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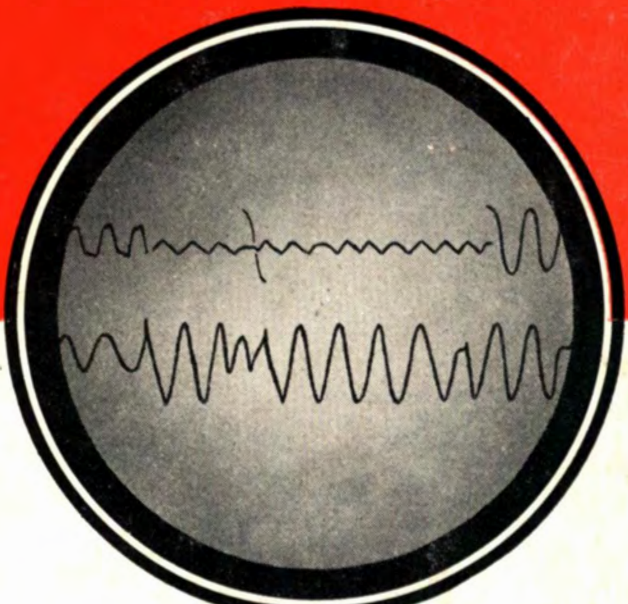

dumont

Cathode-ray EQUIPMENT

J. T. Hill Sales Co
500 W 11th St.
Los Angeles 15

ADDENDA

Since the publication of this catalog the following changes have been incorporated in our line of instruments:

(1) The Type 248 Cathode-ray Oscillograph has been discontinued. The Type 248-A, without the Type 263-B High-voltage Power Supply, has been designed as a direct replacement for the Type 248. If the need for a high-voltage oscillograph develops at any time, the Type 263-B High-voltage Power Supply may be added without the necessity of modifying the Type 248-A.

(2) The Type 263-A High-voltage Power Supply has been superseded by the Type 263-B. The Type 263-B supplies up to 12,000 volts output and utilizes an improved high-voltage cable.

Catalog No.	Type No.	Description	Code Word
1208-E	263-B	High-voltage Power Supply for 115 V., 50-60 cycles a.c..	YALAC
1209-E	263-B	High-voltage Power Supply for 230 V., 50-60 cycles a.c..	YALAD

(3) The Type 274 Cathode-ray Oscillograph has been superseded by an improved instrument which is designated as the Du Mont Type 274-A. Changes in design have resulted in an instrument having a vertical amplifier whose gain has been increased by a factor of nearly three and a band width which has been increased by a factor of approximately two. Type 274-A is also available for use from either a 115-volt or 230-volt power source.

Catalog No.	Type No.	Description	Code Word
1420	274-A	Cathode-ray Oscillograph with Type 5BP1 Cathode-ray Tube for operation from 115 V., 50-60 cycles a.c.......	YALKA
1422	274-A	Same as above, with Type 5BP11 Cathode-ray Tube....	YALKC
1423	274-A	Cathode-ray Oscillograph with Type 5BP1 Cathode-ray Tube for operation from 230 V., 50-60 cycles a.c......	YALKD
1425	274-A	Same as above, with Type 5BP11 Cathode-ray Tube....	YALKF

(4) The Type 281 Cathode-ray Indicator has been superseded by the Du Mont Type 281A. This instrument is improved chiefly in mechanical design with the electrical specifications remaining the same as those listed for the Type 281.

Catalog No.	Type No.	Description	Code Word
1397	281-A	Cathode-ray Indicator with Type 5RP2-A Cathode-ray Tube for operation from 115 V., 50-60 cycles a.c.......	YALJC
1400	281-A	Same as above, with Type 5RP11-A Cathode-ray Tube..	YALJF
1402	281-A	Cathode-ray Indicator with Type 5RP2-A Cathode-ray Tube for operation from 230 V., 50-60 cycles a.c......	YALJH
1405	281-A	Same as above, with Type 5RP11-A Cathode-ray Tube..	YALJL

(5) The Type 286 High-voltage Power Supply has been superseded by the Du Mont Type 286-A. The improvements are chiefly in mechanical design. The electrical specifications remain the same as those listed for the Type 286.

Catalog No.	Type No.	Description	Code Word
1416	286-A	High-voltage Power Supply for 115 V., 50-60 cycles a.c..	YALJW
1417	286-A	High-voltage Power Supply for 230 V., 50-60 cycles a.c..	YALJX

(6) The Du Mont Type 2515 Adapter is now available for the Type 314 Oscillograph-record Camera. This unit permits the camera to handle 1000-ft. standard 35 mm.-film magazines as manufactured by both Bell & Howell, Lincolnwood Plant, 7100 McCormick Road, Chicago 45, Illinois, and J. M. Wahl, 107 North Franklin Street, Syracuse, New York. The 1000-ft. magazine itself is *not* sold by Du Mont.

Catalog No.	Type No.	Description	Code Word
1430	2515	Adapter for Type 314 Oscillograph-record Camera......	YALKL

ALLEN B. DU MONT LABORATORIES, INC.

4-

DUMONT
Offices and Plant

A CATALOG
of
EQUIPMENT
for
OSCILLOGRAPHY

INSTRUMENT DIVISION
ALLEN B. DU MONT LABORATORIES, INC.
CLIFTON, NEW JERSEY, U. S. A.

ALLEN B. DU MONT LABORATORIES, INC.

INSTRUMENT DIVISION

CLIFTON, NEW JERSEY

Fifth Edition

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Form 754

FOREWORD

This catalog is a description of the products of the Instrument Division of Allen B. Du Mont Laboratories, Inc. In addition, we explain some fundamental principles and some design problems which are encountered in the development of these products. We feel that any prospective user who understands these principles and who recognizes the goal which the designer tries to attain will be the better qualified to select the proper equipment to fulfill his specific needs.

The scope of activity of this Division embraces the development and manufacture of cathode-ray instruments which will meet the needs of government and private industry for oscillograph equipment. It is our desire to make such equipment available in commercial form at the earliest possible time consistent with the state of the art. To this end, we feel it is the duty of an organization such as ours, which is devoted to engineering service, to work closely with the users and the prospective users of cathode-ray instruments, and we earnestly desire the opportunity to discuss their problems with such people.

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GENERAL INFORMATION

INTERPRETATION OF OSCILLOGRAPH SPECIFICATIONS

GENERAL DESCRIPTION OF THE CATHODE-RAY OSCILLOGRAPH

OSCILLOGRAPH DESIGN CONSIDERATIONS

GENERAL INFORMATION

Introduction and Definition

The cathode-ray oscillograph is perhaps the most versatile of electronic instruments. It is invaluable in the investigation of any phenomenon which can be converted into a proportional electrical potential, so its use is not restricted to any one field.

Fundamentally, the oscillograph may be defined as a device for plotting one quantity as a function of another quantity in a system involving at least two mutually exclusive coordinates, in which is included a means for providing at least one of these coordinates. The presentation of the plot may be either temporary, as in visual observation, or permanent, as when recording systems are used.

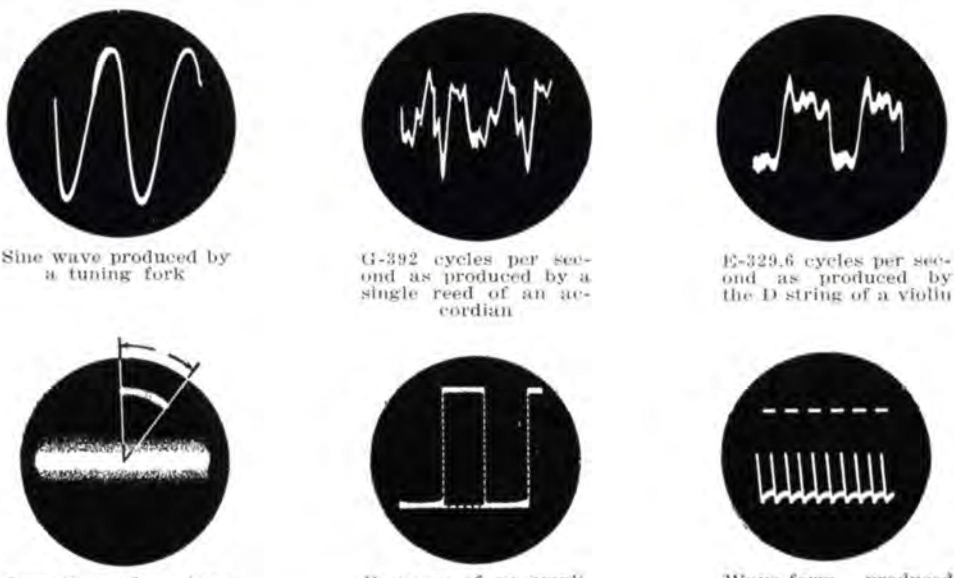
The cathode-ray oscillograph may be defined as a device performing the functions of an oscillograph, and in which a cathode-ray tube is used as the indicator or means for display. The indicating element is an electron beam which is produced within the cathode-ray tube and directed at a screen. The properties of this screen are such that a visible fluorescence is produced wherever the electron beam strikes.

This cathode-ray tube, which is fully described in another section of this manual, is the heart of the cathode-ray oscillograph. Its electron beam indicating element has certain characteristics which make it preeminently suited to its use as such:

1. It has negligible inertia, and is therefore sensitive to rapidly changing quantities which could not be plotted by any other indicating system.
2. It requires a negligible amount of power for indication, and therefore imposes a minimum load upon the signal being studied.
3. It cannot sustain damage from application of too large a deflecting voltage, and is therefore not a delicate indicator.

History and Utility of the Cathode-Ray Oscillograph

The first practical commercial cathode-ray oscillograph was introduced in the United States in 1932 by the Allen B. Du Mont Laboratories. Limitations of the first instruments were of course quite severe, especially when a comparison is made to those more recently developed. However, an important step had



Sine wave produced by a tuning fork

G-392 cycles per second as produced by a single reed of an accordian

E-329.6 cycles per second as produced by the D string of a violin

Operation of a two-way snap-switch accurately timed

Response of an amplifier to a square-wave signal

Wave-form produced by an instrument used for brain study and research

Figure 1. Typical oscillograms taken from a cathode-ray oscillograph

been taken, because the oscillograph opened the door for circuit development which, in turn, helped to create better oscillographs. This spiral has continued, greatly accelerated by the war, up until the present day.

It would not be possible to list here all of the practical applications of the cathode-ray oscillograph. As a matter of fact, new ones are discovered almost every day. Hundreds of ideas for specialized applications may be born of a fertile mind. General types of applications are found in the study and development of radio receivers and transmitters, electronic networks, nuclear reactions, welding equipment, transmission lines, control devices, circuit breakers, relays, and coils; also in the investigation of vibrations, properties of metals, dynamic balance, and internal combustion engines.

Du Mont Research and Development

The intensive program of research and development continuously carried on at the Du Mont Laboratories is largely responsible for our company's leading position in the industry. New instruments are constantly being developed, making the Du Mont line of oscillographs and associated equipment the most complete one available. New cathode-ray tube types are also developed to fulfill the requirements created by advanced studies and design, for Du Mont is a leading manufacturer of cathode-ray tubes as well as oscillographic equipment.

The design of any electronic equipment resolves from a series of compromises which represent the designer's opinion of an ideal instrument consistent with contemporary engineering and production techniques.

We feel, however, that the real test of an instrument is the opinion of those who use it. This day-to-day test of its advantages and its limitations will prove, more than any other method, just what characteristics are desirable, why the range of any given function of the equipment should be extended, and how important such modification is.

It is only by cooperation between the customer and our Engineering Department that satisfactory designs can be achieved. In an attempt to extend the applicability of our equipment to all kinds of engineering problems, we sincerely request suggestions from our customers.

Engineering Service and Specialized Equipment

In addition to a complete line of cathode-ray oscillographs, auxiliary and accessory equipment, and cathode-ray tubes which are listed and described in this catalog, Allen B. Du Mont Laboratories, Inc., offers the services of a thoroughly experienced engineering staff for the purpose of technical consultation with regard to application of that equipment or the design of special equipment to meet particular specifications. In any instances where it is thought desirable and practical for us to do so, we may design and produce such special-purpose devices.

Repair and Servicing Facility

Du Mont's interest in satisfying its customers does not end at the time the sale is completed. Du Mont equipment is recognized as quality merchandise, and it is backed by a worthy guarantee. Every precaution is taken in design and in production to insure that long years of trouble-free operation will be delivered. However, since there are exceptions to all rules, it is possible that a customer will at some time be confronted with a difficulty which he is not equipped to overcome. Du Mont maintains a qualified, capable Instrument Service Department to insure that proper service is at all times available. Authorization to return an instrument or tube for repair or replacement may be obtained by contacting this department. While it is in our hands, we will not only correct the fault which has occurred, but we will subject the instrument to a complete check-up before returning it to the owner.

Du Mont Publication

Our quarterly publication, the Du Mont "Oscillographer", contains articles prepared by various members of our Engineering staff which we believe will be of interest to engineers in all fields. Those who read the "Oscillographer" are kept abreast of latest oscillographic developments. Often the articles concern new instruments and tubes which have just been announced, or they describe interesting application techniques which can be gainfully adopted by users of oscillographic equipment. Request that your company's name or your own name be added to our "Oscillographer" mailing list by writing to the editor at our home office address.

INTERPRETATION OF OSCILLOGRAPH SPECIFICATIONS

It is a well-known fact that in our language words can many times have ambiguous meanings. Now it is easy to see why, in the relatively new art of cathode-ray oscillography where exact definitions have not as yet been agreed upon, specifications written by different people may have as many different interpretations and meanings in terms of actual oscillograph performance.

It has been the policy of Du Mont to publish specifications which are conservative so that persons using our instruments are assured of performance at least equal to that inferred from the specification. Elsewhere in the industry there has occurred the practice of publishing maximum specifications which indicate the best performance which is possible, and which cannot be duplicated by any instrument chosen at random. In writing, these maximum specifications may make an inferior instrument seem to compare favorably with another oscillograph, even though performance-wise there could be no real comparison. There are also many points to be considered which cannot be judged by reading written specifications alone.

The following outline will be helpful as a guide in appraising the true performance of any cathode-ray oscillograph.

