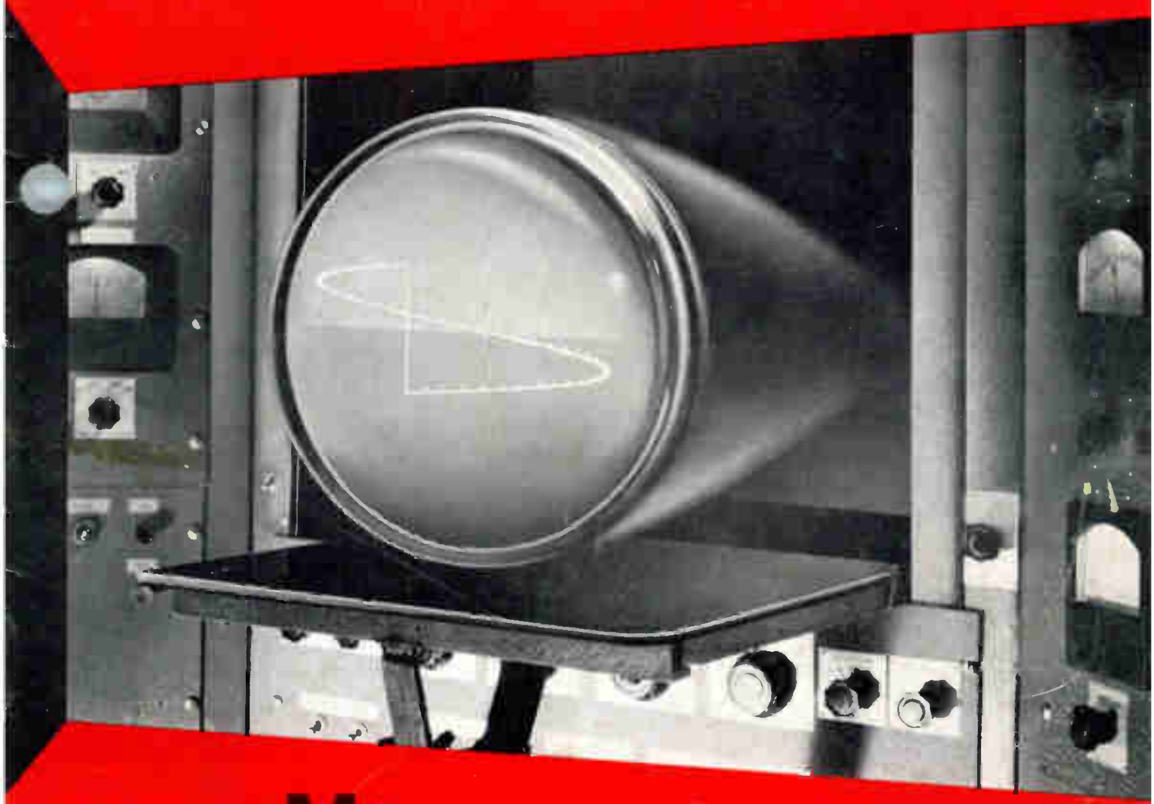
ISSUE 9

DU MONT JOURNAL of Instruments and Tubes



Simultaneous testing of two different types and colors of screen phosphors for aging characteristics.

DU MONT

ALLEN B. DU MONT LABORATORIES, CLIFTON, N. J.

DIVISIONS OF

FAIRCHILD
CAMERA AND INSTRUMENT
CORPORATION

DU MONT JOURNAL of Instruments and Tubes

A PUBLICATION DEVOTED TO ELECTRONIC INSTRUMENTATION, ELECTRONIC TUBES AND THEIR RELATED FIELDS — PROVIDING THE LATEST INFORMATION ON DEVELOPMENTS, APPLICATIONS AND TECHNIQUES. PERMISSION FOR REPRINTING ANY MATERIAL CONTAINED THEREIN MAY BE OBTAINED BY WRITING TO THE EDITOR AT THE ADDRESS BELOW.

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Editor: L. A. Hoyt

On the Cover

New name? Not really.

In our last issue of the *Du Mont Instrument Journal* we began publishing articles pertaining to electronic tubes as well as electronic instrumentation. As we stated, the two fields are so inter-related that it is difficult to talk about one without the other.

With similar reasoning, we can't justly call a publication that is oriented to the two subjects an "Instrument Journal". Thus the slight change in name — to *Du Mont Journal of Instruments and Tubes.*

Binders Available

Orders are now being taken for handsome red vinyl plastic binders to accommodate issues of the *Du Mont Journal of Instruments and Tubes.* Anyone desiring a binder please send a check or money order for $1.70, payable to Allen B. Du Mont Laboratories, and send it to the Instrument Advertising Department, Allen B. Du Mont Laboratories, 750 Bloomfield Avenue, Clifton, N. J. Please do not send cash.

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Fairchild Camera and Instrument Corp. is a 40-year old corporation with headquarters in Syosset, Long Island, New York. A pioneer in aerial photography and military reconnaissance equipment, the company has diversified during the years, both through the development of new products within the company and the acquisition of other companies with comparable interests. Prior to the Du Mont acquisition, it operated six divisions, with plants on both the east and west coasts of the United States and in the Netherlands. Its wide range of products include military intelligence gathering systems, photo-instrumentation for industrial and commercial use, electronic components for missiles, high performance aircraft and special applications, electronic engraving and automation equipment for the graphic arts, domestic and expeditionary aerial surveys, silicon transistors and diodes and 8 mm home sound movie cameras and projectors.

Du Mont's Industrial Electronics Division and Electronic Tube Divisions will be operated as the Allen B. Du Mont Laboratories Divisions of Fairchild Camera and Instrument Corporation, with Dr. Allen B. Du Mont serving as Group Division General Manager. Du Mont's Military Electronics Division has been merged with Fairchild's Defense Products Division and will operate as its Military Electronics Department.

The merger of these two pioneer companies is expected to result in new products, engineering in greater depth and better service for Du Mont's customers.

ABOUT CATHODE-RAY TUBE SCREENS

by: Nicholas Williamson
Technical Coordinator
Allen B. Du Mont Laboratories, Inc.

This discussion of cathode-ray tube screen characteristics has been prepared to assist the increasing number of users of industrial type cathode-ray tubes in understanding the theory, application, and the selection of the phosphors used for screens. This information will be of particular use to the consumer in judging whether his existing equipment will accept a screen with different properties than the one being used, and will guide the designer of completely new equipment in choosing the proper screen for his application.

