-magnetic (including hardware) and finished in gold anodize.

Circle Reader Service Card No. 62

Low Frequency Receiver

A low-frequency receiver designed for electromagnetic and radio interference (EMI/RFI) measuring, spectrum analysis and surveillance applications has been announced by the Honeywell Test Instruments Division's Annapolis operations. Model 6869 VLF receiver is described as a wideband, electronically tuned, programmable device with digital readout capability. It covers a frequency range of 1 to 500 kHz. A wide selection of IF bandwidths and detector functions including AM, FM, NFM, FSK, CW and Pulse reception is possible, according to Honeywell, making the unit suitable for use in automated EMI/RFI measuring systems.

Other features of the Model 6869 were listed by the firm as:

Internal or external frequency sweep, internal or manual turning; Six voltage- or manual-selected bandwidths (100 Hz to 30 kHz), with remote capability; IF, audio, video, and wideband output; Narrowband dynamic range (greater than 70 db); Maximum noise figure, 6 db (typically 3 db).

Circle Reader Service Card No. 63

Indicating Focatron

Model P-122 Indicating Focatron instrument is now being ofered for optical alignment and gauging in assembly and quality control by Photomechanisms Division, Inc., Huntington Station, N.Y., a subsidiary of LogEtronics, Inc. The plane of best focus in optical systems is located accurately (limited only by mechanical precision) and instantly as a peak reading of the Focatron meter. In replacing the human eye with a consistent photoelectric probe, the Photomechanisms Model P-122 eliminates the variable differences from person to person.

 Circle Reader Service Card No. 65

Illuminating range is from 0.01 to 100 Lux, and standard Focatron probes cover a spectral range of about 400-700 millimicrons. Besides the Model A Universal probe 1.1″ in diameter and 0.4″ thick, other probes are designed for use with microscopes, graphic arts copy, cameras and enlargers, microfilm cameras, and optical benches. Size of the Model P-122 is 9″ x 10″ x 12″; power requirements are 105-130 volts ac, 50-400 cps, and 100 ma.

Circle Reader Service Card No. 66

Solid State Rectifier

Development of a suitable solid state high voltage rectifier for television sets has been announced by Varo, Inc., which will replace the high voltage rectifier and shunt regulator tubes which have been identified as sources of x-ray radiation in color receivers.

In addition, it will permit the manufacture of complete solid state receivers since the high voltage rectifier tube is the only remaining tube—other than the picture tube—in some sets currently being produced. Other advantages of the solid state device are said to be longer life, cooler operation and less power drain.

Circle Reader Service Card No. 67

Annuniciator Combines Lighted Indication With Voice Messages

Master Specialties Co., Costa Mesa, Calif., has developed an annunciator system that combines the standard lighted word-indicator with

a coresponding pre-recorded voice message. This system is called AVA for Audio/Visual Annunciator, and it said to distinguish itself from other voice systems by its compact size and the use of miniature, individual, plug-in type tape cartridges for each voice message. The system is suited for fault identification in aircraft, aerospace ground support equipment, and military applications, as well as for monitoring status condition in industrial or commercial process control installations, according to the firm

Circle Reader Service Card No. 68

Incremental Recorder

Peripheral Equipment Corp., Van Nuys, is now in production on the 800 bit per inch, 700 character per second digital incremental recorder. System/360 compatibility is said to be assured with the technology employed in the PEC Model 807, which features a wide band velocity servo drive coupled with an optical capstan encoder to provide higher speeds and greater data precision than possible with stepping motor drives. Skew is of critical importance when placing bits 1.2 mils apart for IBM compatibility at a packing density of 800 bpi. A single capstan (without pinch roller) and electronic de-skewing combine to eliminate the major skew components, assuring true IBM compatibility when reading back on the computer transport.

Fast gapping is supplied on all recorders without requiring a second capstan. Synchronous or asynchronous read capability is provided as an option. All silicon semiconductors and DTL integrated circuits are used in the simplified circuitry.