Screen Size and Maximum Deflection

Oscillographs are available which employ 7-inch and 9-inch cathode-ray tubes and in which the tube size alone has been pointed out as a distinct feature. To be sure, the larger screen is desirable, but only if everything else is equal. However, specifications should be examined to determine if the amplifiers in the instrument are capable of producing sufficient undistorted deflection to utilize the entire area of the screen. If such deflection is not available, there is no advantage in the large screen. Furthermore the fluorescent spot size in a 5-inch tube is smaller than in an equivalent larger tube, and better resolution is possible with the 5-inch tube for studying small details in the pattern.

All Du Mont oscillographs, other than the Types 248, 280, and 288, are capable of producing more than full-screen undistorted deflection. In the specifications on the instruments named, maximum available undistorted deflection is stated.

Shape of Amplifier Frequency-Response Curves

One method of evaluating performance of an amplifier in an oscillograph is in terms of its sinusoidal frequency-response characteristic, or its band-width characteristic. A specification may read: "Vertical amplifier response down 30% at a frequency of 1 megacycle per second." This, however, does not tell a complete story because another amplifier, while similarly specified, might give entirely different performance due to the shape of its frequency response curve.

The response curves of Figure 2 are drawn for three amplifiers, all of which have the same nominal band-width. Note, however, that curve A slopes gradually at the higher frequencies. It is typical of an amplifier without high-frequency compensation. Curve B is flat to a higher frequency, but then drops off more sharply, as is typical of an amplifier with compensation. Curve C rises slightly before falling off very sharply, typical of an amplifier not properly designed, but over-compensated so that its response specification may read the same as the others.

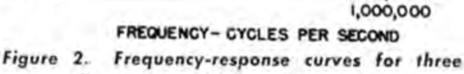


Figure 2. Frequency-response curves for three oscillograph amplifiers with different degrees of compensation

The oscillograms in Figure 3 indicate the waveforms which might appear on the cathode-ray tube screen if a square pulse were applied to each of the three amplifiers. From them it is obvious that the performances of the amplifiers are not at all similar.

Specifications for Du Mont oscillographs shown in this catalog are accompanied by actual response curves. Note that all amplifiers are designed so that there are no positive slopes or rapid declines at the high-frequency end of the

A

B

C

Figure 3. Oscillograms showing respectively the response of the three amplifiers represented by curves A, B, and C in Figure 2 to a square-wave signal with fundamental frequency of 100,000 cycles per second.

characteristics. Maximum performance in the amplification of complex as well as sinusoidal signals can be expected from these amplifiers.

Phase Shift vs. Frequency Response

Many oscillograph specifications, particularly for those instruments which have wide-band amplifiers, give only the response of such amplifiers to a sinusoidal signal. However, the response of an amplifier to a complex signal (one which contains a number of sinusoidal frequency components) depends as well upon the constancy of delay through the amplifier at all these frequencies, the delay usually being expressed in terms of phase-shift of a sinusoidal signal. If the component frequencies in the complex signal are not all delayed by the same amount (i. e.—phase shift proportional to the frequency), the complex waveform will be distorted in passing through the amplifier.

Du Mont oscillographs, such as the Types 256-D and 280, which are designed for the investigation of short pulses and other complex signals, have specifications for the response of their amplifiers to pulse waveforms.

Amplifier Band-Width vs. Gain-Control Setting

In oscillographs which have high-impedance gain controls, the specified amplifier band-width will only hold when that control is at its maximum position. At all other positions, because of the effects of stray capacities across the high-impedance, band-width may be seriously decreased.

The oscillograms of Figure 4 illustrate what may happen if a square-wave signal is applied to an amplifier which has a high-impedance gain control. The one at the left is obtained when the gain control is at maximum position, while the one at the right is obtained with the control at an intermediate position and it shows

Figure 4. Oscillograms illustrating the effect of a high-impedance gain control upon amplifier band-width. They were made with maximum gain (left) and with reduced gain (right)

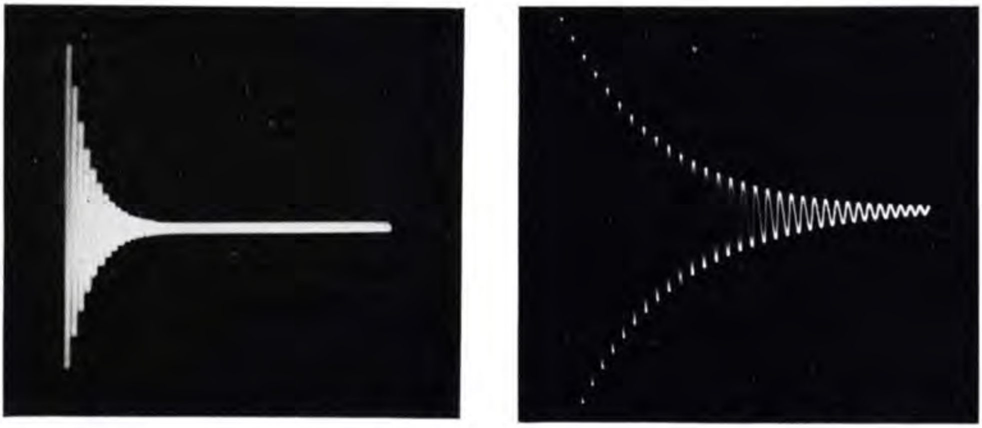


Figure 5. Oscillograms illustrating the limitations upon usable band-width of an oscillograph due to insufficient sweep speed (left) and insufficient pattern brightness (right)

distortion produced by the narrower band-width characteristic.

Specifications should be checked to see if amplifier frequency response is specified at some particular gain-control setting, or whether it applies to all gain-control positions. The better, more-expensive oscillographs should have low-impedance gain controls and, therefore, a band-width characteristic independent of amplifier gain.

All Du Mont oscillographs except the low-priced Types 164-E and 274 have specifications which state that frequency response of the amplifiers is the same for all positions of their gain control.

Usable Band-Width

Amplifier band-width by itself does not determine the usable band-width of any cathode-ray oscillograph. Maximum available sweep speed and maximum brightness of the cathode-ray tube are also factors to be considered. In Figure 5, a damped sine-wave oscillation is used as an illustration of this point. In the oscillogram on the left, brightness is satisfactory but sweep speed is not high enough to prevent crowding of the pattern at the frequency which is being plotted. The oscillogram on the right illustrates the effect when the sweep speed is high enough but brightness is insufficient because of improper selection of cathode-ray tube or accelerating potential. Only the peaks of the sine-wave are visible during the first few cycles where the fluorescent spot is moving most rapidly. As the oscillation is damped, the spot moves more and more slowly until the complete cycles are finally visible.

We may conclude therefore that an oscillograph should have sufficiently fast sweeps and adequate accelerating potential in order to derive full benefit from the band-width provided by its amplifiers. Note that the Du Mont Type

Figure 6. Oscillograms comparing resolving power of a low-voltage cathode-ray tube with large spot-size (left) with that of a high-voltage tube (such as the 5RPA) which has a smaller spot-size (right)

280 Cathode-ray Oscillograph has a maximum sweep speed of 0.25 microsecond per inch, and 12,000 volts acceleration in order to make full use of its 10 megacycle amplifier response.

Balanced vs. Single-Ended Deflection

In general, the use of single-ended or unbalanced deflection amplifiers is confined to the smaller, more inexpensive oscillographs. When a signal is applied to only one plate of a deflection-plate pair, it is ordinarily not possible to properly focus the resultant trace across the entire screen. The focus control on the oscillograph may be adjusted in order to focus some particular portion of the trace, but then some other portions will be de-focused. If unbalanced signals are applied to both pairs of deflection plates, there may be produced an astigmatic condition where either horizontal or vertical portions of the trace can be focused, but not both simultaneously.

In some oscillographs, such as the Du Mont Type 256-D, unbalanced vertical deflection is employed, but an auxiliary focus control as well as a conventional focus control provides perfect focusing over the entire screen.

Resolving Power

Comparisons between oscillograph performances cannot be made solely on the basis of deflection sensitivity (reciprocal of deflection factor). In order to make a fair evaluation, we should rather compare in terms of "deflection sensibility", a factor which combines the characteristics of deflection sensitivity and tube spot-size, and which is, therefore, a figure of merit for resolving power of an oscillograph.

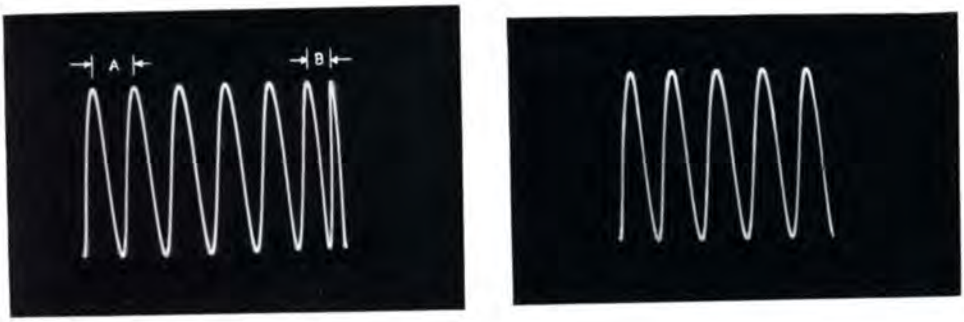
In Figure 6 the oscillogram on the left is typical of that obtained on a cathode-ray tube operated at low accelerating potential and having good sensitivity but large spot-size. Note the incompleteness of resolution even though the pattern itself is of large size. The oscillogram on the right is typical of one obtained when the same signal is applied to a cathode-ray tube operated at high accelerating potential. Every detail shows up clearly because this tube has much smaller spot-size and therefore better "deflection sensibility", even though deflection sensitivity is not nearly as great.

Figure 7. Oscillogram of a non-linear sawtooth voltage (solid line) showing comparison with a perfectly linear sawtooth (dotted line)

"Deflection sensibility" is particularly important in connection with the Type 5RP-A series of cathode-ray tubes. These are designed to operate with accelerating potential from 7,000 to 29,000 volts and they have a little lower sensitivity than other tubes operated at 2,000 to 3,000 volts. However, they have much smaller spot-size and actually greater resolving power.

Sensitivity vs. Input Impedance

A probe is furnished with some oscillographs in order to provide a high-impedance, low-



Percentage Non-Linearity $= \left(\frac{A-B}{A}\right) \times 100$

Figure 8. Oscillograms showing a sinusoidal voltage plotted on a time-base which is non-linear (left) and also on one which is linear (right)

capacity, shielded input for the vertical amplifier. It is wise in these instances to check the specifications concerning input capacitance at the panel terminals. This capacitance may be so high that the panel-terminal input will impose too great a loading effect upon high-frequency signal sources and it will therefore be useless. If the use of the probe is absolutely required, then be sure that specified sensitivity (deflection factor) includes the probe, because it may introduce a signal attenuation in the order of 20:1.

Sweep Linearity

The time-base in most oscillographs is supposedly linear unless otherwise stated. However, not many oscillograph specifications include a statement concerning the linearity of their sweeps. Figure 7 is an oscillogram showing the waveform of the voltage generated by the linear time-base generator. The dotted line represents a sweep voltage which is perfectly linear; the solid line indicates the departure from linearity which occurs in many time-base generators. In the oscillograms of Fig. 8, the one on the left represents the appearance of a sine-wave signal as plotted on the non-linear time-base, while the one on the right shows the same sine-wave plotted on the linear time-base. Linearity of the time-base may be measured as shown on the left-hand oscillogram. Note that the spacing between peaks of the sine-wave remains uniform if the sweep is linear.

Usable Duty Cycle on Triggered Sweeps

For certain low-priced oscillographs, sweep speeds are advertised which are higher than those available in the Du Mont Type 248, and which even approach the speeds available in the Type 280 (1/4 microsecond per inch). Note, however, that such high speeds are useless if the sweeps are to be triggered at low repetition rates, because accelerating potential on the cathode-ray tube is insufficient to make them visible on the screen. An oscillogram of a phenomenon having a repetition rate of only 30 cycles per second may be plotted on the 1 microsecond sweep of the Type 280. In order to produce a trace of comparable intensity on a competitive low-priced instrument, the repetition rate needed to be in the order of 600 cycles per second.

Since it is the energy furnished to the cathode-ray tube screen per unit of time which determines the brilliance of the trace, and since the energy is dependent upon accelerating potential, the Type 280 which can operate with 12,000 volts on the tube is far superior to the instrument operating with, say, 3,000 volts.

Maximum Input Voltage

In a great many instances, the signal to be examined on an oscillograph has a d-c component as well as an a-c component. As an example, the potential at the plate of an amplifier tube is composed of the a-c or signal potential, plus an average or d-c potential. The input coupling circuits of an oscillograph should therefore be designed to withstand the sum of these components.

The voltage rating of input coupling capacitors is rather low in some oscillographs, whereas Du Mont oscillographs are generally designed to handle either 600 or 1000 volts d-c plus peak a-c input.

Connections to Deflection Plates

It may sometimes be necessary to investigate with an oscillograph signals which contain frequency components beyond the frequency-response limits of the deflection amplifiers. Such signals may be directly connected to the deflection plates of the cathode-ray tube, provided that terminals are available for this purpose. All Du Mont oscillographs have terminals for direct connection either on the front panel or through an opening in the cabinet.

It is extremely desirable that positioning controls on the oscillograph retain their usefulness even when connections are made to the deflection plates. Positioning of the trace on Du Mont oscillographs is either retained automatically or else may be retained by observing certain precautions outlined in the instruction book which is supplied with the instrument.

Synchronizing-Signal Polarity

It is very convenient to be able to synchronize the sweep in an oscillograph from signals of either positive or negative polarity, since many times only one of them is readily available. Most Du Mont oscillographs are equipped with provision for such sync-phase-selection.

Stability of Operation

An oscillograph should be sufficiently stable in operation that it is not affected by line-voltage changes of ordinary magnitude. Instability may exhibit itself as shifting of trace position, change of beam intensity, non-operative amplifiers, etc., any one of which renders the instrument more or less useless.

Some oscillographs, for instance, derive amplifier bias from a negative high-voltage supply, the regulation of which is extremely poor with respect to line-voltage changes. Line surges are thereby actually amplified, and will appear on the screen of the cathode-ray tube.

Du Mont oscillographs are designed to deliver specified performance with power-line fluctuations up to 10% of the nominal line voltage.