Part II

3. *Photographic Detection:*

Photographic detection is used for making oscillographic recordings from cathode-ray tube screens with still cameras — when test records are to be kept, when proof of performance is required, and when pulses must be analyzed that move too fast for the eye to follow or are too weak to be detected by other methods. The moving film camera is used for recording a series of rapidly changing signals for leisurely analysis, and to provide a time sweep to compare a number of related fluctuating signals which have a common time base. The advantages of this method of detection are that it offers permanence of the records, the opportunity to enlarge the negatives for closer study and the elimination of parallax errors associated with visual detectors.

While the camera is basically an objective detector, it is not nearly as adaptable as the photometric devices just described — which can be had with many spectral responses and sensitivities. The spectral characteristics of the camera are restricted first to the photosensitive films and papers available, and then are modified by the spectral properties of the lenses (and dichroic mirrors) used in the camera. Most of the photosensitive media, which have been successfully adapted for recording from cathode-ray tube screens, have been found to have peak spectral sensitivity to light that is rich in blue emission. These films, because they were originally made for general purpose photography, have a wide spectral bandpass. If there is sufficient light output from the image display, passable photographs can be made with almost any of the standard screens. For the marginal cases where the light output of the screen is low, the best screen to use is one with a spectral emission characteristic in the blue range — such as the P-11.

Besides having a blue sensitivity, the screens used for cathode-ray photography should have a short persistence to prevent blurring when the signal or the film is moving rapidly. Where the screen has a phosphorescent property with an unwanted color, it is possible to filter out the color or choose a photographic emulsion insensitive to this color.

The preparation of tables with the proper exposure and writing rates for each of the screens under all conditions is extremely difficult because of the variables in equipments used, in choice of films, in the age of the film, in the methods used for development, in the presensitizing of the emulsion and in the use of reducing agents during development to increase contrast. (See article "Oscilloscope Photography By Polaroid-Land Process", by H. P. Mansberg, in issues 6 and 7 of the *Du Mont Instrument Journal.*) For this reason, it is recommended that tests be made for each individual application of the photographic technique.

Although most cameras can be adapted for photographing cathode-ray screens, the convenience and advantages of using equipment specifically designed for such work cannot be overemphasized.

Applications of Cathode-Ray Tube Screens

The common applications of cathode-ray screens are for displaying signal images in oscillography, radar, television and as light sources. In each of these applications, the type and kind of signal required has to be closely related to the physical properties of the screen.

Basically, there are only a limited number of ways the cathode-ray beam can be controlled — such as intensity modulation, deflection modulation and/or a combination of the two. In an intensity modulated display, the flow of electrons from the cathode to the screen is increased or decreased by varying the voltage on the control grid, or the cathode, which lightens or darkens the trace appearing on the cathode-ray tube screen. In deflection modulation, the cathode-ray beam is moved vertically or horizontally by magnetic or electrostatic forces, and its path can be followed on the screen (see Figure 4). By varying these methods of modulation, an infinite number of displays can be presented. However, practical experience has helped to define the methods used for each of these applications.

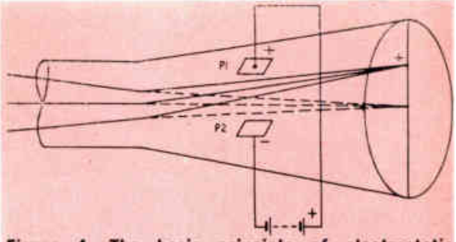

Figure 4. The basic principle of electrostatic deflection of an electron beam.

1. Oscillography

Essentially, the modern commercial oscilloscope uses deflection modulation for its display, although it has an intensity control and very often has beam-blanking circuits to avoid screen burns while the beam is at rest. This prevents film exposure before the arrival of a signal, and provides timing pulses when desired.

The oscilloscope is ordinarily used to relate the variation of a voltage under analysis with a second voltage — which is usually a time presentation, but can be any phenomena that can be expressed by a voltage. The number of screens that can be used

Typical of cameras designed especially for photographing directly from cathode-ray tube screens — particularly those mounted in oscilloscopes.

for this purpose is necessarily large because of the versatility of oscilloscopes, which can indicate changes in phenomena lasting several minutes down to millimicroseconds. Even general purpose oscillographs designed to operate within certain frequency band-width areas will accommodate a variety of screens to resolve all the problems these instruments are capable of handling.

For visual detection, the screens must provide a spectral color emission which most closely matches the spectral response of the human eye—under the lighting conditions of the actual application—and must satisfy the requirements of the eye in respect to persistence and fatigue. The light output efficiency of the phosphor must be as high as possible for the chosen application.

There are two important kinds of signals encountered in oscillography; repetitive and transient. Short and medium persistence screens are used to depict repetitive phenomena when these are repeated within the retentivity of the human eye and to follow transient signals moving slowly enough to be observed without having to resort to persistence. These screens also have the advantage of rapid erasure of signal image picture that eliminates blurring as new images are introduced.

Longer persistence screens are required when rapidly recurrent repetitive signals or very fast moving transient signals have to be studied. The image will remain on the screen long enough so that a composite picture is available and enough time is allowed to make the required measurements. This long persistence is desirable when using multigun cathode-ray tubes where the eye has to compare two or more separate image pictures. The several images will remain on the screen so that the eye has time to examine each of them. It is also used where a transient signal is moving so slowly that the portion of the image on the starting side would fade before the beam has transversed the full useful width of the screen.

Whether or not the screen will produce a useable visual image is determined by the maximum writing speed. This factor has three variables, the luminescence efficiency of the specific phosphor, the cathode-ray beam current and the screen accelerating voltage — in addition to the rate at which the cathode-ray beam is being deflected. If the beam is moving slowly for a given condition of these variables, each element of the screen it contacts will receive more excitation than it would if the beam were moving faster. As the travel of the beam is increased, a point is reached where the duration of excitation per screen element is insufficient to produce a light pulse.

The intensity control can be used to vary the light output range within the limits established by the accelerating potential, the specific screen and the type of cathode-ray tube. When these limits are exceeded, consideration should be given to different phosphor, different means of detection, a change of ambient light conditions and/or a different instrument.

The same type and kind of signals are displayed when photographic detection is used with oscilloscopes, but the photosensitive emulsions are not subject to the stringent demands of the eye. The most efficient producers of light under cathode-ray excitation are phosphors with blue emission characteristics. Although this light color is effective for films, it is quite far removed from the maximum spectral sensitivity response of the eye. Therefore, when the writing speed of the cathode-ray beam is very fast, the film will be able to detect signals that the eye can not possibly see. The persistence characteristic of screens for photographic use should be as short as can be obtained with high light output to prevent blurring of the image picture.