Circle Reader Service Card No. 69

Statistical Voltmeter

A solid-state voltmeter which analyzes random or noiselike waveforms on a statistical basis has been introduced by Micom, Inc., Palo Alto. Called the Model 3100 Statistical Voltmeter, the instrument makes a simple, direct measurement of waveforms and has application wherever it is necessary to measure electrical signals such as dynamic signal variations or noise generated by various types of transducers that detect mechanical movement, fluid changes, weight variations, electrical fluctuations, and many other physical and chemical phenomena.

The primary advantage of the 3100 over amplitude distribution analyzers is said to be that the unit can track a changing input signal and conveniently read the signal voltage because it directly reads the voltage for preset statistical limits. In other words, given a specified percentage of time that a signal will be found within some peak-to-peak voltage, the 3100 can find that corresponding level or voltage.

Circle Reader Service Card No. 70

Miniaturized Digital Readout and Remote Control

A miniaturized digital readout and remote control, model 825, is now supplied as standard equipment with the Selectroslide Model SLT-750 automatic slide projector, built by Spindler & Sauppe, Inc., Glendale.

This direct control system provides continuous numerical indication of the slide being projected, and permits forward and reverse slide intermixing at speeds approaching random-access selection systems.

Focus may also be remotely controlled by the new unit if projector is equipped with a Model 715 focus accessory. A third control, an on/off lamp switch, turns the projection lamp off without disabling the slide-changing mechanism or numerical indicator.

Circle Reader Service Card No. 71

Serial printer

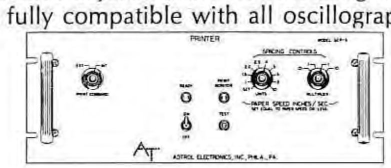
The Serial Character Printer (SCP-6) provides a fully digital printout capability for light beam galvanometer oscillographs, according to Adtrol Electronics Inc., Philadelphia, Pa.

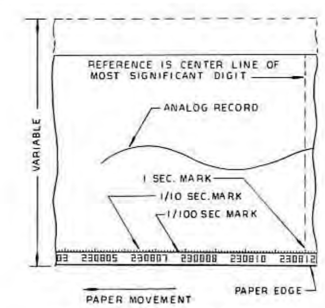
The SCP-6 prints six numeric characters in serial form along the edge of the oscillogram in time coincidence with the analog trace. The analog record may then be directly correlated to the numerical information at any oscillograph speed—1500 characters per second.

Relative or absolute time from digital time sources may be recorded simultaneously with the analog record, or any digital data may be printed, such as from frequency counters, digital voltmeters, etc., to provide the oscillograph user the full advantage of both digital and analog recording from the same oscillogram without sacrificing galvanometers and magnet block positions.

The SCP-6 accepts six BCD characters in parallel, and records each character serially by a single character recording head mounted within the oscillograph. Signals to accessory equipment are available enabling multiple oscillographs to record identical data. Storage is incorporated to allow the input data to change during the printing cycle. Three timing channel inputs are provided for independent time marking of the record adjacent to the numerical data. Any three time bases may be used to yield discrete time references or event markers.

The character size remains constant independent of paper speed. The paper speed controls set the optimum character spacing to the oscillographs, automatically, without calculations, setups, gain or balance adjustments. The recording head is fully compatible with all oscillographs.





TYPICAL REAL TIME PRINTOUT

The SCP-6 is rack mounted (19″W x 7″H x 16″D) weighing 30 pounds. All connections are rear entry with mating connectors, power cable and data output cable provided. Power requirements are 115 VAC ± 10V @ 2 amperes maximum.

Circle Reader Service Card No. 72

 Circle Reader Service Card No. 73

New Literature

Colorful Magnets To Assist Scheduling

Rol-a-chart , Mill Valley, Calif., offers a full-color 16-pg. catalog of permanent ceramic and flexible plastic magnets, illustrated in actual size, for use on all types of magnetic scheduling boards. Illustrated are round magnets, square magnets, rectangular magnets, strip magnets, magnet sets, and magnets imprinted with numbers, letters, and scheduling symbols. Marking pens and pencils, Rol-a-chart magnetic visual control boards, and other accessories for use with magnets are also illustrated.