Adequate Shielding

The cathode-ray tube in an oscillograph should be shielded against magnetic disturbances to prevent undesirable deflection or modulation of the electron beam. All Du Mont oscillographs are housed in steel cabinets which serve to provide some shielding, and all except the Type 164-E contain a mu-metal shield which surrounds the tube itself and effectively prevents any magnetic field from reaching the tube. The choice of mu-metal is made because it has the most excellent magnetic properties of any material known. Other materials provide inferior shielding.

Accessibility for Servicing

While an oscillograph is primarily a test instrument which should not require much bench-space, it is nevertheless unwise practice to gain compactness at the expense of accessibility. Some small-size oscillographs are so compact that whole sections must be removed in order to reach a single component. This is particularly bad when the oscillograph is to be used under other than ideal laboratory conditions.

Du Mont oscillographs are as carefully designed mechanically as they are from an electronic standpoint. Size and weight are kept at minimum values consistent with good engineering practice, which certainly includes serviceability.

Flexibility of Operation

The specifications of some oscillographs indicate that close tolerances on power-line voltage must be maintained. Overheating and reduced transformer life may result if line-voltage should be consistently higher than nominal.

Du Mont oscillographs are designed to perform with power-line potential as much as 10% higher than nominal. Furthermore, most Du Mont instruments can be operated from either 115-volt or 230-volt lines, and they often will perform normally at power-line frequencies other than their rated 50-60 cycles per second.

Accessories and Auxiliary Equipment

The variety of accessories and auxiliary equipment which Du Mont provides does much to increase the value of our customers' oscillographic investment. Items such as the Type 215 Low-Frequency Time-Base Generator, the Type 264-A Voltage Calibrator, the Type 185-A Electronic Switch, the Types 271-A and 314 Oscillograph-Record Cameras, the Type 2088 Projection Lens, and the Type VP-5 Vibration Pickup are invaluable in extending the usefulness of an oscillograph. Complete information concerning their descriptions and applications is given in this catalog.

Manufacturers' "Know-How"

Before one makes an investment such as oscillographic equipment represents, one should first satisfy himself that the manufacturer from whom he makes his purchases is qualified by experience to specify and recommend instruments to fit his particular problems.

Oscillograph equipment manufacturers fall into two general classes: those who have only recently entered this highly-specialized field, and those whose major activities concern other types of products. The latters' interests in oscillographs as instruments are only a small fraction of their total and they cannot therefore afford to devote to them more than a fraction of their development, research, and sales service.

Du Mont has long been associated with the oscillographic industry, and the manufacture of oscillographs and cathode-ray tubes represents a major portion of its activities. We have gathered experience from many fields, and we know from experience what you need to do your job.

Guarantee

When a manufacturer guarantees his product, he provides both protection and service to the customer. Protection, in that no one makes a guarantee unless he feels that his product can meet it; service, in that any fault occurring in the guarantee period will be the responsibility of the manufacturer.

Du Mont instruments carry a guarantee for one year; cathode-ray tubes, for six months or 1000 hours of operation.

GENERAL DESCRIPTION OF THE CATHODE-RAY OSCILLOGRAPH

Cathode-ray Tube

In the Introduction, we have said that the cathode-ray tube is the heart of the cathode-ray oscillograph. Inside the tube the electron-beam indicating element is formed and directed toward the fluorescent screen upon which the indication is visible. Also inside the tube is contained the means by which the beam may be deflected in accordance with the particular quantity being studied. However, the cathode-ray tube by itself is not a complete indicating device; the proper potentials must be applied to its various electrodes. (Refer to the section on Cathode-ray Tubes for a complete description of their construction and operation.)

High-voltage Power Supply

The potentials applied to the electrodes of the cathode-ray tube serve to form the electron beam, to accelerate the electrons toward the fluorescent screen, and to focus the beam so that a small, intense fluorescent spot is produced on the screen. Power requirements of the electrodes are small although the potentials furnished by the high-voltage supply may be in the order of thousands of volts. The combination of the cathode-ray tube and high-voltage supply is sufficient to form the indicating device.

Deflection Amplifiers

This device, however, is a relatively insensitive one, and it would require signals in the order of hundreds of volts to produce full-screen deflection of the beam. Since the majority of applications involve signals of much smaller amplitudes, amplifiers are necessary to furnish deflecting potentials to the tube.

An amplifier permits investigation and study of small potentials; it also imposes certain limitations on the character of those potentials. If the potential to be studied were applied directly to the deflection plates, the maximum amplitude that could be observed would be limited only by the full-screen deflection of the beam; the maximum frequency, by transit-time, or time required for an electron to pass between the deflection plates, and the shunt capacitance between deflection plates. Transit-time effects generally restrict usefulness to frequencies below 200 megacycles per second in commercial tubes operating with accelerating potentials of about 1500 volts. Shunt capacitance may load down the investigated signal at frequencies above this value. Connection of a d-c (zero frequency) potential directly to the deflection plates deflects the beam an amount proportional to the amplitude of that potential; the beam will remain in the deflected position until the d-c potential is removed. Therefore no low-frequency limitation exists when direct connection is used.

Now suppose the potential to be studied is passed through an amplifier before it reaches the deflection plates. The maximum amplitude that can be observed is limited by the level of signal that can be reproduced by the amplifier without distortion. The frequency of the signal must lie within certain upper and lower limits, since amplifiers of the type used in oscillographs are designed to amplify over a given range of frequencies without introducing distortions. (Refer to the section on Design Considerations for more complete information on amplifier design.)

Linear Time-base Generator

The time-base generator is an important part of an oscillograph. It generates a voltage which can be connected to produce horizontal deflection of the beam. Of course, there are many types of time-base generators, but the sawtooth, which varies linearly with time and is most commonly used, is the one which is of particular interest.

The generated sawtooth voltage, when applied to the horizontal deflection plates, produces a deflection which causes the fluorescent spot to move from left to right on the screen of the cathode-ray tube so that the distance traveled is directly proportional to time. When it reaches the extreme right end of its travel, the spot moves rapidly back to the left and begins again. The frequency at which it performs this excursion may be varied by means of suitable controls.

The frequency of the sawtooth voltage may be synchronized or "locked-in" with the frequency of a recurrent signal being observed on the vertical deflection plates. Since the spot then begins its left-to-right motion at the same point in each cycle of the signal, the resultant pattern on the screen appears stationary to the observer.

Sometimes it is necessary to observe a phenomenon which is not recurrent but transient in nature. Such a phenomenon occurs only once or at a non-cyclic rate. If the sawtooth generator as described above were used, there would be no assurance that the beginning of the phenomenon would correspond with the start of the left-to-right travel of the spot. The time-base generator is therefore modified so that the left-to-right travel is initiated by the occurence of the transient, and so that there is no motion of the beam at any other time. This modified operation of the time-base generator is referred to as "driven" or "single" sweep.

Sometimes, in photographic recording, the motion of a continuously exposed film provides the linear time-base, and the time-base generating circuits of the oscillograph are not used.

Low-voltage Power Supply

In general, the low-voltage supply furnishes power to the amplifier and time-base generator circuits. Requirements for this supply are more stringent than for the high-voltage supply in order to avoid cross-coupling between various circuits. (Refer to section on Oscillograph Design Considerations for explanation).

Intensity Modulation Circuits

A signal applied to the grid or cathode of the cathode-ray tube will modulate the intensity of the spot on the screen in accordance with the polarity and amplitude of that signal. This principle is utilized to provide timing marks or reference points on the pattern. Such marks can be made by using an oscillator or pulse generator of known frequency or repetition rate.

Intensity modulation is also a useful means for intensifying the beam over portions of the pattern where the motion of the spot is extremely rapid. In these portions, the fluorescent screen might not otherwise be sufficiently excited to afford good visibility of indication

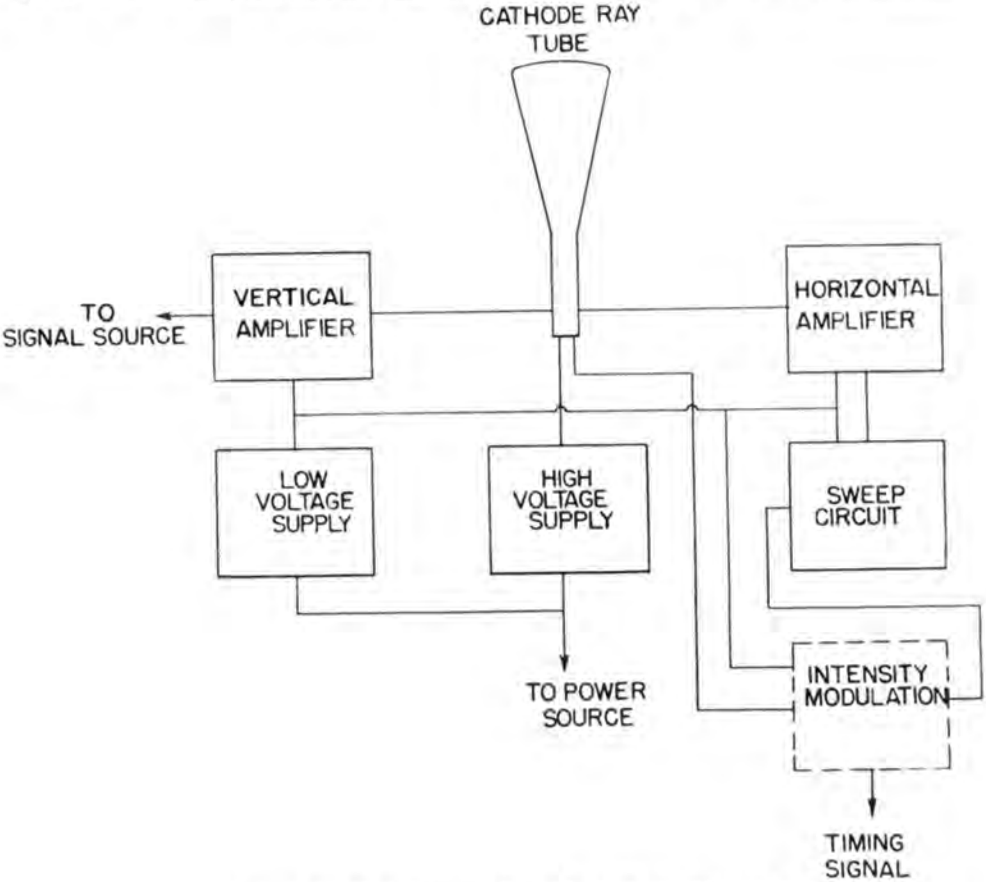


Figure 9. Block diagram of a cathode-ray oscillograph

OSCILLOGRAPH DESIGN CONSIDERATIONS

Power Transformer

Since the cathode-ray tube is sensitive to both electric and magnetic fields, it is essential that the power transformer be designed to have a low external magnetic field. Sometimes a magnetic shield is provided for the transformer to cut down the external field to a negligible magnitude. The transformer should generally be separated from the cathode-ray tube by as great a distance as possible, and should be so oriented with respect to the tube that its field produces a minimum of beam deflection. In addition, since the transformer is about the heaviest single component in an oscillograph, it should be located so that the instrument will balance well. The location of the transformer is therefore very important in designing an oscillograph; it may influence the design of other portions of the instrument.

Needless to say, it is well to keep the size and weight of the transformer at minimum values consistent with good design practices. However, sacrifice of ratings should never be made to obtain small size or light weight. Insulation of each winding must be adequate for much greater voltage than it will have to withstand during operation. The lamination stack should be designed for at least the minimum power-line frequency, and preferably for a lower frequency in order to keep the external magnetic field low. For the same reason a high turns-per-volt ratio and low flux density are desirable. It will be noted that transformers for cathode-ray oscillographs, because of the variety of rectifiers and amplifier circuits which they supply, are much more complex and have several more secondary windings than those transformers used in most other services.

(a) Primary

The primary windings of the transformer should be shielded by a grounded electrostatic shield to prevent capacitive coupling from high-voltage windings in the secondary side, and to minimize interference from the power line.

(b) Secondary

The exact voltages and currents required of the secondary windings will depend upon the circuits which they supply. The cathode-ray tube heater winding must be surrounded by a grounded electrostatic shield to prevent capacitive coupling from other windings. Such coupling would constitute an intensity modulation signal which would cause modulation of the beam intensity at power-line frequency.

Center-tapped secondary windings are generally used to supply the rectifiers which furnish B+ power to amplifiers, time-base generator, etc. Ratings of about 400 rms volts each side of the center tap and 20 to 200 d-c milliamperes are common for these windings. They are a part of the Low-voltage Power Supply mentioned in the section on General Description and more completely described in the following section.

It is common practice to extend one side of the center-tapped winding in order to supply the rectifier which furnishes high voltage for the cathode-ray tube electrodes. Voltage and current ratings of 800 to 1500 rms volts and 3 to 5 d-c milliamperes are usual for this extended winding. It is a part of the High-voltage Power Supply mentioned under General Description and more completely described in one of the following sections.

Figure 10 is a schematic of a typical cathode-ray oscillograph transformer.

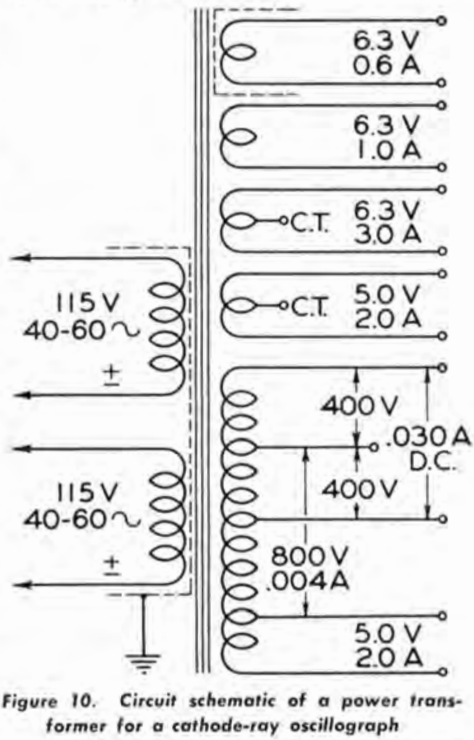


Figure 10. Circuit schematic of a power transformer for a cathode-ray oscillograph

Low-Voltage Power Supplies

Low-voltage power supplies are derived from the center-tapped winding referred to above. This winding feeds a full-wave rectifier; output from this is a pulsating d-c voltage. A capacitive inductive filter is connected to the rectifier output to smooth the pulsating d-c into a nearly pure d-c potential. More than one supply potential can be derived from this same transformer winding; the supplies may be of either positive or negative polarity, and they may or may not be regulated. They furnish power to amplifiers, time-base generator, etc.