2. Radar

In radar, an echo principle is employed to locate objects by means of signal which is sent from an unidirectional antenna, then reflected by an object in its path, back to the sending source. By measuring the time elapsed from the start of the signal to its return, and knowing the speed of the propagation of the signal, the object can be detected and its distance from the sending antenna can be calculated.

Two fundamental methods are used with cathode-ray tubes to display and measure these signals, although many variants of the methods may be applied in modern radar sets. The first method is purely a deflection modulated display. The independent variable, time, is swept out on one axis and the transmission signal is amplitude deflected perpendicularly to the first axis. The return (echo) signal is displayed in a similar fashion as it is received (see Figure 5).

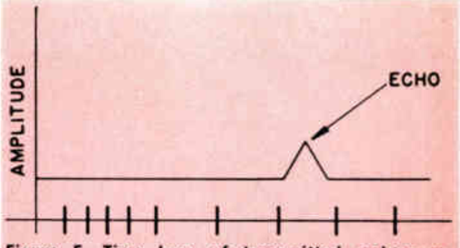

Figure 5. Time base of transmitted and/or reflected signal as used in radar, calibrated in terms of distance on one axis.

The second method combines deflection and intensity modulation and introduces the concept of scanning. The independent variable, time or range, is still swept from one point of the screen to another point, but the sweep is in turn rotated or scanned about the first point on the screen to correspond to the direction the antenna is pointing. The "echo" signal is used to intensity modulate the beam and will appear as a brightening of the trace sweep.

Much of the successful operation of radar will depend upon the circuitry designed to send, receive and prepare the scanning and echo signals before they are sent to the cathode-ray tube. In the final analysis though, the proper choice of screen will guarantee the operator the maximum amount of information possible. The cathode-ray screen used for radar purposes is called on to distinguish the reflected signal from the inherent and random noise signals of the radar circuits.

Like all other visual uses of cathode-ray tube screens, the choice of spectral emission characteristics will depend on the ambient light conditions under which the operator has to view the display. The light emitted from the screen must be of such magnitude and color that it can not change the level that the observer has to maintain (as in a cockpit of a night fighter or a blacked-out ship deck). The other problems that the screen has to solve involve flicker, resolution and contrast.

If the scanning rate is very slow, information from the individual sweeps will vanish from the radar screen before a composite picture is presented, and the operator will be unable to make comparisons. Longer persistence screens will preserve individual pieces of information until the whole picture has been presented. If the persistence is too long, flicker and blurring will occur; therefore, a proper persistence selection has to be made based on the image repetition frequency.

Resolution and contrast are closely related, and will dictate whether wanted signals can be distinguished from noise signals in adjacent areas. Unfortunately, the screens with the longest persistence often have the largest crystal size — as a result the large spot size may make it difficult to tell the signals in one area from those in another nearby area. Quite frequently a compromise has to be made between the persistence and the physical properties of radar screens.

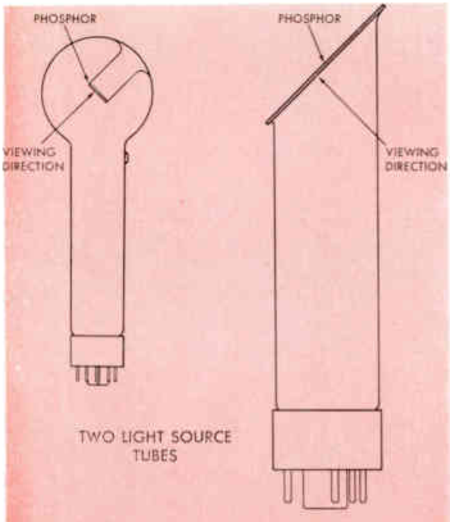

Figure 6. Two forms of cathode-ray tubes designed especially as light sources.

Since noise and interference (such as enemy jamming) signals are random in nature, another property of certain phosphors is used to help make the signal stand out. This is the property of build-up, which is defined in part I of this article (*Du Mont Instrument Journal,* Volume 8, page 15). The wanted signal, being constant in amplitude and repetition, will cause the screen to emit more light after a few excitations than will the random signal.

3. Television

In the television application of cathode-ray tube screens, the image presentation is formed by a combination of deflection and intensity modulated signals. Each element of the presented picture is scanned in accordance to a rigidly controlled and synchronized pattern (raster), and the color hue or degree of light and dark areas of the picture is translated by means of instantaneous intensity modulation (video signal). Since the type and kind of signals used in this application are fixed by standards set by the government and the television industry, further technical discussion is unnecessary.

4. Light Sources

There are two major applications of cathode-ray tube screens as light sources, and each has its own signal treatment. In one application the cathode-ray tube screen supplies either a stroboscopic light, or a light with fixed spectral emission characteristic and variable intensity for color comparison work.

Specially designed cathode-ray tubes have been made by Du Mont Electronic Tube Research Laboratories for this purpose that may take either of the two forms shown in Figure 6. The cathode-ray beam used in these two tube types is emitted by a flood gun, and may be intensity modulated and accelerated to obtain maximum light output efficiency. Because the emitted light is viewed as an area source, there is no need for deflection plates. Greater light output is gained by using light from the bombarded side of the screen and by using a metal anode upon which the screen is coated. The metal anode can be cooled by an air blast, permitting high current densities without screen temperature rise (and resulting screen decomposition), and can be connected to a metal conductor to carry away the excess electrons — preventing space charge buildup which could cause current saturation of the screen.

When used as a "strobe" light, the screen should have a short persistence and supply a fairly white light. When used for color comparison work, the screen may have any persistence because the light output is continuous. The spectral emission characteristic may be selected from the standard JEDEC phosphors or by the creation of a special phosphor.

The second major application is for a light source in flying spot scanners (see Figure 7). In the flying spot scanner, a moving spot of light from the screen of a cathode-ray tube is focused on an object to be analyzed. This spot is usually swept by deflection modulation in the cathode-ray tube from side to side and top to bottom — in effect, scanning each element of the object. A multiplier phototube, or bank of multiplier phototubes, is placed to receive either transmitted or reflected light from the object.

Since the intensity of the light spot is not changed, the multiplier phototube will receive a light signal which is modulated according to the transmission (or reflection) of the various parts of the object — which, in turn, will produce a modulated output current of the phototube for each part of the object being scanned at that specific instant.

The primary use for the flying spot scanner is in television applications—for reproducing slides and motion pictures. The system will produce black and white television pictures or color television pictures by using phototubes adapted to receiving primary colors. Industrial uses of the flying spot scanner include surface inspection for quality and color characteristics, quality inspection of translucent materials, the electron microscope, electronic counting of objects of all sizes, and in electronic control of automatic production machinery.