Circle Reader Service Card No. 74

CRT Display Techniques

A 12-page booklet containing four articles on cathode ray tube displays gives a comprehensive picture of present status of displays opinions of leading manufacturers on raster-scan techniques, technical considerations which are influencing CRT display design, description of a CRT console for remote computing, and use of magnetic disc with TV monitors for low-cost graphic displays. Each article contains illustrations, some with complete schematics of the system described. Booklet is issued by Display Division, Data Disc, Inc., Palo Alto.

Circle Reader Service Card No. 75

Miniature Decoder/Driver with Memory

Instrument Displays, Inc., Danvers, Mass., offers the Mini-Diget Multi Decade BCD Decoder/Driver with Memory, which comes complete in one package ready for mounting.

The memory function is provided by a silicon monolithic four bit, gated latch circuit which accepts 4 lines 8-4-2-1 BCD input from DTL & TTL circuitry and provides decimal readout on miniature cold cathode display tubes.

Reduced installation costs, simple front panel mounting and front panel customizing capability are some of the features provided by the Mini-Diget line, according to the firm.

Circle Reader Service Card No. 76

Logic-Lites Catalog

Eldema, a division of Genisco Technology Corp., Los Angeles, has published an eight-page condensed catalog listing specifications of the line of indicator lights and logic-lites. Used in military, industrial and commercial applications, the lites feature built-in transistorized lamp driver networks, and the RFI/EMI shielded versions of lampholders which provide attenuation for interference shielding.

Circle Reader Service Card No. 77

High Resolution Cathode-Ray Tubes

Fairchild Du Mont Electron Tubes, a division of Fairchild Camera and Instrument Corp., Clifton, N.J., offers a 2-color brochure for the firm's line of standard high resolution cathode-ray tubes. Bulletin HR-8 furnishes general information on these specialized type of display tubes including detailed design on physical and electrical characteristics of the 34 types listed. It discusses typical operating conditions, notes on magnetic deflection, fiber optics capabilities and application assistance from Du Mont.

Circle Reader Service Card No. 78

Neon Glow Lamps Brochure

An eight page illustrated brochure has been published by Signalite Inc., Neptune, N.J., describing neon glow lamps for indicator applications, circuit components, and voltage regulations. This includes discussions on light output, longevity of the lamp and external conditions acting on the glow lamp. The brochure includes an ionization time vs. percent overvoltage graph, plus a circuit drawing showing various breakdown measurements, as well as a compilation of relevant terms which are clearly defined.

Circle Reader Service Card No. 79

Dac Systems Brochure

Adage Inc., Boston, Mass., has completed a brochure describing their "Y" Series Digital-to-Analog Conversion Systems. System structure and operation are discussed, including features such as the flexible addressing capability and the availability of two Data Distributors to provide different degrees of sophistication in system control.

Circle Reader Service Card No. 80

Magnetic Visual Control Systems

Methods Research Corp., Staten Island, N.Y., offers a 28-pg. color and descriptive catalog-price list depicting photographs and descriptions of installations of its' Magnetic Visual Control Systems. It deals visually with ideas and pictures of a variety of boards for handling almost every company type of job in maintaining perpetual data for daily, weekly, monthly or yearly use. Illustrations include computer scheduling, PERT planning, organization charts, sales incentive, stock market boards, hospital admissions and nurse scheduling, and controls for production, maintenance, personnel scheduling, shipping and ordering, trucks, schools, utilities and government.

Circle Reader Service Card No. 81

Librascope Brochure

An aircraft flight-control system is described in a brochure, "Librascope L-193 Head-Up Display", published by General Precision Systems Inc., Glendale, Calif. Illustrated and printed in full color, the brochure provides technical information on the servoed cockpit display system. The information on the L-193 includes aircraft attitude, altitude, heading, airspeed, flight-director, localizer, glide path, flare out, and other flight conditions.