(a) Voltage and Current Requirements

Amplifier stages and similar circuits which deal with large signals and large outputs will in general require a d-c supply potential of from 350 to 500 volts, while those stages which furnish less output may be operated from lower potentials of 150 to 250 volts. The current which any supply must furnish is determined by adding the current requirements of all the circuits connected to it.

(b) Filtering and Regulation

The supplies which furnish power to the first stages of the amplifiers must be exceptionally well-filtered and regulated as a rule. Spurious signals or power-line frequencies appearing in the power supply potential would be amplified by subsequent stages and would therefore appear as deflections on the cathode-ray tube screen. A general design rule is that the amplitude of power-line or other a-c voltages appearing on the output of the power supply should not exceed 0.5% of the d-c supply voltage. Furthermore, since it is general practice to operate from a common supply several circuits performing different functions, coupling through the impedance of that supply must be reduced by reducing the impedance. This may be accomplished by the use of voltage-regulating devices.

Two general types of voltage-regulator de-

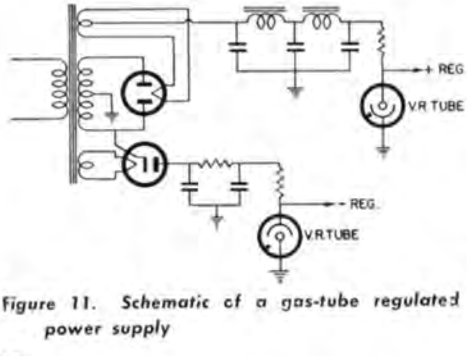


Figure 11. Schematic of a gas-tube regulated power supply

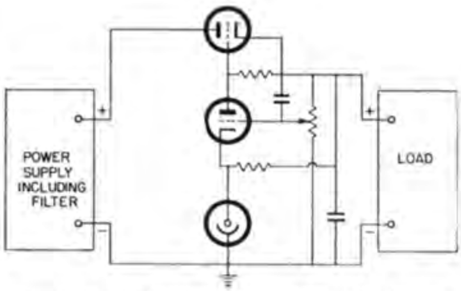


Figure 12. Schematic of an electronically regulated power supply

vices are used. They are 1) the gas-tube regulator, and 2) the electronic regulator.

The characteristics of gas-tubes are such that, over a range of currents, the voltage between electrodes is constant. Some neon tubes and the VR series of cold-cathode discharge tubes are used in this application. VR tubes will maintain constant voltage with current ranging from 5 to 40 milliamperes. Figure 11 illustrates the use of VR tubes in regulating power supply potentials. Positive and negative polarity supplies are shown. Resistors must be used in series with the gas-tubes to adjust their current to the correct operating range.

The electronic regulator circuit, such as the one illustrated in Figure 12, generally employs a vacuum tube connected between the power supply and the load. The impedance of this tube is varied automatically if the voltage across the load tends to change; it is varied in such a way as to furnish a constant voltage to the load despite variation in power supply output or current requirements of the load.

High-Voltage Power Supply

The high-voltage power supply is often derived from the extended winding which was described with reference to the Power Transformer. This winding feeds a half-wave rectifier, which is ample because filtering requirements are not nearly so strict as for the low-voltage supplies. The rectifier output is usually filtered by a resistance-capacitance combination. Resistance can be used in this filter because the current furnished by the high-voltage supply is very small, and the resultant voltage drop across the resistor is small.

In many cathode-ray tubes the accelerating electrode is operated at ground potential and the cathode at some negative high-voltage which may range from 1000 volts up to 6000 volts or more. Other electrodes obtain their potentials from a bleeder connected to the high-voltage supply. Some cathode-ray tubes, however, are equipped with intensifier electrodes, and the total accelerating potential is divided, part of it being applied between the cathode and accelerating electrode and the remainder between accelerating electrode and intensifier. Ordinarily the potential between accelerator and intensifier should not exceed 50% of the total.

If the accelerator electrode is to be operated at ground potential, which is usually the case in order to permit operation of the deflection plates at ground potential, the cathode should be at negative potential and the intensifier at positive. Positive and negative high-voltage supplies are required in this case but they can both be derived from the same transformer winding, and for a given accelerating potential, each supply need have only half the voltage required of a single supply. This simplifies considerably the design of the transformer and also the high-voltage filters.

Deflection Amplifiers

The design of deflection amplifiers in a cathode-ray oscillograph is usually carried out to meet specifications with regard to the following:

1. frequency-response or band-width
2. deflection factor
3. maximum output capabilities

The frequency-response or band-width specification fixes the range of frequencies over which the gain of the amplifier must lie within certain limits. Under General Description we have already discussed the fact that, in general, amplifiers do not have constant gain characteristics from d-c (zero cycles per second) to the limit of usefulness of the cathode-ray tube (about 200 megacycles per second). Limitations exist both at low and high frequencies which restrict the constant-gain characteristic to a small fraction of this range, although compensating devices may be incorporated to extend the characteristic at both low and high frequencies. These devices will be discussed in a later section.

The term "deflection factor" is peculiar to oscillographic language. It has been customary to refer to the voltage or power gain of an amplifier as a measure of its performance. However, for oscillographic applications, these references have no significance since a given amplifier will produce entirely different results with different cathode-ray tubes. The results will also be different if the accelerating potential is changed on the same cathode-ray tube. Deflection Factor is dependent upon amplifier gain, but it is a measure of the amplifier input signal required to produce a given amount of deflection on the screen of the cathode-ray tube. Its unit is volts per inch; it is a true measure of the performance of an amplifier in conjunction with a given cathode-ray tube operated with a certain accelerating potential.

The considerations of band-width and deflection factor in amplifier design tend to pull in opposite directions. An amplifier that has a low deflection factor (high gain) will not usually have a wide band-width; an amplifier with wide band-width characteristics will have a high deflection factor (low gain). Of course, it is always possible to increase gain by adding stages of amplification, but there is usually a practical limit as well as a limit imposed by stability and noise requirements. Since the oscillograph provides a visual indication, stability must be excellent and noise level extremely low. The design of the deflection amplifiers is therefore usually a compromise between deflection factor and band-width.

(a) Square-Wave Testing of Amplifiers

The cathode-ray oscillograph is a test instrument; its amplifiers should therefore provide faithful reproduction of signals being investigated. In order to make a rapid determination of amplifier characteristics, a square-wave signal may be passed through it, and certain inferences made from the shape of the indication on the cathode-ray tube. The square-wave is particularly valuable because of its harmonic content. Its steep front gives an indication of high-frequency or "transient" response of the amplifier; its flat top gives indication of the low-frequency characteristics. The terms "high-frequency" and "low-frequency" are of course relative to the fundamental frequency of the square wave signal. A general rule in regard to square-wave testing is that an amplifier which will reproduce a square-wave of fundamental frequency, f, will satisfactorily amplify sine-wave signals between the frequencies of 1/10 f and 10 f.

The application of three square-wave frequencies, one near the center of the amplifier band-width, one near the upper end of the band, and one near the lower end, will almost completely indicate the amplifier frequency-

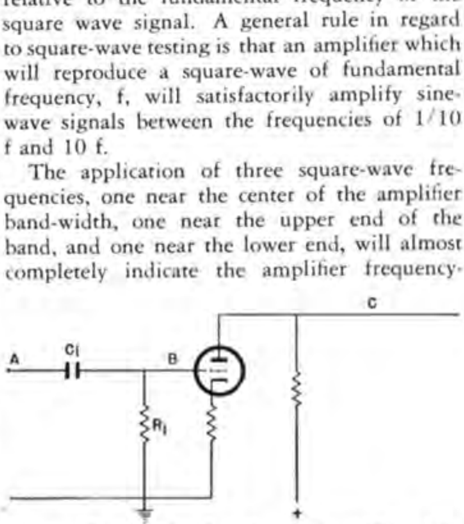


Figure 13. Circuit of a typical amplifier stage with capacitive input coupling

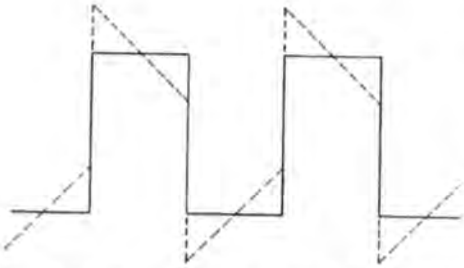


Figure 14. Oscillogram showing a square-wave signal (represented by the solid line) and sawtooth distortion (dotted line) which might result from an RC time-constant

response characteristics if correct interpretations are made of the reproduced waveforms.

(b) Low Frequency Distortion and its Compensation

The type of low-frequency distortion which may be introduced by an amplifier is illustrated by the following discussion. Suppose a low-frequency square-wave signal is applied to the amplifier in Figure 13 between point A and ground. If the time-constant in the input circuit (product of C1 and R1) is small with respect to the period of the square-wave, the waveform at point B, and therefore at point C (output of the amplifier), will be similar to that shown by the dotted line in Figure 14. This is referred to as sawtooth distortion because of the shape which it takes. It is caused by the discharging of C1 through R1 during the flat-top portion of the square-wave.

This type of distortion could obviously be eliminated or reduced by making the values of C1 and R1 sufficiently large to produce a large time-constant. However, it has been found that the physical size of C1 becomes impractical if such a solution is attempted. The value of R1 is limited by the grid current characteristic of the amplifier tube. Another reason for keeping C1 and R1 as small as possible is that the time required for the circuit to recover from a large transient pulse will depend directly upon this time-constant.

One method of compensating for low-frequency distortion is illustrated in Figure 15A. Addition of R2 and C2 in the plate circuit of the amplifier produces a potential at point D of the form shown in Figure 15B. When this potential is added to that shown by the dotted line in Figure 14, the original square-wave results. The correct amount of compensation is quite critical, over-compensation is apt to introduce a sawtooth distortion which slopes the flat tops of the square-wave in the other direction.

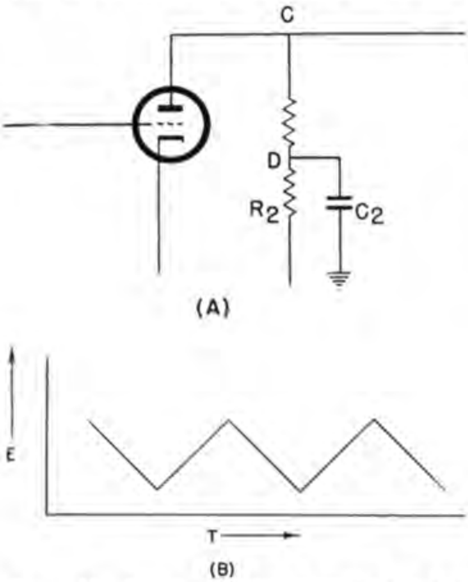


Figure 15. Circuit illustrating a method of compensating for low-frequency distortion in an amplifier stage

(c) High-Frequency Distortion and its Compensation

There are certain stray circuit capacitances and vacuum tube interelectrode capacitances which impose a load on an amplifier stage as illustrated by C_o in Figure 16. This load, being in parallel with the plate load, R_L, has the effect of reducing the plate load impedance as the signal frequency is increased. The gain of the stage therefore falls off at high frequencies and the response curve might look like curve A in Figure 17. A square-wave passed through this amplifier would begin to exhibit a rounded front corner instead of a square one as the fundamental frequency of the square-wave was increased.

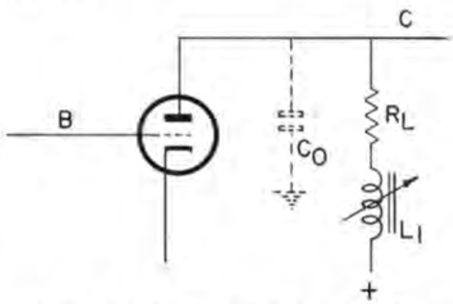


Figure 16. Circuit illustrating stray capacitance in an amplifier stage and a method of compensating for it

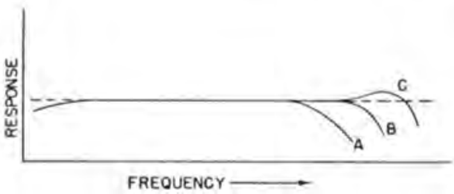


Figure 17. Frequency-response characteristics of three amplifiers with different degrees of high-frequency compensation

Addition of an element in the plate circuit, the impedance of which increases at higher frequencies, is one method of compensating for high-frequency distortion. In combination with the other elements, it tends to maintain a constant plate load impedance and therefore a constant gain characteristic. This is the function of L1 in Figure 16. The degree of compensation must be carefully designed. A value for L1 which is too large will cause a rising gain characteristic over a limited frequency range as shown by curve C in Figure 17. This would introduce a type of distortion on a square-wave similar to that in Figure 18. An over-compensated amplifier is no more desirable than one without compensation.

(d) Amplification of DC Signals

The resistance-capacitance coupled amplifiers ordinarily used in cathode-ray oscillographs will not handle d-c signals because capacitors will not transmit direct current. Any signals containing a-c and d-c components therefore produce deflection on the screen corresponding only to the a-c component.

Some oscillographs do contain resistance coupled amplifiers for the purpose of amplifying d-c signals. These are usually relatively low-gain amplifiers since the problem of stability is extremely important in d-c amplifiers. Instability is roughly proportional to the gain.

(e) Amplifier Noise

Noise is an important factor to be considered in amplifier design. It includes such things as spurious signals introduced by resistors, tube microphonics, and signals in the d-c power supplies. An oscillograph provides a visual indication; noise therefore is apparent since it distorts the signal being investigated. Extreme care must be exercised in regard to selection of gain-controls, vacuum tube types, and power supply filtering and regulation.

Intensity Modulation

Many cathode-ray oscillographs provide a means for connecting external signals to the grid or cathode of the cathode-ray tube in order to modulate the intensity of the beam. Some contain an amplifier for these signals so that modulation can be accomplished with smaller signal amplitudes.

The channel for connecting a signal to the grid or cathode of the cathode-ray tube is generally referred to as the Z-Axis of the oscillograph, and the amplifier, if one is incorporated, is known as the Z-Axis Amplifier.