Screen requirements of flying spot cathode-ray tubes will be established by the specific applications. In most of these applications optical transmission of the scanned light is necessary, so particular emphasis should be placed on the crystal size of the phosphor—which must be kept small to prevent a grainy presentation of the final signal.

Enhancing Screen Properties

The ultimate performance of a screen with color and persistence characteristics will depend upon the cathode-ray tube, its operation, its construction, and the various devices used with it. Because of this, a general review of some of the factors involved and their relation to each other will be presented.

By changing the different operating conditions, the light output of cathode-ray tube screens can be drastically altered. However, each of these changes will affect some other property of the screen or the tube. A proper balance of the variables may be the deciding factor in determining whether the advantages gained are justified economically as well as in the final performance of the tube. An

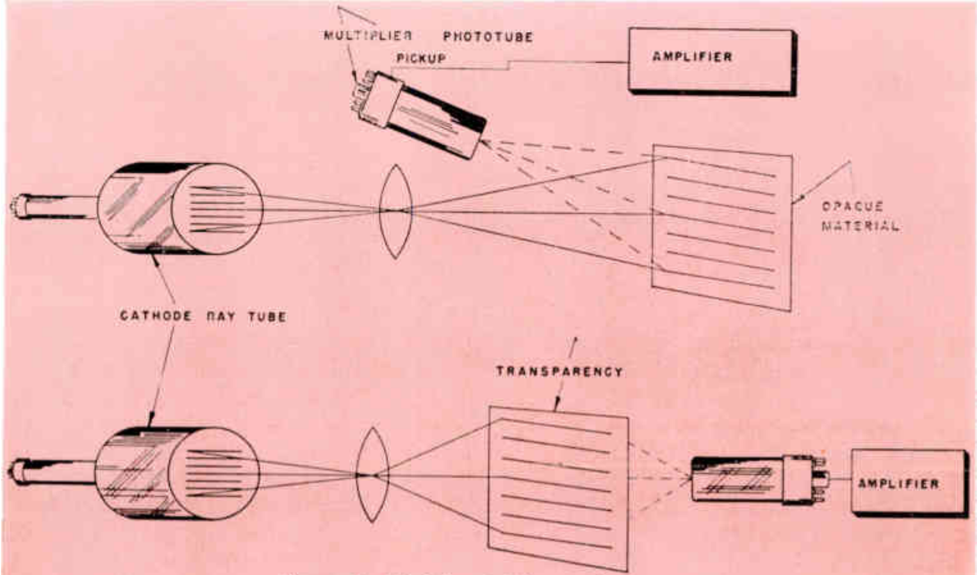

Figure 7. Principle of flying spot scanner.

understanding of these variables is particularly valuable to the designer of new equipment in which cathode-ray tubes are to be used, but will aid the consumer of standard industrial tubes in judging the performance of screens in his present equipment,

1. Tube Operating Conditions

The principle object in cathode-ray tube design is to produce as bright and small a spot as possible with the minimum amount of power to generate and deflect it. The brightness of the spot makes it visible against a contrasting background of other signals, the basic color of the phosphor, and ambient light. The size of the spot determines the resolution which establishes the sharpness of detail available, the number of pieces of information that can be presented on a sweep or the total area of the tube screen, and the accuracy in detecting a difference between two signals in oscillography.

The light output at the screen of a cathode-ray tube is determined by the energy in the cathode-ray beam —which is a product of the screen current and the screen accelerating potential. The electrons emitted by the cathode are mechanically, electrically or magnetically shaped and focused into a bundle of rays, i.e. a beam, which is brought to as sharp a point as possible at the screen of the tube. The flow of electrons is maintained in the gun by modulating the voltages on either the cathode or control grids to repel or attract the negative electrons. The beam is then focused by electrostatic or magnetic fields depending on the tube type. Finally, provision is made by magnetic or electrostatic fields to move this beam so that it can be controlled to cover the useable area of the screen.

Since the control, focusing, accelerating and deflecting voltages (in the case of the electrostatic tubes) are all interdependent on each other, a change in any one of them will effect the final spot size and brightness. The interrelations of these operating voltages are set forth in the tube manufacturer's specifications, which should be carefully analyzed before the selection of a tube and a screen is made.

The light output of a screen will vary as shown in the formula:

$$\text{Light output} = \text{K (Accelerating Potential)}^{n}$$

where K and n are constants of the screen material, and n varies from 1.5 to 2. It is easy to see how increasing the accelerating potential will cause a corresponding increase in brightness — which is accompanied by a smaller beam diameter, another advantage. The increased speed of the electrons will make their deflection harder and will require more deflecting power to move them. This necessitates larger magnetic or electric power supplies, which increases the overall weight and cost of associated equipment.

Another undesirable effect of increasing the accelerating potential is an increase in the deflection factor; the number of volts applied to the deflection plates to produce a related deflection on the screen. If light production is the prime factor in an application, and the extra weight and cost with decreased sensitivity can be absorbed, then increasing the accelerating potential offers a good method of getting more light.

An increase in the beam current, the other factor in producing light on the screen, will also give more light output—but unlike increasing accelerating potential will cause an increase in spot size. Judicious manipulation of the two factors can often produce a better combination than a straight increase in either of them.

The common types of cathode-ray tubes in which screens are used are designated as magnetic or electrostatic, depending on the method of deflection used. Magnetically deflected tubes employ either magnetic or electrostatic focusing, while electrostatically deflected tubes usually employ electrostatic focusing.

The magnetic tube, with the deflecting magnets on the outside of the tube and no internal plates, can be made shorter and with a much wider angle of deflection than the electrostatic tube. It is ordinarily magnetically focused, but when high beam accelerating potentials are used to obtain high light output, the size of the focusing magnets and the power consumed by them becomes large. Electrostatic focusing can reduce these limitations. The magnetic tube is limited, too, by the frequency response of the deflecting magnets which in turn limit deflecting signals to relatively low frequencies.

Magnetic tubes have the advantage of high resolving power, and are used where small spot size and high resolution with large screen areas are prime considerations; for example, in flying spot scanners, television and for some radar displays.

The electrostatic deflecting tube, on the other hand, is ideally suited for oscilloscopes and radar usage — where a wide range of signals with a large range of frequency requirements have to be handled. The slightly longer tube is no handicap for oscilloscopes, and the advantages of extremely high-frequency response of this type of tube more than offset any disadvantage of extra length.