Circle Reader Service Card No. 82

Programmed Image Analysis

A 6-pg. color brochure describing a general purpose visual image processor which reads from or records on film, differentiating between wanted and unwanted data, is offered by Information International, Los Angeles, Calif. Under control of a stored program it can identify and trace only the object of interest, as opposed to "flying spot" techniques, which gather and store all data points. Subunits of the complete system, including the film handling optical/mechanical unit, signal processing and logic unit, programmable light source (point-plotting CRT), scan control monitor unit and CRT graphic terminal with light pen are also described. An introduction to the field of automatic image analysis, as well as operations involved in a typical applications such as the reading of theodolite film are given.

Circle Reader Service Card No. 83

Production Tools for Industry

Tool Importers Inc., N.Y., N.Y., offers a "Production Tools for Industry" catalog. It features: 2nd Operation Lathes, Hardness Testers, Vertical & Horizontal Milling Machines, Turret Tooling, Bench Centers, Dial Bore Gages, Measuring Tools, Granite Surface Plates and Comparators, Toggle Clamps, Portable Clamps, Carbide Tipped Tool Bits, Lathe Chucks, Chucks Converters, Rotary Tables, Dividing Heads, Boring Heads, Arbor Presses, Angle Machine Vises, Adjustable Angle Plates, Heavy Duty Milling Machine Vises, Drill Press and Shaper Vises, Magnetic Chucks, Time Savers, Step Blocks, V-Blocks and Clamps, Tapping Attachements, Precision Live Centers.

Circle Reader Service Card No. 84

Electronic Measuring Apparatus

Philips Electronic Instruments, Division of Philips Electronics and Pharmaceutical Industries Corp., Mount Vernon, N.Y., offers a 50-pg. illustrated catalog describing Norelco measuring units, and delineates all specifications and product features. The catalog is divided into three product sections. The first is devoted to the Norelco oscilloscope series . . . that presents wide bandwidths combined with high sensitivity. The second deals with electronic multimeters, many of which offer capabilities such as upscale meter reading, automatic polarity indication, and built-in 2000-3000 times overload protection. The third covers signal sources which provide low frequency generating measurement. Each product section contains full descriptions of companion and accessory equipment.

Circle Reader Service Card No. 85

Multicell Magnetic Shielding Enclosure

A new multicell magnetic shielding enclosure which shields high energy output x-ray tubes used in nuclear and other research applications against external high level magnetic fields, is illustrated and described in Data Sheet 194 offered by Magnetic Shield Division Perfection Mica Co., Chicago, Ill.

Circle Reader Service Card No. 86

Easy-To-C Program Computer

Clary Datacomp Systems, San Gabriel, Calif. has published an eight-page brochure describing digital computing equipment. Model DE-600 computer can be used either as a calculator or as a decision-making digital computer. Included in the brochure are solution times for such problems as third-degree polynomial curve fit, solution of simultaneous equations, correlation and T-test, and compound interest. There is also a brief summary of pre-programmed problem-solving packages and computer peripheral equipment available from Clary.

Circle Reader Service Card No. 87

Flash Photolysis

Xenon Corp., Watertown, Mass., is now offering a brochure describing their Flash Photolysis System #384. The system is stated to include high hold-off pluse flashtubes, micro pulsers, and spectroscopic delay trigger systems.

Circle Reader Service Card No. 88

Circle Reader Service Card No. 89

Visual display unit permits "conversation" with computer

People who know nothing about a computer can use one simply by pointing an electronic probe at a new image display unit introduced by International Business Machines Corporation.

The IBM 2760 optical image unit provides a two-way conversational link with System/360. It can be used by nurses who update patient records, design engineers who estimate manufacturing costs, insurance agents who plan client coverage, and in many other applications.