Considerations for the design of the Z-Axis Amplifier are different from those for the Deflection Amplifiers. Whereas hundreds of volts on the deflection plates are required to deflect the beam over the entire screen of the cathode-ray tube, a signal of 5 to 100 volts at the grid or cathode will usually produce satisfactory beam-modulation. Since there is a much smaller voltage-output requirement in the case of the Z-Axis Amplifier, a low-gain amplifier will suffice. We have already discussed the fact that low gain means wide band-width, so that the problem of obtaining good frequency-response for this amplifier is not a difficult one. However, the problem of obtaining direct coupling and good low-frequency response may be difficult because both the grid and cathode of the cathode-ray tube are usually operated at negative high voltage. There is often included in the amplifier circuit a phase selecting device which will allow either reduction or increase of the beam intensity with any given signal polarity.

(a) Uses of the Z-Axis

One of the principal applications of the Z-Axis channel is for impressing timing marks upon the pattern being observed. The signal used to create these markers is preferably in the form of sharp pulses of short duration which occur at a high rate with respect to the frequency of the signal being investigated. The sharp wave-form permits precise measurement of the time interval between pulses. The resultant pattern on the cathode-ray tube will have a number of bright or dark spots corresponding to the occurrence of the pulses and depending upon whether they increase or decrease the beam intensity.

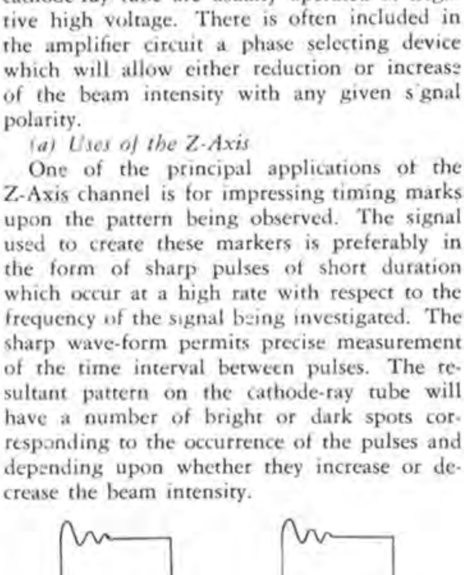


Figure 18. Response of an over-compensated amplifier to square-wave signal

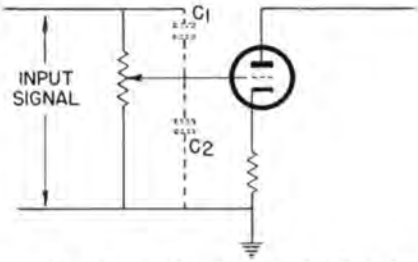


Figure 19. Circuit showing the distributed capacitances in a simple potentiometer attenuator

Attenuator Circuits

Preceding the deflection amplifiers in the cathode-ray oscillograph, there must be provided means for attenuating (reducing amplitude of) the incoming signals. These attenuator circuits are designed to meet the following requirements:

1. high impedance to impose minimum loading upon the signal
2. sufficient attenuation that the amplitude of the signal will not overload the first amplifier stage

The simplest method of obtaining such an attenuator would be to connect a high-resistance potentiometer across the input terminals

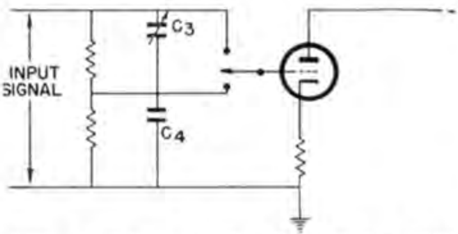


Figure 20. Circuit of an attenuator with fixed attenuation ratios and adjustable capacitive elements

to the amplifier. Such an attenuator, however, has distributed capacitances as shown in Figure 19, and the voltage attenuation will not be the same for all frequencies at any given intermediate position of the movable arm. A lower-resistance potentiometer would improve upon this characteristic but would load down the source of the input signal.

A solution to the problem lies in using an attenuator with fixed attenuation ratios and adjustable capacitive elements as shown in Figure 20. Proper adjustment of the capacitors will allow uniform attenuation over a wide frequency range. Experience with this circuit has shown, however, that a square-wave attenuated by it has rounded front corners unless the voltage-coefficients of the resistive elements are extremely low. Metallized types of resistors have been found to give best results.* An additional low-impedance attenuator must be used, however, if continuous adjustment of attenuation between the fixed ratios is desired.

A cathode-follower circuit such as that shown in Figure 21, having a low-impedance output and suitable for use with a continuous gain-control, may be used to provide this adjustment. It will handle a wide range of signal

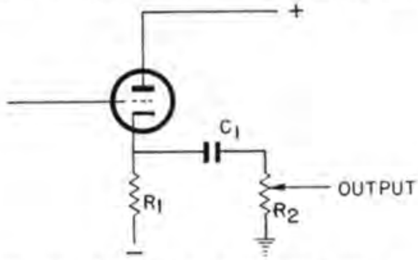


Figure 21. A cathode-follower circuit used as a low-impedance gain control

amplitudes and, with R1 and R2 being low resistances, has an output impedance so low that circuit capacitances will be ineffectual even at frequencies of several megacycles per second.

This circuit, in conjunction with the compensated, fixed-ratio attenuator, permits a wide range of signal attenuation without frequency discrimination at any setting.

Positioning Circuits

(a) D.C. Positioning

A cathode-follower circuit similar to the one illustrated in Figure 21 may be used in conjunction with direct-coupled amplifiers to pro-

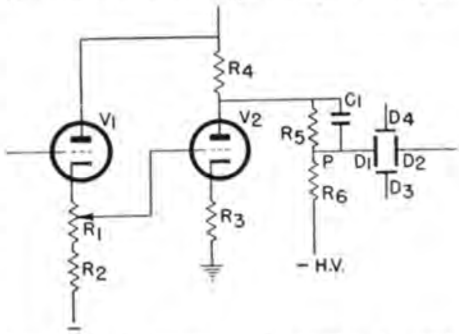


Figure 22. A circuit which provides d-c positioning of the spot on the cathode-ray tube screen

* See Du Mont "Oscillographer," July-August, 1946.

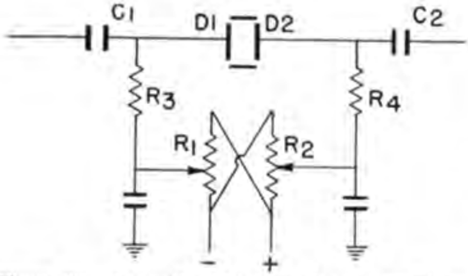


Figure 23. A circuit which provides a-c positioning of the spot on the cathode-ray tube screen

vide positioning voltage to the deflection plates of the cathode-ray tube. The circuit is shown in Figure 22.

The cathode of V1 operates at some positive potential with respect to ground, and R2 is connected to a negative supply. A d-c potential therefore exists across R1, and the bias of V2 may be varied by moving the arm of R1. This causes a change in the plate current of V2, and therefore a change in the d-c voltage at its plate, which is connected to the deflection plate of the cathode-ray tube through R5. Resistor, R4, is the plate load for the amplifier stage, V2. R5 and R6 provide d-c potential division to set point P at ground potential. This is done since the deflection plates must be operated at nearly the same potential as the accelerator electrode, which is ordinarily connected to ground particularly when external connections directly to the deflection plates are desired. C1 provides a path for the amplified signal from the plate of V2 to the deflection plate, D1. If it were not present, this signal would suffer some attenuation from the combination of R5 and R6.

(b) A.C. Positioning

A circuit such as that shown in Figure 23 is used to provide positioning when there is no direct connection to the deflection plates. There is a lag in operation due to the time required for the capacitors C1 and C2 to establish a steady d-c potential at the plates, D1 and D2, after the potentiometers R1 and R2 are adjusted to some new value. Time-constants of C1 and R3, and C2 and R4 must be large in order to preserve the necessary amplifier low-frequency response. R3 and R4 are high re-

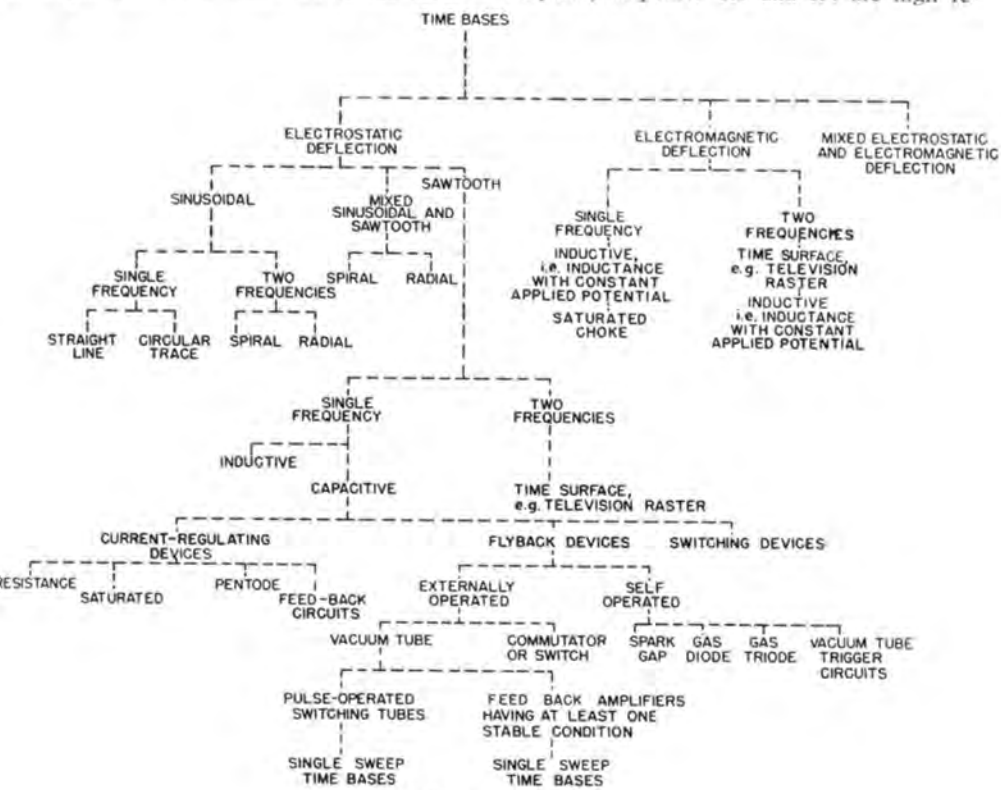


Figure 24. A time-base family tree

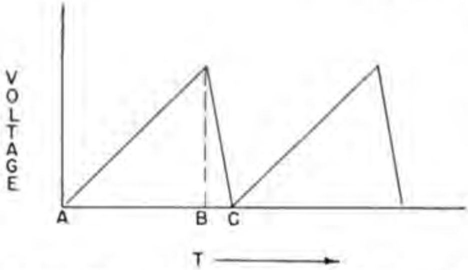


Figure 25 Wave-form produced by a linear time-base generator

sistances to maintain a high impedance path to the deflection plates.

Time-Base Generators

Most applications of the cathode-ray oscillograph require some investigated phenomenon to be plotted as a function of time. This is accomplished by applying to one pair of deflection plates a potential which is proportional to the phenomenon, and to the other pair of deflection plates, a potential proportional to some function of time. A circuit which generates this latter potential is referred to as a time-base generator or sweep generator. There are many varieties of time-bases, as illustrated by the family tree in Figure 24. All of them will not be discussed here, but it is important to remember that each type has certain advantages for some investigations.

(a) Linear Time-Base Generator

The linear time-base is probably the most universally adaptable of all the types. The potential applied to the deflection plates is proportional to time and is of the form shown in Figure 25. This is called a sawtooth voltage, and the circuit which produces it is therefore sometimes referred to as a sawtooth generator. The interval A to C comprises one cycle of the sawtooth. The linear portion A to B is referred to as "go time" or "sweep time" of the time-base because during this portion the fluorescent spot sweeps across the screen of the cathode-ray tube. The interval B to C is the "return time" or "fly-back time" because this is the time when the spot returns rapidly across the screen to begin the next cycle, from C on.

The sawtooth for the ideal linear time-base increases in linear fashion during the sweep time, and has a return time of extremely short duration. Some of the factors which must be considered in designing a linear time-base generator are:

1. Linearity of the sweep time
2. Ratio of return time to sweep time
3. Possible frequency range of the sawtooth potential
4. Ease of synchronization (refer to following section)
5. Driven-sweep operation (see section on Driven Sweep)
6. Power supply potential required
7. Sawtooth output level and output impedance.
8. Number and types of vacuum tubes required
9. Number of variable circuit components necessary to provide operation over required range of frequencies.

Each of these factors must necessarily be considered in the light of the particular application for which the time-base is to be used.

1. Synchronization

In order to obtain a stationary pattern on the screen of the cathode-ray tube, the sawtooth voltage produced by the time-base generator must have either the same period as the signal which is applied to the other pair of deflection plates, or some sub-multiple of that period. Adjustment of the time-base to satisfy this condition is called synchronization. It is usually accomplished by injecting into the time-base generator, in such a manner that it controls the frequency of the sawtooth, voltage of the proper frequency to produce a stationary indication. The amplitude of the voltage necessary for synchronization depends upon the particular circuit employed.

2. Return-Trace Blanking

The rapid motion of the fluorescent spot during the return time of the sweep will cause a relatively faint trace to appear on the screen of the cathode-ray tube. It is usually of no value and may only create confusion in the interpretation of the pattern. To eliminate such confusion, the beam may be extinguished or blanked during the return time by applying a sufficiently negative voltage to the grid of the cathode-ray tube.

The blanking voltage may be obtained by applying the sawtooth potential to a circuit which will produce a pulse corresponding to the rapid voltage-change during the return time. Once this pulse is generated, it is only

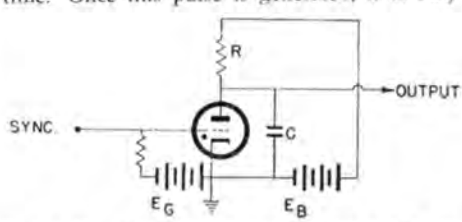


Figure 26. Basic circuit using a gas-triode for generating a saw-tooth voltage

necessary to apply it, in correct polarity and sufficient amplitude, to the grid or cathode of the cathode-ray tube.