There are several methods used for increasing the light output of electrostatic cathode-ray tubes. One method is to apply a high accelerating potential to the beam after it has been focused and has passed through the deflecting plates. This method has the advantage of obtaining very high screen potential without seriously disturbing the focusing and deflections potentials, and without unduly decreasing deflection sensitivity. The disadvantage of this method lies in the difficulty of maintaining uniform electrostatic fields between the plates and the screen. The lack of uniformity will affect the display as the beam is scanned to the outer extremities of the screen, causing "barrelling" or "pincushioning" and a tendency for the spot to defocus. The application of a spiral conductive coating instead of bands for post accelerators, new types of post accelerators, and innovations in plate design have greatly minimized these disadvantages. The highest writing speeds recorded by cathode-ray tubes have been made with this type of tube.

The second method of getting high light output from electrostatic tubes is based on the older principle of using a very high accelerator potential. Du Mont developments in gun and tube construction, with rigid tolerance specifications, led to the evolution of the mono-accelerator tube. In this type of tube the beam is not subject to electrostatic fields after it leaves the deflection plates. As a result it produces very linear patterns with a uniform spot. Since the screen potential can never be as high as might be obtained with post acceleration, compensation is made by increasing the screen current which results in a slightly larger spot size.

In order to determine what light output can be expected from a screen no matter what type of tube is chosen, the user need only know what the screen acceleration potential and current are. Then the tables of dynamic ranges of the screen phosphors will indicate the light output for these conditions.

2. Faceplate Glass

In standard JEDEC industrial cathode-ray tubes, all problems relating to faceplate glass have been analyzed. Du Mont supplies a faceplate which has been designed to give the maximum transmission of light, and broad spectral response to adapt it for use with most of the standard phosphors. The thickness and structural shape of the glass are made compatible with each tube's performance and safety requirements.

Du Mont also supplies special faceplate glasses for beyond-the-usual requirements. One of these is grey faceplate glass. With this glass there is an effective increase in contrast, but at the expense of light output—a reduction of approximately a third. This glass is recommended for use in flying spot scanners used for television purposes—where the loss in transmission is more than offset by the gain in contrast detail.

Another method of increasing the contrast and reducing the reflected light from the faceplate glass (where a visual detector is to be used), is to coat the glass-to-air surface with a thin single molecular layer. This coating is put on during the tube manufacturing process and is temperature hardened at the same time. With reasonable care in handling, this surface is durable and will give an effective increase in contrast and lower reflectance.

Another type of glass is one designed to give more efficient transmission of ultraviolet light. Many of the standard phosphors have a peak in the ultraviolet region, and this glass offers less attenuation to the ultraviolet emission from the phosphor.

Still another type of glass is available where the light output demands unusually high screen accelerating potentials and high current densities. Under these conditions, soft X-rays are produced which cause a decomposition and a gradual darkening of the glass, resulting in loss of light output. Du Mont can supply a non-browning glass, either clear or gray glass, to minimize this effect.

The thickness of the faceplate is important when the screen is being operated with very high accelerating voltages and beam currents. The thinner the glass, the faster the generated heat will be conducted away. If not removed, heat can cut down light output efficiency—as phosphors show a distinct loss of light with increasing temperature. Continued applied heat may also cause a chemical breakdown in the phosphor which will completely destroy its emission properties.

3. Metallization

A method for increasing the light output from a cathode-ray tube screen is to deposit a thin layer of metal over the phosphor surface inside the tube. This metal layer reflects light forward, from the back of the screen, where the first incidence of the electron stream with the screen occurs.

The crystals nearest the electron gun and the deflection system are the first to receive irradiation. The further these particles of energy penetrate the layer of crystals the more they are absorbed—leaving less to produce luminescence in crystals farther away. With the major part of the light produced at the back of the screen, a good portion is reflected back inside the tube where it is lost to an observer in front of the faceplate. Some of the back reflected light will strike the inner surfaces of the tube and will be reflected forward in a random fashion and can cause an uneven lighting of the whole screen.

There is a loss of emitted light through absorption in the crystal layer on its way to the face of the screen. The usual methods of increasing light output—such as raising the accelerating voltage and screen current—will improve the light output, but will aggravate the undesirable effects of glow and may conceivably saturate the screen phosphor.

It was discovered that a thin layer of metal could be placed on the screen crystals. This serves to reflect forward the light previously lost back of the screen, thus eliminating background glow and almost doubling the light output of the specific screen. Aluminum is the metal commonly used for this purpose, although the spectral properties of other metals might recommend them for a specific use—such as viewing through a transluscent screen with a darker colored metal reflector to increase contrast. A carbon backing has also been used with a transparent evaporated phosphor. (See page 17 Issue 8 *Du Mont Instrument Journal*).

The thickness of the metal coating will vary with the operating conditions of the tube and with the physical surface of the screen. In general, a few extra kilovolts of beam voltage are necessary to penetrate a micron of the aluminum layer. After the crossover potential has been reached, however, the metalized screen will always produce a greater light output than an unmetalized screen with an equivalent accelerating potential. Crossover potentials for standard screens are between 1.5 and 6 kilovolts.

The main benefits that may be obtained with metalization are:

(a) *Higher light output* — particularly important with phosphors that are subject to burning at low screen current densities.

(b) *Reduction of ion burning* — the metalized screen is pervious to the lighter electrons, but is impervious to heavier ions that might be present in the tube.

(c) *Reduction in charge on the phosphor* — the electron population on the screen may be increased to the point where space charge effects would limit the efficiency of the screen current. Most phosphors are poor conductors, and the metal backing connected to the accelerating material will serve to distribute the electron charge.

(d) *Reduction of background glow* — the elimination of reflection from the inner metal and glass surfaces is assured.

(e) *Reduction of cathode glow* — the light which can pass through the cathode-ray tube — emanating from a radiant cathode — is effectively blocked by the metal back.

4. Filters

While the use of color selective filters in front of the cathode-ray tube will not increase the light output, they are used for two purposes in enhancing screen characteristics. The first purpose is similar to the use of the gray faceplate mentioned above—where the primary effect is to increase contrast. It differs from the use of neutral gray glass by being color selective in nature. If the color of the emitted trace is closely matched to the color of the phosphor, and the ambient light is high, it will be difficult to distinguish the trace. By selecting a filter with a color transmission mated to the spectral output of the screen emission, the light emitted by the screen will be attenuated only once, but the reflected light will be attenuated twice —going through the filter and being absorbed in reflection from the phosphor. The triple effect in reducing reflected light will make the trace stand out more clearly.