The display may be located wherever it is needed—at a hospital nursing station, in a laboratory, factory, warehouse or branch office. Linked by telephone lines to a remotely-located computer, the display permits users to get information into and out of the data processing system in terms completely familiar to them. They don't even have to know how to operate a keyboard.

Through a split-screen technique, information and questions are projected from a film cartridge onto a page-size area at the right of the unit's screen. They can be shown as words, pictures and checkpoints. The film images are tailored by the user to a particular task. They represent a series of logical steps that must be taken, or questions that must be answered, to complete the job.

The left side of the 2760 screen is used to identify relatively permanent information. The response points on this side of the screen can be labeled by a transparent overlay or template corresponding to such fixed information as bed locations in a hospital, or storage areas in a warehouse. In effect, the operator can—by overlaying a template—use these response points to quickly provide the computer with supplementary data about the particular job.

The user also may enter variable alphabetic and numeric information by touching different points on the image of a keyboard. When all necessary questions are answered, the results are printed on an IBM 2740 communications terminal adjacent to the display.

VARIETY OF APPLICATIONS

In use at a hospital nursing station, for example, a nurse might insert a film cartridge on patient care into a slot on the front of the unit. Triggered by the computer, the first few images would ask her to identify the patient. Then, with the tip of her light pen, she would tell the computer exactly what information she wanted to record. As subsequent images flashed in front of her, she might note that medication was dispensed. More images would appear asking her the medication's type, dosage and frequency. When finished, she could ask the computer to print out a full, updated patient report.

With the touch of an electronic light pen to the screen of this image display unit, an engineer can speed information to a remotely-located computer.

In a manufacturing plant, an engineer might use the display terminal to find the most economic way of making a product. With the light pen, he would specify materials, shapes, methods of drilling, depths of holes and other variables. When finished, he would signal the computer to give him a detailed analysis. He could also get comparative cost estimates rapidly by changing only those variables or manufacturing methods he wishes to re-examine.

An experimental version of the optical image unit has been used in a pilot engineering cost estimation program at several IBM facilities.

In addition to patient record-keeping, cost estimating and insurance applications, the 2760 might be used to keep track of warehoused stock by quantity and size, to enter sales orders into computer files, or to process driver licenses at motor vehicle bureaus. The applications are programmed by the user to meet his requirements.

FILM CARTRIDGE

The film used in the 2760—16 millimeter color or black and white—is stored in cartridges that are inserted into a slot on the front of the unit at the beginning of a job. A single cartridge can hold up to 128 separate images, or frames. When the cartridge is inserted, a signal is transmitted to the computer identifying the nature of the job. The computer then calls into memory the appropriate instructions and data that will allow it to make the necessary calculations and record revisions.

IMAGE DISPLAY

Film threading and feeding are controlled by the computer. The first few images, displayed on the right side of the viewing screen, ask for basic identifying information such as the name of a patient, or the type of manufacturing operation. In many cases, the alternative responses would be multiple choice and the operator would touch the light pen to the appropriate response. If a person's name is needed, or a number, an image of a keyboard will be automatically displayed. The operator may touch several points to spell out the name or indicate a series of digits.

OPERATOR INTERACTION

With each touch of the light pen to the screen, a "beep" lets the user know that the computer has received the information. If a mistake has been made, the computer will signal either through the display or through the adjacent typewriter terminal. The operator also may change or cancel previously transmitted entries by pressing a button or touching the light pen to the appropriate point in the display.

SID Activities

NEW *SID* MEMBERS

ADAMS, David L., Wichita State University; BAGE, Earl A., General Electric; BEAN, Elizabeth S., Navy Undersea Warfare Center; BIDWELL, John L., General Dynamics; CAMPBELL, George C., Allstate Insurance Company; CARSON, David R., Control Data Corporation; CINQUE, Gregory, CBS Laboratories; CUMMINS, David E., Stanford University; CUNNINGHAM, James E., Electronic Image Systems Corp.; DIEHL, Alan E., Electrosystems; ELY, William Brewster, Engelhard Hanovia; FARR, Marshall J., Office of Naval Research; FAULKNER, L. E., LTV Aerospace; FINE, Joan K., Digital Equipment Corporation; FITTING, Frederick N., Metra Instruments; FRANZ, Warren L., Shell Development Company; GONYOU, George W., Federal Aviation Administration; GORKIEWICZ, Walter J., RCA Laboratories; GREIG, W. G., Moore Business Forms Inc.; GUZMAN, Adolfo, (STUDENT), Project MAC; HECHT, Laurence W., Owens-Illinois Inc.; HENRY, Raymond V., LTV Electrosystems; HOISETH, Roland L., COMCET Inc.