3. Driven or Single Sweep

If a phenomenon of transient nature is to be investigated with a cathode-ray oscillograph, it is necessary to have a time-base which is initiated by that transient. The beginning of the sawtooth cycle will therefore coincide with the start of the phenomenon, and only a single sawtooth cycle will be generated for each time the time base is initiated. A description of one method for obtaining driven sweeps appears in the section on Gas Triode Time-Base Generators.

(b) Gas-Triode Time-Base Generators

One of the simplest methods of generating a sawtooth voltage is by means of the circuit shown in Figure 26. The capacitor, C, charges through resistor, R, from the battery, E_B. As it does so, it raises the plate potential of the gas-triode until a value is reached where the tube suddenly conducts current. This discharges the capacitor, and the cycle is repeated over and over. The discharge tube might also be a gas-diode, but the advantage of the triode lies in the fact that a synchronizing voltage may be applied to its grid, providing both sensitivity and isolation.

1. Synchronization of Gas-Triode Time-Base

Figure 27 illustrates the operation of this circuit as well as the method by which the synchronizing voltage locks the frequency of the sawtooth. The characteristic of the gas-triode is such that it will conduct current only with certain combinations of potentials on its plate and its grid. Graphical representation of this characteristic is the Static Control Characteristic in Figure 27. Once the tube does conduct, however, the grid has no control again until the tube has been extinguished or made to stop conducting. This can only be accomplished by reducing the plate potential to a sufficiently low value that the tube is extinguished.

If no synchronizing signal is used, the gas triode will conduct when its plate reaches E_f. As it conducts, it shorts the capacitor, C, and its plate potential drops to the value E_{ex}, which is the extinction potential for the tube. The tube ceases to conduct and C begins to charge again. The rate at which the plate voltage rises depends on the values of C and R, and also on

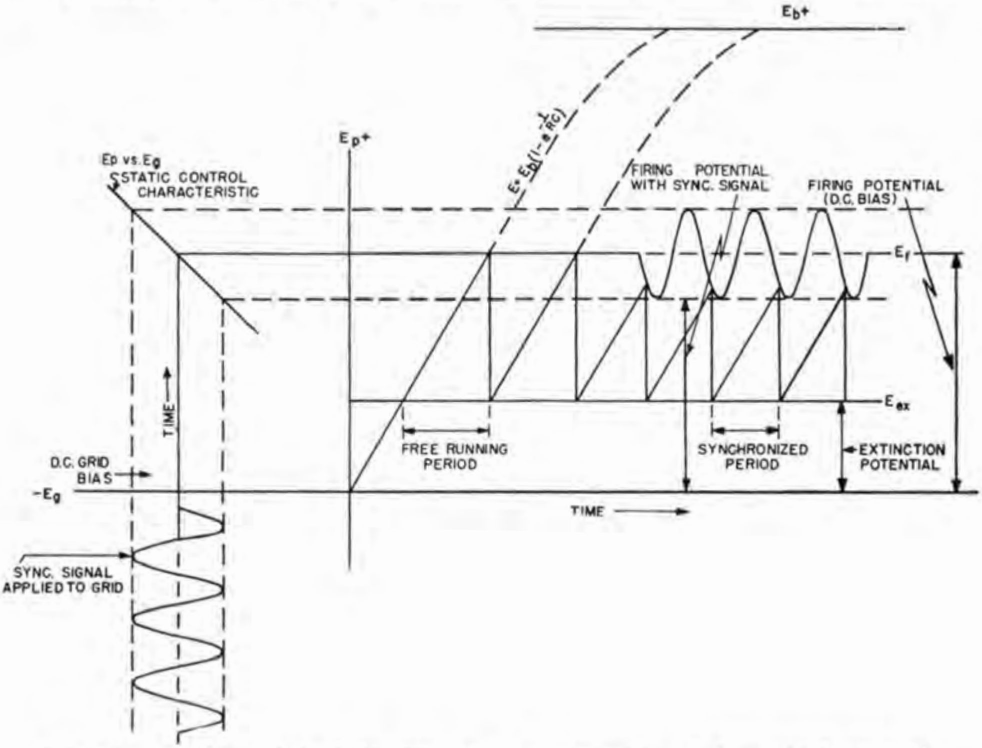


Figure 27. Graphic analysis of the operation and synchronization of the gas-triode sawtooth generator

E_B. The expression for the voltage, E, across C at time, t, is: $E = E_B \left(1 - e^{\frac{-t}{RC}}\right)$ The symbol, e, represents, of course, the natural logarithmic base. The "free-running" frequency of the sawtooth voltage will be approximately:

$$f = \frac{E_B}{RC} \left(\frac{1}{E_f - E_{ex}}\right)$$

If a synchronizing voltage is applied to the grid of the gas-triode, its firing potential, E_f, will vary in accordance with the signal as shown. The tube will therefore conduct when the line representing its plate potential intersects the line which represents the conducting potential. If the "free-running" period of the time-base generator is slightly greater than the period of the synchronizing signal, the sawtooth frequency will be locked-in with the synchronizing signal.

2. The Practical Considerations

In the practical form of this circuit, R is ordinarily a variable resistor and C is replaced by a number of capacitors, any one of which may be selected. This scheme provides for both coarse and fine adjustment of sawtooth frequency and makes possible a continuous variation over a wide frequency range.

It is also practical to allow selection of the synchronizing signal from one of several sources. An external signal may be used, a power-line frequency voltage may be used, or a signal may be obtained from the amplifier which amplifies the phenomenon being plotted against the time-base deflection.

If the synchronizing voltage is obtained from this amplifier, it must be obtained at a point where its amplitude is sufficient to provide satisfactory synchronization. A control is ordinarily provided to allow adjustment of the synchronizing signal amplitude which reaches the grid of the gas-triode. Only that amount of synchronizing voltage should be applied to the tube which is necessary for stable synchronization. An excess may introduce non-linearity into the sweep.

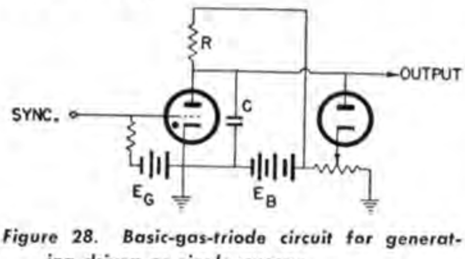


Figure 28. Basic-gas-triode circuit for generating driven or single sweeps

The charging curve for the capacitor, C, is a portion of an exponential curve, as is seen in Figure 27 and by the mathematical expression previously given for the voltage across it. In practice, a sawtooth with linear rise is obtained by utilizing a small fraction of that charging curve; usually the amplitude of the sawtooth represents only 10 to 15% of the available power supply voltage, E_B.

A time-base generator such as the one just described will furnish sawtooth voltage over a range of frequencies from about 0.5 to 50,000 cycles per second. At higher frequencies, the time required to discharge the capacitor (return time) becomes an appreciable fraction of the total sawtooth cycle because of the de-ionization time of the gas-triode. Thus de-ionization time is a limiting factor in this type of time-base generator.

At low frequencies, leakage of the capacitor becomes a factor in determining the linearity of the sawtooth sweep time. The leakage prevents the capacitor from charging exponentially as it should, and the sweep will slow down during the last portion of its sweep period.

A form of feed-back circuit may be used to compensate for non-linearity in the sawtooth voltage. It utilizes some of the sawtooth voltage and feeds it back to a point in the charging circuit of the capacitor. If non-linearity exists, it tends to compensate for itself.

3. Driven or Single Sweep Operation

The gas-triode time-base lends itself to driven sweep operation without much revision of the circuit. Figure 28 illustrates a typical driven-sweep circuit in which the only addition is the diode vacuum tube and a suitable source of bias voltage. If the cathode of this diode is set at some potential below the conducting potential of the gas-triode, the diode will conduct when its plate also reaches that same potential. As long as the diode is conducting, the plate of the gas-triode is held at that potential and the triode will not conduct. If a synchronizing signal of positive polarity and sufficient amplitude is introduced on the grid of the gas-triode, its firing potential will be lowered to a value below that at which it is held by the diode, and the triode will conduct. The capacitor discharges until the triode ceases conduction, at which time it begins to charge again through the resistor, R. If the synchronizing signal has meanwhile been removed from the grid of the triode, the capacitor will charge only to the potential fixed by the setting of the diode. Thus a single sawtooth cycle is generated by initiation of the circuit with the syn-

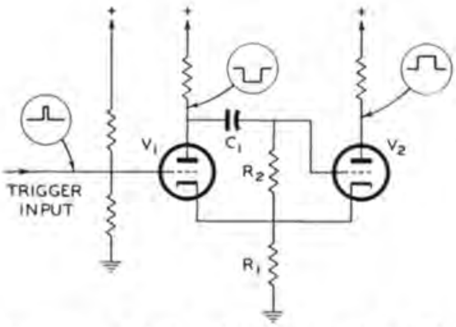


Figure 29. A basic multivibrator used in high-vacuum sweeps circuits

chronizing signal. Another sweep will not occur unless the circuit is again initiated.

By initiating the driven sweep with a signal occurring simultaneously with the transient to be studied, and by adjustment of the values of R and C, the driven sweep may be made to occupy the same period as the transient.

If photographic recording is to be made with driven sweep operation, there arises a problem peculiar to this application. The fluorescent spot on the screen of the cathode-ray tube remains stationary except during the actual period of the sweep, and may therefore cause exposure and "fogging" of the film before and after the transient occurs. It is possible to use a camera shutter which opens only during the sweep period, but this is not practical for fast sweep speeds. The most effective method of preventing this fogging is to have the cathode-ray beam in the "on" condition during the sweep time and "off" at all other times. To accomplish this, a positive pulse may be applied to the biased-off grid of the cathode-ray tube during the sweep period. Such a pulse can be derived from the driven sweep circuit by one of several methods which will not be described here.

(c) High-Vacuum Time-Base Generators

As the name implies, these time-base generators do not make use of gas discharge tubes and they are therefore not subject to the limitations of de-ionization time. A number of different circuit configurations may be employed, but most of them make use of the "trigger" or "flip-flop" characteristic of triodes or pentodes connected as in the circuit of Figure 29. This "flip-flop" action is the result of a small potential change in one portion of the circuit producing a sudden large change in another portion.

Suppose in Figure 29 that V1 is cut off while V2, having no bias, is conducting. A positive voltage of sufficient amplitude to cause conduction applied to the grid of V1 will produce a negative signal at its plate. This negative signal will be transferred to the grid of V2 through capacitor, C1. V2 will be cut off and its plate voltage will rise rapidly to power supply potential. The time-constant of R2 and C1 determines the length of time which V2 is cut off. When C1 is no longer discharging through R2 at a sufficient rate to bias V2 to cut-off, it will conduct and in so doing will develop a potential across R1 which will bias V1 to cut-off. Thus the circuit when initiated by a signal, produces a rectangular pulse the

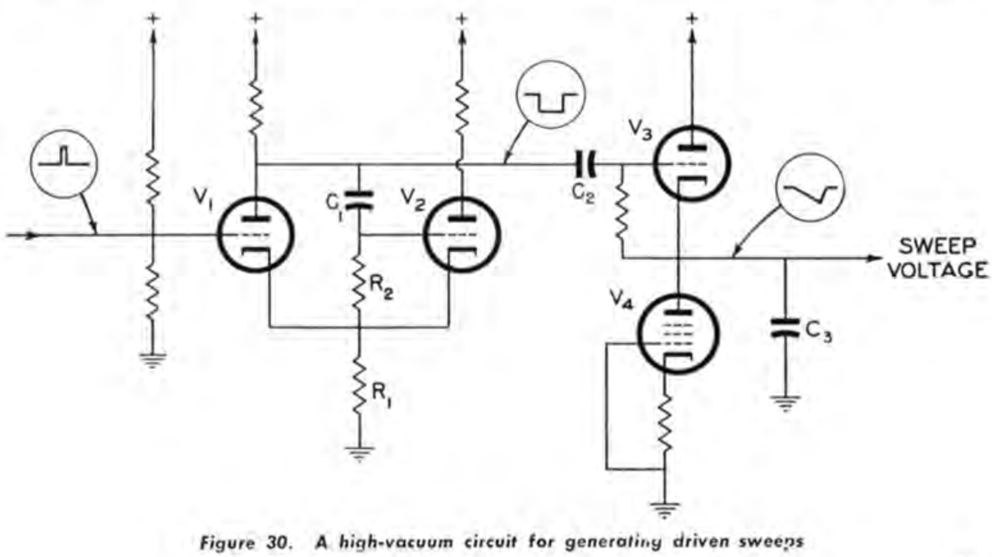


Figure 30. A high-vacuum circuit for generating driven sweeps

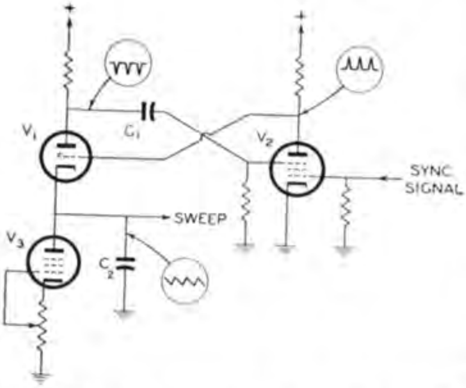


Figure 31. A high-vacuum circuit for generating both recurrent and driven sweeps

duration of which depends upon the values of C1 and R2.

1. High Vacuum Circuit for Generating Driven-Sweep

It is only a step from the elementary circuit of Figure 29 to one which is suitable for driven-sweep operation. The circuit of Figure 30 shows this same trigger circuit with addition of a discharge tube, V3, and a constant-current pentode, V4. V3 and V4 are normally conducting providing a current path from the power supply to ground and allowing C3 to charge. Introduction of the pulse of negative polarity from the trigger circuit to the grid of V3 cuts this tube off and allows C3 to discharge through V4, the constant-current tube. A linear, sawtooth voltage which begins immediately upon triggering is generated. The return time occurs after the sweep. In the gas-triode circuit, the return time occurs before the driven sweep and some time is consumed before the sweep gets under way.