The second purpose in using filters is to select a limited bandwidth of light from the total spectrum present in a screen's emission characteristic. Filters are supplied for this purpose with screens such as the P7 — which has a blue or blue-green emission during excitation, and a yellow emission after excitation. If an operator is primarily interested in the persistence characteristic (yellow), the presence

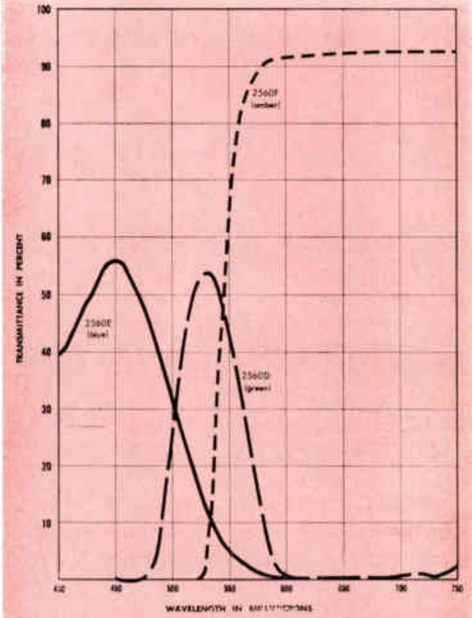

Figure 8. The average spectral transmittance of light through typical color selective filters. Such curves are helpful in determining light loss caused by filters.

of the fairly bright blue flash will be disturbing and very fatiguing over long periods of observation. The use of an amber filter in front of the screen will effectively quench the blue light. If, however, the P7 screen image is to be recorded photographically, the presence of the yellow persistence component can blur the negative. A blue filter can be used in this case to block out the yellow component.

Still another purpose is to limit the emission so that the trace light will not disturb the dark adaption level of the observer. Red and amber filters are used with long persistence screens, such as P7, P19 and P25, to effect this end.

Regardless of the purpose, it is assumed that the unfiltered light output will be enough to tolerate the attenuation of the filter and still give a useable light output. The average spectral transmittance of light through typical Du Mont filters is shown in Figure 8. The Du Mont Type 2560D is a green filter, the Du Mont Type 2560E is blue, and the Du Mont Type 2560F is amber. Loss of light due to filters can be calculated with such curves.

NOTE: Those interested in more complete data on screens can obtain a copy of a revised catalog on JEDEC phosphors by sending $5.00 to Electronic Industries Association, 11 West 42nd Street, New York 36, N. Y. Request JEDEC Publication No. 16, entitled Opitcal Characteristics of Cathode-ray Tube Screens.

Regional Sales Office In Washington, D.C.

Stanley J. Parnas

The Du Mont Instrument Division of Fairchild Camera and Instrument Corp., officially opened a new Washington, D.C. regional sales office on Nov. 7, 1960. Located at 1625 Eye St., N.W., the new office is responsible for instrument and parts sales, as well as service, within the states of Virginia, Maryland (except Harford County), in several counties of West Virginia, lower Delaware and Washington, D.C.

The office houses complete facilities and personnel for handling all facets of sales administration and service. Original equipment and parts are stocked on the premises for quick delivery. The service shop is equipped with the latest test equipment to fulfill rapid repair and return policies. To augment customer service, direct telephone tie-line and teletype connections with factory have been established. For any assistance or information, the office can be contacted by phoning MEtropolitan 8-1232.

In charge of the Washington office is Stanley J. Parnas, who joined Du Mont in November, 1959. Mr. Parnas is a graduate of C.C.N.Y., where he earned his engineering degree in 1953. Mr. Parnas was formerly with the Weston Instrument Division of Daystrom, Inc., serving as their Washington, D.C. sales representative for four years. During his tour of military service he was Proof Director for experimental tank ordnance at Aberdeen Proving Grounds, Maryland.

An Apparatus And Instrumentation For High Pressure Dynamics

by: Leo D. Schultz
Dynex, Inc.

How a firm interested in the pressure vs. loading density characteristics of liquid propellents designed a test rig for such studies, and how they set up measurement procedures. An explanation of parameters of interest is included .

The work described here is a first phase investigation of research into the problem of developing and maintaining controlled pressures of high order (100,000 psi) using liquid propellants. This first phase is to determine the maximum pressure vs. loading density developed by typical liquid propellants and to gain information as to their combustion rates through knowledge of their pressure-time curves.

Calculated performance can be inaccurate due to assuptions made concerning the thermodynamics involved or the composition of the combustion

Figure 1. Typical test sight for liquid propellent study at Oynex, Inc.

gas. In addition, calculations give only the maximum theoretical performance. Therefore propellant evaluation should not rely on calculations, but these calculations should be augmented by experiment before firm conclusions are made. It is felt that this information could best be obtained with sufficient accuracy through the use of a constant volume ballistic bomb using suitable instrumentation. It is estimated that the time required to complete combustion will be several milliseconds, gas temperatures will rise to 5 or 60000°R and pressures can exceed 100,000 psi.

The bomb consists of a tapered cylindrical plug fitted into a body 7 inches square by 12 inches long. The tapered plug is held in position by a retaining plug threaded into one end of the bomb body. The combustion chamber is located within the tapered plug (see Figure 2). The lapped surface of the tapered plug when positioned in the bomb body forms an effective seal against the leakage of high pressure gas from the combustion chamber. This design feature minimizes the longitudinal forces that can be transmitted from the combustion chamber to the threaded retaining plug. This design is calculated to withstand pressures in excess of 200,000 psi.

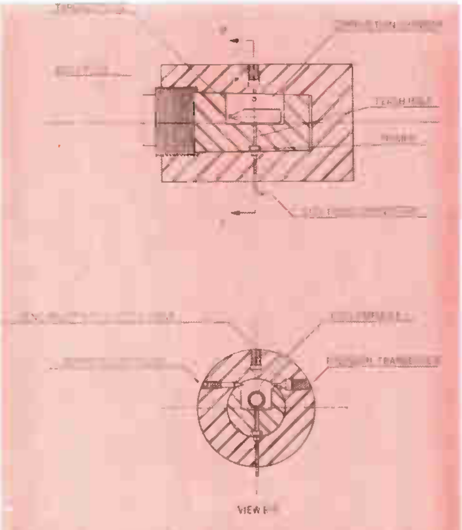

Figure 2. Cutaway diagram of ballistic bomb test rig used for determining parameters related to liquid propellent combustion-pressure vs. time.

There are four (4) access holes into the combustion chamber through the bomb body for instrumentation and firing. A piezo-electric pressure transducer is located through one edge, an experimental temperature probe through the top and a combination vent pressure relief and fuel loading valve is through the other edge. The primer flash hole is through the bottom of the tapered plug and aligns with the firing pin mechanism that is built into the bomb body.

Practically all of the propellant combinations to be investigated are hypergolic, that is, burn spontaneously when mixed. This property requires that the fuel be kept from contact with the oxidizer until the moment of firing.