HOLLAND, John R., Bell Telephone Labs.; JENKIN,Deith R., Speedring Corporation; JOHANNS, J. H. M., N. V. Phillips Gloeilampenfabrieken (Netherlands); JOHNSON, Bud, Brown Engineering Company; KAZUK, Walter F., Clinton Electronics; KEPPLER, Eugene F., General Electric Company; LEYENDECKER, Jerome J., Westinghouse Elec. Corp.; LOWRY, William, SIOC Ltd.-Canada; MAUTER, Keith F., Owens-Illionois Inc.; MICKELSON, Nils B., Otis Elevator; MOFFAT, Burnham, Communications & Systems Inc.; NEVIN, Donald M., Integral Systems Inc.; OGLE, James A., Burroughs Corp.; PHILLIPS, H. Don., Westinghouse Electric; PILLA, Michael A., Bell Telephone Laboratories; POWERS, Cyril M., McDonnell Douglas; PURDY, Robert S., Philco-Ford Corporation; RASH, Ross D., COMCET Inc.; REID-GREEN, Keith S., Mobil Oil Corporation; REYLING, George F., Jr., Litton Systems, Inc.; RICKERSON, Donald M., National Security Agency; RIEKERT, Robert H., Information Displays, Inc.; SWANSEN, William G., Torkelson Associates; TORSUN, Imad Shakir (STUDENT), University of Manchester (England); VACHE, Raymond, Texas Instruments Inc.; WEBB, George N., John Hopkins Hospital.

BAY AREA

The Bay Area Chapter held a recent meeting at which George H. Balding, Manager of Advanced Development, Kaiser Aerospace and Electronics, spoke on "Cathode Ray Tube Displays for the Aircraft Pilot." He described and demonstrated several CRT devices to display information to a pilot. Included were devices employing conventional TV raster scan with synthetically generated pictures and point-to-point drawn symbols to supplement both conventional aircraft instruments and the out-the-window-view.

The annual dinner meeting is planned at the Paul Masson Vineyards, featuring wine-tasting with the compliments of Paul Masson, and a dinner subsidized from Chapter funds.

The Journal regrets to report the death of *SID* member Sherman C. Blumenthal, 39, well-known specialist in business information systems, employed by Union Carbide. Mr. Blumenthal, chairman-elect of the New York Chapter of ACM, had served as Exhibits Chairman of *SID's* Sixth National Symposium.

BBRC/Miratel's *TU Monitor*

SOLID-STATE–AND PROVEN

This is a TU Series eight-inch b/w utility monitor from Ball Brothers Research Corporation's Miratel Division. Miratel makes the TU with transistors for added reliability, and reduced heating. No big array of vacuum tubes. No heating problem. TU monitors have regulated power supplies, and are available with display tube sizes from eight through 27 inches. They are NASA proven and competitively priced. We could go on and on about solid state quality and performance, but our monitors can say it better than we can. Contact us for data sheets and an evaluation of the TU in your operation.

MIRATEL

MIRATEL DIVISION • BALL BROTHERS RESEARCH CORPORATION • 3600 RICHARDSON STREET • NEW BRIGHTON • ST. PAUL, MINNESOTA 55112

What Kollsman knows about digital electronics

finds 1 out of 2100 pages in 10 seconds.

Kollsman calls it DataSKan.™

In 10 busy seconds, it counts, scans, selects and displays information from among 2100 pages spread out on a 100-ft film roll.