2. High-Vacuum Circuits for Generating Recurrent and Driven Sweeps

Figure 31 is a typical example of a circuit for generating recurrent sweeps. V2 and V1 are connected as an unbalanced multivibrator, and the circuit constants are so proportioned that a short positive pulse of large amplitude is delivered periodically to the grid of V1. This pulse lowers the impedance of V1 and allows C2 to charge rapidly from the power supply. During the time between pulses, C2 discharges through V3, a constant current pentode. The multivibrator frequency, and therefore the sweep frequency, is determined by the size of C2 and the impedance of V3. In practice, C2 is usually replaced by a number of capacitors, any one of which may be selected. The sweep frequency is thereby varied in steps by selection of the capacitor, and is variable between steps by adjusting the bias on V3. Synchronizing signal may be applied to the grid of V2.

Driven sweep operation is possible by application of a sufficiently positive bias to V2 to prevent the continuous sweep. Then a negative potential on the grid of V2, sufficient to momentarily restore the circuit to its normal condition, will initiate the sweep for a single cycle. As in the case of the gas-triode driven sweep, the return time occurs before the sweep. However, both return time and sweep time may be made considerably shorter than is possible with the gas-triode circuit.

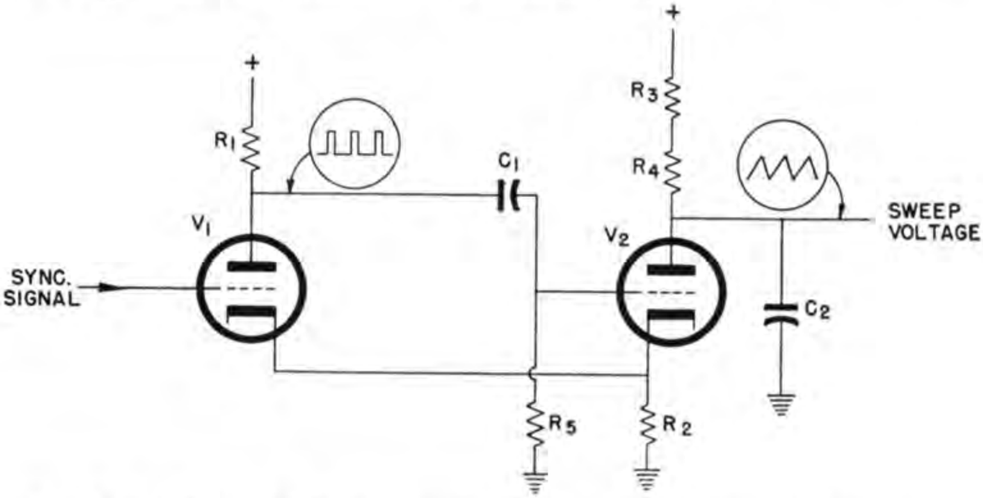


Figure 32. Another example of a high-vacuum circuit for generating recurrent and driven sweeps

Figure 32 is still another example of a high-vacuum sweep generator which will furnish either recurrent or driven sweeps. On recurrent operation, V2 is not conducting at first. Then C2 charges through resistors R3 and R4 until the plate potential of V2 reaches a value sufficient to cause conduction. V2 and V1 are connected in a "flip-flop" circuit as described at the beginning of the section on High-Vacuum Time-Base Generators. As V2 begins to conduct, it raises the bias on V1 through the common cathode resistor, R2, and decreases the plate current of V1. The plate potential of V1 begins to increase, and the increase is transferred to the grid of V2 through C1. V2 therefore draws more plate current and cuts off the current in V1. This entire action takes place instantaneously, so that V2 flips from non-conduction to full-conduction at once. Of course when V2 does conduct, C2 discharges rapidly through it until it becomes non-conducting once more. Sawtooth voltage is obtained from C2. Synchronizing signal may be applied to the grid of V1.

For driven-sweep operation, the grid of V2 is biased negatively, and a diode is connected in parallel with C2. C2 begins to charge through R3 and R4, but the diode is set so that it conducts before V2 does. When the diode conducts, C2 cannot charge further so it stays at that potential until an initiating voltage of negative polarity is introduced on the grid of V1. A positive signal will be produced at the plate of V1, and this will be transferred to the grid of V2 through C1. If it is of sufficient amplitude, it will cause V2 to conduct, and C2 will discharge through it. C2 then charges up to the level where the diode conducts, and holds until the circuit is again initiated. A single sawtooth cycle is generated for each time the initiation occurs.

The practical revisions of this circuit are much the same as with the circuits previously described. Frequency of the sawtooth is variable by providing a selection of capacitors for C2 and by making R3 a variable resistor.

(d) Other Time-Bases

Although the linear time-base is probably most useful of all the time-bases, and a linear time-base generator is usually incorporated in the cathode-ray oscillograph, other time-bases are often valuable for special applications.

1. Sinusoidal Time-Base

Application of a sine-wave voltage to one pair of deflection plates of the cathode-ray tube provides a proportional deflection. Near the center of deflection where the sine-wave changes from one half-cycle to the next, the potential variation is nearly linear with respect to time. By expanding this center portion sufficiently, the time-base may be made practically linear. Then, by shifting the phase of the sinusoidal voltage through 180 electrical degrees, a phenomenon which occurs during any portion of the sine-wave period may be centered on the screen of the cathode-ray tube.

Still another type of time-base may be produced by applying two sine-wave voltages which are 90 degrees out of phase, one to each pair of deflection plates. If the amplitudes of these voltages are equal, a circular trace will be produced on the screen. The potential to be investigated may also be applied to one pair of deflection plates to produce rectilinear deflection, or it may be used to simultaneously modulate the two sine-wave voltages to produce radial deflection. This potential might also be connected to the grid of the cathode-ray tube to produce intensity modulation of the beam.

2. Spiral or Radial Time-Bases

A combination of sawtooth and sinusoidal voltages may be employed to generate a spiral or radial time-base. The circular time-base is produced as described above, and the sawtooth voltage is used to modulate the signals producing the circle. The radius of the circle varies in accordance with the sawtooth voltage, and the time-base will resemble in form the main spring of a watch.

The chief advantage of the circular and the spiral time-bases over the linear time-base is that, for a given size of cathode-ray tube, the length or duration of the time-base may be made much greater. The circular time-base is also useful in rotary motion studies where the quantity to be investigated can be plotted as a function of angular position.

(e) Marker Circuits

Many modifications and refinements may result from the circuits described in the preceding sections. One of the most useful is the circuit which provides time marks on the time-base. These marks may be in the form of intensity modulation of the cathode-ray tube beam, or short pulses applied to the deflection plates (*not* the same pair of deflection plates to which the time-base voltage is connected).

Such pulses are usually obtained from an extremely stable oscillator which is started as the time-base begins, and which stops oscillating before the succeeding cycle of the time-base begins. Shaping circuits are usually required to form sharp pulses from the oscillator output.

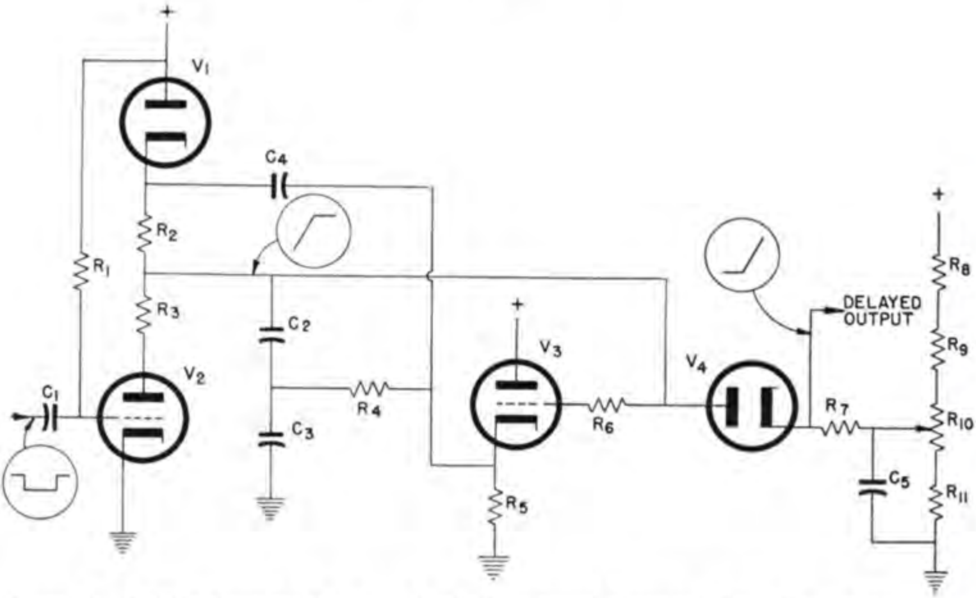


Figure 33. A delay circuit which is used to initiate or trigger a precision-delayed sweep generator

Sweep Delay Circuits

It is possible to produce a pulse, the occurrence of which is delayed a known interval of time from a given pulse, in order to initiate or trigger a precision-delayed sweep circuit. This may be accomplished by means of a circuit such as is shown in Figure 33.

The grid of V2 is connected to a positive potential through R1, and therefore V2 is conducting until the negative initiating pulse is applied through C1. This pulse has sufficient amplitude to cut off V2; capacitors C2 and C3 charge up through V1 and R2. Their charge would collect exponentially, as has been previously discussed, except for the compensation provided by the feedback through V3, C4 and the integrating action of R4 and C3. The linear sawtooth output is applied to the plate of diode, V4.

Potential on the cathode of V4 is determined by the position of potentiometer, R10. This potentiometer is accurately wound so that the resistance variation between one end and the movable arm is linear with respect to the position of that arm. V4 will not conduct until such time as the sawtooth potential on the plate reaches the potential of the cathode. Waveforms at plate and cathode of V4 are shown in the circuit.

The time delay is measured from the start of the negative initiating pulse to the point where the diode conducts. If the position of R10 is such that the cathode potential of V4 is low, then V4 will conduct relatively soon after the start of the initiating pulse. If the cathode potential is high, V4 will not conduct as soon after the pulse is applied.

In practice, a calibrated dial can be attached to the potentiometer, R10, and the output delay read directly from it. The delayed output pulse from this circuit may be used to initiate a linear time-base generator, thus varying the start of the time-base with respect to the initiating pulse. Time intervals between investigated pulses may be measured by varying the delay to bring each pulse to the same point on the time-base, and subtracting the dial readings obtained thereby. Accuracy of measurements may be limited to the accuracy with which R10 is wound.

NOTICE

No liability is assumed with respect to the use of circuit and tube information contained in this manual.

DU MONT
CATHODE-RAY INSTRUMENTS

SPECIFICATIONS
and
DESCRIPTION

TYPE 164-E
CATHODE-RAY OSCILLOGRAPH

- Small, portable, for general-purpose duty
- Signals may be connected to deflection plates either directly or through amplifiers
- Vertical amplifier response at full gain within ±20% from 5 to 100,000 cycles per second
- Identical amplifiers for vertical and horizontal deflection
- Recurrent sweeps from 15 to 30,000 cycles per second
- Return-trace blanking
- Sine-wave test signal output

FUNCTION

The Type 164-E Cathode-ray Oscillograph is a small, compact instrument for general-purpose work in the laboratory or field, or for radio servicing duty. In its design, emphasis has been placed upon combining simplicity and portability with utility. An ideal balance of these three has been accomplished, none having been sacrificed at the expense of another.

DESCRIPTION

Cathode-ray Tube

The Type 3AP-A Cathode-ray Tube is used in the Type 164-E. This tube has a 3-inch screen diameter, high deflection sensitivity, and is capable of producing a bright, finely focused trace even with the use of a medium accelerating potential and unbalanced deflection. It is available with either the medium-persistence green P1 screen for visual observation, or the short-persistence blue P11 screen for photographic recording.

The entire accelerating potential is applied prior to deflection of the beam. The deflection plates average at ground potential.

Vertical Deflection

Signals may be applied to the vertical deflection plates by either of two methods: (1) they may be connected to vertical input terminals on the front panel which are capacitively coupled to the input of the vertical amplifier, or (2) they may be connected to the terminal board at the rear of the instrument which provides direct coupling to the deflection plates.

Normally, signals are applied through the vertical amplifier. Those, however, which have sufficient amplitude that they do not require amplification, or those containing d-c components may be connected to the terminal board at the rear.

The frequency response characteristic of the vertical amplifier at full gain is uniform within ±20% from 5 to 100,000 cycles per second.

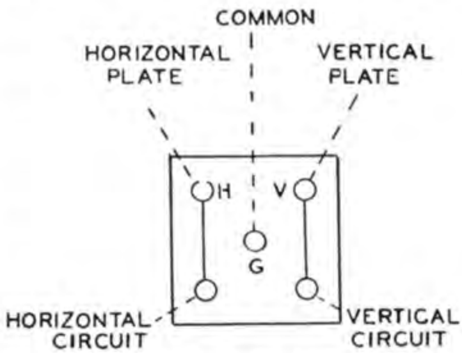


Figure 1. Terminals on the back of the Type 164-E where deflection plates and amplifier circuits are available without removing the instrument from its cabinet

Horizontal Deflection

The horizontal deflection plates are accessible by the same means as are the vertical plates. The characteristics of the horizontal deflection circuits are identical to those used for vertical deflection. This feature is especially valuable for measurement of phase shifts in external circuits.

Positioning

The trace on the screen of the cathode-ray tube may be moved to any portion of the screen by means of vertical and horizontal positioning controls on the front panel. Four inches of positioning are available both horizontally and vertically. It is possible to retain the positioning feature even when connections are made to deflection plates through the rear terminal board by observing certain precautions. (Refer to the March-April, 1946, issue of the Du Mont Oscillographer for a complete discussion of connections to the deflection plates.)

Linear Time-Base

The time-base generator furnishes a recurrent sawtooth voltage, the frequency of which is variable from 15 to 30,000 cycles per second. This voltage can be connected by means of a horizontal input switch to the input of the horizontal amplifier, producing a horizontal deflection, or sweep, which is linear with respect to time. Direction of sweep on the cathode-ray tube screen is from left to right.

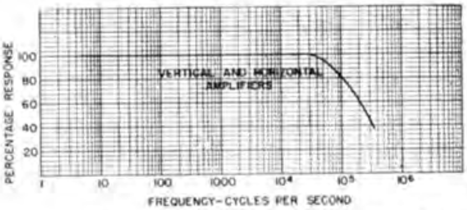


Figure 2. Frequency-response characteristics of the Type 164-E

Return-trace blanking is included to make invisible the rapid right-to-left travel of the sweep, and to eliminate confusion of the pattern which might result without blanking.