In our investigation the fuel will be capsulated in ampoules prior to use. The loaded fuel ampoules are held in position over the primer flash hole and are shattered by the primer blast. The oxidizer is injected through the vent and relief valve hole and flows around the fuel ampoule. The firing of the primer shatters the ampoule, mixes and ignites the propellants. The amount of mixing, though not complete is sufficient for complete combustion.

After a critical review of the current available instrumentation, we felt that a combination of a Kistler miniature piezo-electric pressure transducer and a Du Mont dual beam oscilloscope would provide maximum flexibility, more than adequate sensitivity, and excellent response at minimum cost. An oscilloscope was chosen in preference to an oscilograph for the following reasons: higher response frequency, no chart or pen difficulties and expense, higher writing speeds, ability to produce (using camera attachment) inexpensive negatives capable of direct reproduction.

In particular, the Du Mont 411 oscilloscope was selected because of its ability to synchronize itself on the information signal. This feature eliminates a rather nasty problem of external synchronization that would have required electrically ignited primers at a prohibitive cost. Even with electric primers, the delay between primer ignition and the mixing of propellants would rule out any accuracy in propellant ignition-delay determinations. This oscilloscope has more than sufficient sensitivity to trigger itself on the primer blast and synchronizing with the shattering of the ampoule with a total delay at only a few microseconds.

For the investigation in progress we are primarily interested in maximum pressure and the time-rate of pressure rise. However, this apparatus as instrumented can be used to gather a wide variety of data concerning both liquid and solid propellants. It is anticipated that we shall gather much of this data after our initial objectives have been met. Figure 3 depicts typical information obtainable, and expected, with this instrumentation setup. The value of the dual-beam scope is that, other than temperature, many other related parameters can be individually displayed and studied as well — simultaneously with the all-important pressure time information. The use of separate transducers for each parameter, even with different (but related) calibrations, feeding information to two indepedendent scope channels makes this possible.

Standard practice in the ordinance field is to measure the "impetus" for evaluating gun propellants. The "impetus" of a propellant is determined by measuring the maximum pressure obtained by the burning of a known amount of propellant in a closed, constant volume bomb. This type of measurement is easily accomplished with the apparatus described here.

Standard practice in the rocket field is to measure the "specific impulse" for evaluation of a propellant (or combination of propellants). The "specific impulse" of a propellant(or propellant combination) is a measure of its overall efficiency and it represents the pounds of thrust developed per pound of propellant (or propellants) burned every second. The necessary thermodynamic relationships have been worked out (1) so that proper evaluation of the data will yield the quantities "specific impulse" and "characteristic exhaust velocity". Both factors are essential to proper evaluation of a rocket propellant. A ballistic bomb as described here will yield the necessary data for this evaluation.

In addition, the "co-volume" for the system under investigation may be obtained. "Co-volume" is a constant property of real gases which is nearly independent of pressure and accounts for the difference between real and ideal gas behavior. The value of the "co-volume" must be obtained experimentally and varies for each propellant.

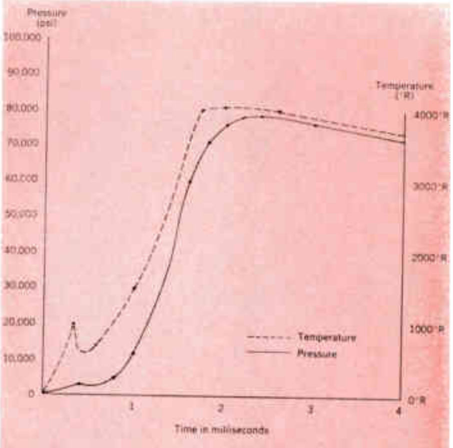

Figure 3. Typical information obtainable, and expected, using a ballistic bomb test rig with separate transducer outputs being simultaneously fed to a dual-beam oscilloscope.

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(1) Griffin, Turner and Angeloff, "A Ballistic Bomb Method for Determining the Experimental Performance of Rocket Propellants," *ARS Journal*, vol. 29, No. 1, 1959, pp. 15-19.

NEW STORAGE OSCILLOSCOPE

TYPE 430
STORAGE OSCILLOSCOPE

Technical Resume: Storage time — seconds to days; Erase time 15 seconds with new storage cycle every 45 seconds (nominal); frequency range 10 kc.; identical X and Y amplifiers; low-cost CRT guaranteed for 10,000 fast erases — 750 hours of continuous erase; sensitivity 10 mv/cm.

The recently developed Du Mont Type 430 Storage Oscilloscope overcomes the most pronounced deficiencies encountered in the storage equipment field; i.e., size, cost, versatility, and short-life CRT's. The 430 also offers a better resolution through smaller spot size, and a larger screen area than most oscilloscopes in this category.

Storage cathode-ray tubes in this type of equipment have been one of the greatest deterents to more extensive use. Short-lived operation is compounded by expensive replacements. The Intelex Type AS 17-21 used in the 430, however, is guaranteed for 750 hours in continuous erase and 10,000 fast erase cycles. Protection circuitry prevents tube burn. The price of a replacement tube is $175.00 — approximately 1/5 the cost of most storage CRT's. It is a rectangular tube with a usable screen area of 8 x 12 cm — and is magnetically deflected.

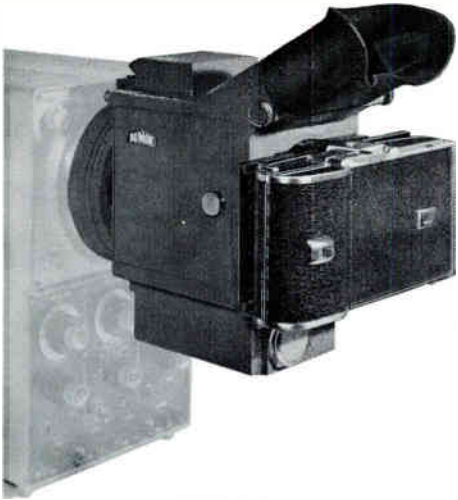
A P10 storage screen is supplied, which is a scotophor; i.e., it does not emit light and the trace is dark. It will store from several seconds to days, depending on the ambient temperature of the CRT. A normal, non-storage CRT for the 430 is available as an accessory.

Housing size has also been a deterent to greater usage of storage oscilloscopes. The 430, because of special attention to compactness of component circuitry, is complete in a *single, one-piece* unit 8¾″ wide x 15½″ high and 23¼″ deep; it weighs 65 pounds.

15 sweep speeds, from 2 sec/cm (can be adjusted to 100 seconds full scale) to 50 usec/cm, are enhanced by a selection of automatic, driven or single sweep. The single sweep is armed manually, enabling transients to trigger the sweep. For transient study, a front panel push-button activates a booster circuit—providing short-time extra-brightness (or bonus contrast).