Kollsman designed the entire mechanism, including logic system and the optics. The all-silicon digital electronics includes 15 photo sensors. And the film drive is a powerful new stepping motor that eliminates expensive Geneva drives and pull-down claws.

Kollsman is developing DataSKan™ for the Naval Applied Sciences Laboratory. But total recall

of active records is important for any industry. And with DataSKan™ portability, it can produce 10-second records almost anywhere.

Now Kollsman is thinking of more applications for DataSKan. Like automatic print-out of copies, or a computer-linked system of one or more units.

DataSKan™ information retrieval is another example of Kollsman ingenuity in action, from flight data instrumentation to systems management to electro-optics.

Kollsman plants at Syosset and Elmhurst, N.Y. Subsidiaries: Kollsman Motor Corp., Dublin, Pa.; Kollsman Instrument Ltd., Southampton Airport, England; and Kollsman System-Technik GmbH, Munich, West Germany.

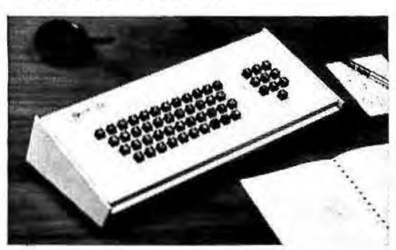
Kollsman Instrument Corporation Syosset, New York. Subsidiary of Standard Kollsman Industries, Inc.

KEYBOARDS

We also make readouts, switches, indicators, panel displays, in-line displays and CRT displays.

NEED A SPECIAL FUNCTION KEYBOARD? *THAT'S OUR BABY!*

■ As uninhibited as your needs. Customized for function and design without the usual price penalties of specials. TEC-LITE Electronic Keyboard Systems generate any code up to eight levels, or more, and can provide command controls and indicators on the Keyboard console itself. Note in unique design above, 10-key numerical input combined with alpha keyboard for data entry. Designed for a specific job, but achieved with standard TEC Keyboard techniques. Pulse action TEC-LITE Keyboard Switches make and break on the downstroke—duplicate the feel and travel of electric typewriter keys. Bounce-free logic and strobed outputs available, too. Average life, 10 million operations. Complete versatility in style, size, function, output code and electrical connections.



Customized from standard TEC Keyboard System components to fit design requirements. Here a TEC-LITE Electronic Keyboard provides 10-key data entry plus alpha, but without space bar.

TEC Electronic Keyboards can provide special function bars when required. Encoder circuitry translates information from switches into input codes up to 8 levels.

TEC-LITE ® **INFORMATION DISPLAY AND CONTROL DEVICES**

TRANSISTOR ELECTRONICS CORPORATION

Box 6191 • Minneapolis, Minnesota 55424 • Phone (612) 941-1100

Circle Reader Service Card No. 96

ID Advertisers

Beta-graphics ®

NEW HARD-COPY CRT PRINTER MODEL HC 610

PRODUCES 8½ X 11″ PRINTS OF COMPUTER-GENERATED GRAPHICS AND ALPHANUMERICS IN SECONDS . . . COMPLETELY DRY (NO LIQUIDS USED).

Model HC610 is designed to be interfaced to a computer, coupled to a display controller or slaved to any graphical computer display.

The Betagraphics Printer is a random-access X-Y device, featuring high-speed magnetic deflection, geometry correction and dynamic focus. Full format settling time is less than 12 microseconds, point-plotting rate is 500,000 points per second, line-writing rate is 2 microseconds per inch and character-writing bandwidth is greater than 1 megahertz.

Operation is simple, with only three controls in addition to the power switch — an exposure TIMER, an EXPOSE-DEVELOP switch for single exposure, development and delivery, and an EXPOSE switch for the multiple overlay or slow-buildup mode. All command and status interface signals are available for remote operation.

The Betagraphics Printer is here, now, to give you high quality computer graphics on paper. We'll be happy to send you complete specifications.

Beta Instrument Corp.

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