The 430 is analogous to a super-high-speed pen recorder or X-Y plotter in application — but with a far greater frequency capability (10 kc). Permanent records are as readily obtained by standard oscilloscope record cameras.

NEW CAMERA, TYPE 450, PROVIDES MULTIPLICITY OF RECORD SIZES



TYPE 450
OSCILLOSCOPE RECORD CAMERA

Technical Resume: Interchangeable lenses for full scale reproduction and approximate image ratios of 2:1 and 4.5:1; interchangeable backs; positive detented positions for sliding camera back — for multiple exposures; all lenses equipped with synchro shutters and external electrical connectors; ratchet mounting clamp; helical rack and pinion focusing.

Du Mont's new Type 450 Oscilloscope Camera features interchangeable camera backs and lenses which enable the operator to obtain permanent records, in any sizes from 4″ x 5″ to 35 mm, in a variety of object-to-image ratios — on regular or Polaroid films.

The standard Polaroid back camera can be interchanged with a 4″ x 5″ Graflok back (for pack film), a 120 Graphic back that accepts regular 120 roll or pack film, a standard 35 mm camera, or a new 35 mm robot camera back for rapid sequential shots. A sliding back with detented locking positions feature makes possible precision-spaced multiple exposures per frame.

Three lenses are available for obtaining ranges of object-to-image ratios of 1:1 to 1:0.85, 1:0.5 to 1:0.45, and 1:0.222 with the 35 mm back. Interchangeability of lens is simplified by a unique quick-disconnect bayonet mount. Focusing is accomplished by a precision helical rack and pinion. Size adjustments are made by turning a knurled ring, but the lens does not rotate — keeping the optical axis at right angles to the film plane. All lenses contain synchro shutters with standard aperture and speed settings — enabling the arming of oscilloscopes with a remote single sweep feature.

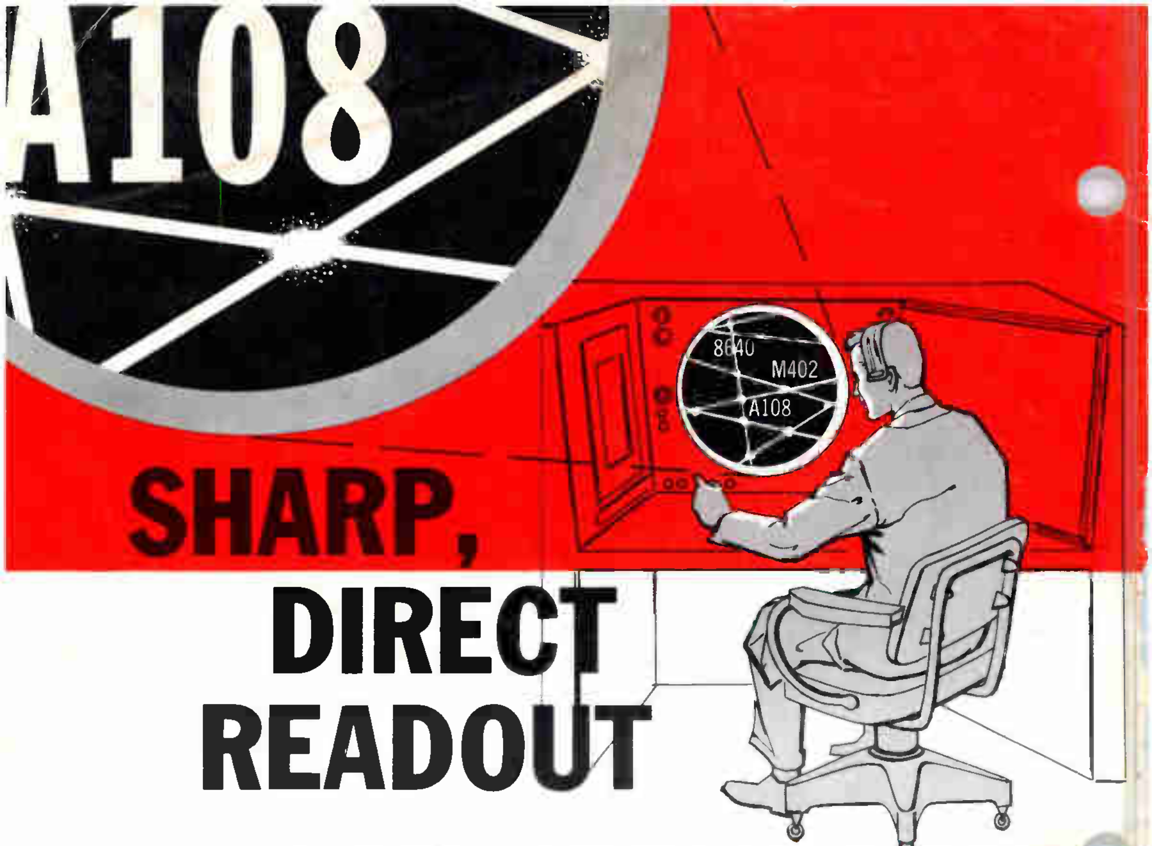
Direct recording with oblique viewing while recording is possible with the 450. Direct viewing through the camera back is possible by utilizing a ground glass slide before it is loaded with film. When using the 4″ x 5″ back the operator can view through the lens for each exposure.

Remote, or camera chain-operation is provided for by an accessory power pack which uses a 2½-volt rechargeable battery and a rotary solenoid. The rechargeable battery is used to avoid power line transients.

Shutter operation is manual through a fixed position exposure release bar. A momentary contact switch is provided, and an indicating lamp to indicate shutter operation.

A large data display area is available as an accessory. It can accommodate either a data card and light source for frame identification, or a Nixie readout that permits the recording of digital information on the Du Mont Type 425 Oscilloscope.

The all-metal lightweight camera is firmly mounted by a ratchet type mounting clamp.



SHARP, DIRECT READOUT

DU MONT CHARACTER DISPLAY TUBES...

DU MONT CHARACTER DISPLAY TUBES ARE USED IN SUCH APPLICATIONS AS:

- Target display and identification
- Air traffic control
- Reproduction of info from coded magnetic tape
- Harbor traffic control
- and many others

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Industrial Tubes Sales

enhance any system requiring versatility of rapidly formed characters for readout. A unique Du Mont CRT gun design enables alpha-numeric characters to be formed electrostatically in any size from ⅜″ to over 1″, and positioned electromagnetically anywhere on the screen — on any size screen from 5″ to 19″. Other background information, such as a separate radar display for target tracking, can be shown simultaneously through time sharing devices.

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