Synchronization of the Time-Base

The frequency of the time-base generator may be synchronized from either an internal or an external signal. The internal synchronizing signal is obtained from the vertical amplifier; an external signal may be connected to a synchronizing terminal on the front panel.

Test Signal

A sine-wave voltage of 6 rms volts amplitude at power-line frequency is available at an output terminal on the front panel. It is valuable for use as a test signal in many trouble-shooting applications, or it may be used as an external synchronizing signal to synchronize the time-base generator at power-line frequency.

SPECIFICATIONS

Cathode-ray Tube—Type 3AP-A, electrostatic tube with two free deflection plates. Operated with accelerating potential of 1,100 volts; deflection plates average at ground potential.

Vertical Deflection—Deflection Factor of not more than 0.8 rms volt/inch with amplifier at full gain; 30 rms volts/inch ±20% with direct connection to deflection plates. Undistorted deflection with amplifier, 4 inches. Sinusoidal frequency response at full amplifier gain uniform within 20% from 5 to 100,000 cycles per second. Input impedance to amplifier of 1 megohm in parallel with 40 $\mu\mu$f.

Horizontal Deflection—Deflection Factor of not more than 0.65 rms volt/inch with amplifier at full gain; 30 rms volts/inch ±20% with direct connection to deflection plates. Undistorted deflection with amplifier, 4 inches. Sinusoidal frequency response at full amplifier gain uniform within 20% from 5 to 100,000 cycles per second. Input impedance to amplifier of 800,000 ohms in parallel with 40 $\mu\mu$f.

Linear Time-Base — Provides recurrent sweeps continuously variable in frequency from 15 to 30,000 cycles per second. Linearity within 3% at 15 cycles. Direction of sweep from left to right; right-to-left return trace blanked out. Synchronization from either the vertical deflection signal or from externally connected signal of 0.2 rms volt amplitude.

Power Source—Type 164-E is available for operation from either 115 volt or 230 volt power, whichever is specified. Power line frequency, 40-60 cycles; power consumption, 50 watts, fuse protection, 1/2 ampere.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle. Overall dimensions, 11-5/8" (height) x 7-5/16" (width) x 13-13/16" (depth). Weight, 22 lbs.

Catalog No.	Type No.	Description	Code Word
1064	164-E	115 volt, 40-60 cycles; with Type 3AP1-A Cathode-ray Tube.	YATOP
1065	164-E	230 volt, 40-60 cycles; with Type 3AP1-A Cathode-ray Tube.	YATPO
1066	164-E	115 volt, 40-60 cycles; with Type 3AP11-A Cathode-ray Tube	YATRY
1067	164-E	230 volt, 40-60 cycles; with Type 3AP11-A Cathode-ray Tube	YATYR

TYPE 208-B
CATHODE-RAY OSCILLOGRAPH

- High-sensitivity vertical deflection—0.01 rms volt/inch
- Frequency response of vertical amplifier uniform within 10% from 2 to 100,000 cycles per second
- Recurrent sweeps from 2 to 50,000 cycles per second
- Deflection plates available for direct connections
- Sinusoidal test-signal output

FUNCTION

The Type 208-B Cathode-ray Oscillograph is an instrument unusually qualified for general-purpose laboratory work, or for most applications where qualitative as well as quantitative data is to be collected. It has extremely sensitive vertical deflection, for amplification of signals even from devices which produce very small potentials. It has excellent response to low-frequency signals, so that it may be used in conjunction with a square-wave generator in testing low-frequency transmission characteristics of circuits, or with many types of transducers in studying low-frequency phenomena such as pressure variations and mechanical motions.

DESCRIPTION

Cathode-ray Tube

The Type 5LP-A Cathode-ray Tube is employed in the Type 208-B. The intensifier electrode permits post-deflection acceleration of the electron beam, and both deflection plate pairs are at ground potential so that direct connections to them may be easily and safely made.

A magnetic shield for the tube prevents deflection or intensity modulation of the beam by external fields.

Vertical Deflection

External signals may be applied to the vertical deflection plates 1) through a terminal on the panel which is capacitively connected to the vertical amplifier, or 2) through terminals at the rear of the instrument which are directly connected to these plates. Signals which do not require amplification, or which contain frequency components beyond the response limits of the amplifier, may be connected at the rear terminals. The sinusoidal frequency response characteristic of the amplifier is uniform within 10% from 2 to 100,000 cycles per second, and within 50% to 325,000 cycles per second.

An undistorted deflection equivalent to more than 2-1/2 times full-screen may be obtained using the amplifier. This means that a pattern may be greatly expanded if necessary in order to carefully study some detail which would not otherwise be visible.

Horizontal Deflection

External signals may be connected to the horizontal deflection plates 1) through a terminal on the front panel which is capacitively connected to the horizontal amplifier, or 2)

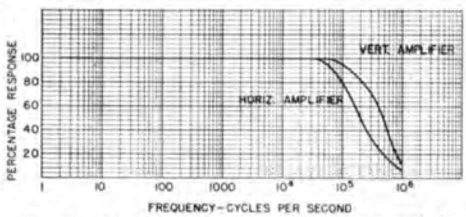


Figure 1. Frequency-response characteristic of the Type 208-B

through a pair of terminals at the rear which are directly connected to these plates. Sinusoidal frequency response of the amplifier is uniform within 10% from 2 to 100,000 cycles per second, and within 50% to 250,000 cycles per second. Horizontal deflections may also be expanded to the equivalent of 2-1/2 times full-screen in order to assist in the study of pattern detail.

Sawtooth potential from the time-base generator may be connected instead of an external signal to produce a deflection which is linear with respect to time.

Linear Time-Base

The sweep generator in the Type 208-B furnishes recurrent sweeps which are variable in frequency from 2 to 50,000 cycles per second.

Synchronization of Time-Base

The frequency of the sweep generator may be synchronized from 1) the vertical deflection signal, 2) a power-line frequency voltage, or 3) an externally connected signal. The first two are obtained internally from the circuits of the Type 208-B. Synchronization will be obtained from the positive polarity only.

Test Signal

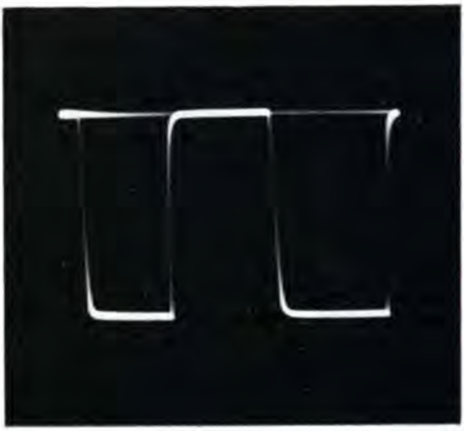
A sinusoidal voltage of power-line frequency and 2.8 rms volts amplitude is available at a terminal on the front panel. It is useful as a test signal in tracing some trouble in a circuit. It is also useful as a means of producing a sinusoidal deflection either vertically or horizontally on the cathode-ray tube.

Positioning

By means of controls on the panel, a pattern on the cathode-ray tube may be moved both vertically and horizontally much more than the diameter of the screen itself in order to take full advantage of the maximum deflection which the amplifiers provide. The amplitude of a signal may be greatly expanded by the amplifiers, and the position of the pattern may be adjusted so that any portion occupies the center of the screen. Minute details may be studied by this method.

Servicing Applications

The Du Mont Type 208-B Cathode-ray Oscillograph has become the most popular oscillograph in the field of radio servicing. It is particularly outstanding in the field of television. The Type 208-B is an absolute necessity for the stage-by-stage alignment of the video IF stages of a television receiver. The sensitivity of its vertical and horizontal amplifiers permits an IF response curve from a single stage to be expanded to full scale. Television manufacturers led by Du Mont utilize the Type 208-B on their production line for the alignment of both the video and sound IF stages. Photographs of such applications are shown on the next page.



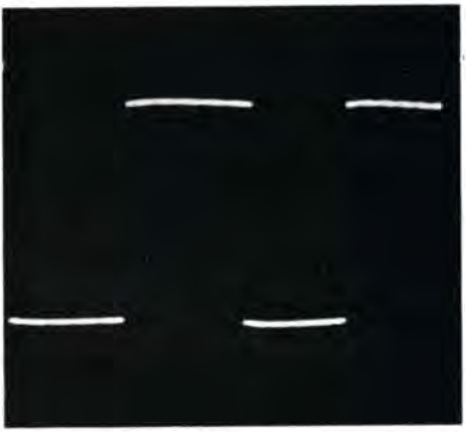


Figure 2. Response of the vertical amplifier of the Type 208-B to a square-wave of 10,000 cycles per second (top) and 5 cycles per second (bottom)

SPECIFICATIONS

Cathode-ray Tube—Type 5LP-A Cathode-ray Tube with four free deflection plates. Accelerating potential, 1400 volts overall.

Vertical Deflection — Deflection Factor not more than 0.01 rms volt/inch with amplifier at full gain; 21 rms volts/inch ±20%, direct to plates. Sinusoidal frequency response of amplifier uniform within 10% from 2 to 100,000 cycles per second, and within 50% to 325,000 cps. Response same for all attenuator settings. Input impedance to amplifier, 2 megohms paralleled by 30 μμf.

Horizontal Deflection—Deflection Factor not more than 0.5 rms volt/inch with amplifier at full gain; 22 rms volts/inch ±20% direct to plates. Sinusoidal frequency response of amplifier uniform within 10% from 2 to 100,000 cps, and within 50% to 250,000 cps. Response same for all attenuation positions. Input impedance to amplifier, 5 megohms paralleled by 25 μμf.

Linear Time-Base — Recurrent sweeps variable in frequency from 2 to 50,000 cycles per second. Sweep linearity within 5% at 15 cycles. Sweep direction, left to right. Synchronization from positive signal of 0.1 volt amplitude.

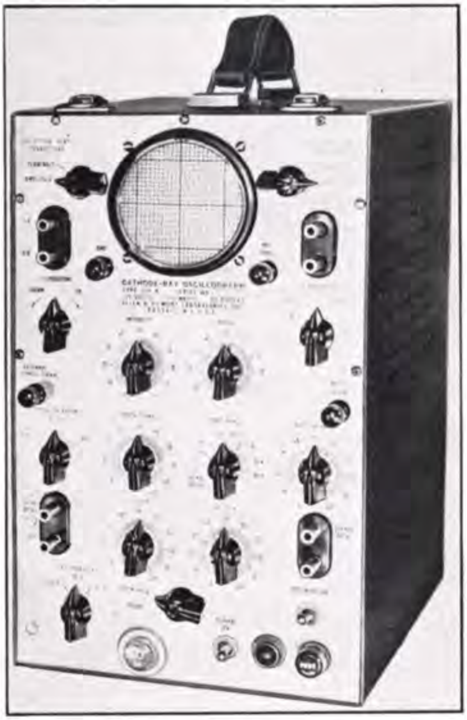
Power Source—Type 208-B is designed to operate from a 40-60 cycle power line at 115 or 230 volts, whichever is specified. Power consumption, 90 watts; fuse protection, 1.5 amperes.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle. Overall dimensions, 14-1/2" (height) x 8-7/8" (width) x 20-1/4" (depth). Weight, 54 lbs.

Catalog No.	Type No.	Description	Code Word
1146	208-B	Cathode-ray Oscillograph, for operation from 115 volts, 40-60 cycles; with 5LP1A Cathode-ray Tube............	YEEGD
1147	208-B	Same as above, for operation from 230 volts, 40-60 cycles.	YEELJ
1148	208-B	Same as above, for operation from 115 volts, 40-60 cycles; with 5LP11A Cathode-ray Tube........................	YEEMK
1149	208-B	Same as above. for operation from 230 volts, 40-60 cycles; with 5LP11A Cathode-ray Tube........................	YEERP
1150	208-B	Same as above, for operation from 115 volts, 40-60 cycles; with 5LP7A Cathode-ray Tube..........................	YAKCE
1151	208-B	Same as above, for operation from 230 volts, 40-60 cycles; with 5LP7A Cathode-ray Tube..........................	YAKFO

Figure 3. The Type 208-B Cathode-ray Oscillograph in use in the testing of television circuits at our own factory

TYPE 224-A
CATHODE-RAY OSCILLOGRAPH



- Vertical amplifier response uniform within 30% from 20 cycles per second to 2 megacycles per second at all attenuator settings
- Input probe for vertical amplifier
- Balanced deflection through horizontal and vertical amplifiers
- Connection of balanced or unbalanced signals direct to deflection plates
- Intensity modulation from external signal

FUNCTION

The Type 224-A is a versatile, small-size oscillograph designed for the investigation of pulses and signals which contain high frequency components. A variety of input signal connections is possible to terminals which are all located on the front panel. Circuits are incorporated which ordinarily are used only in larger, more expensive oscillographs. It is valuable because of its size as a portable test instrument.

DESCRIPTION

Cathode-ray Tube

The Type 3GP-A Cathode-ray Tube is used in the Type 224-A. Accelerating potential is applied prior to deflection of the beam; deflection plates are at ground potential. It is therefore possible to connect external signals which are at ground potential directly to the deflection plates. This tube produces an extremely small spot size and, at this accelerating potential, furnishes an ideal compromise between pattern brightness and deflection sensitivity.

A magnetic shield is provided to shield the cathode-ray tube from the effects of external magnetic fields such as may be found near transformers, welding equipment, generators, etc.

Vertical Deflection

Signals may be applied to the vertical deflection plates (1) through input terminals which are capacitively connected to the vertical amplifier, (2) through a probe and coaxial lead which are connected to the vertical amplifier, or (3) through terminals on the panel which are directly connected to the deflection plates. Either balanced or unbalanced signals which do not require amplification or which contain frequency components outside the response limits of the amplifier may be directly connected to the deflection plates. The amplifier furnishes balanced output to the deflection plates; sinusoidal frequency response is

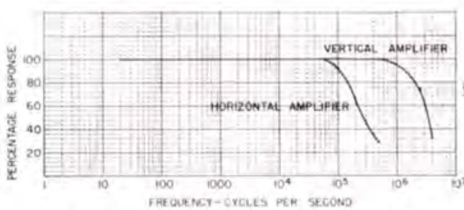


Figure 1. Frequency-response characteristics of the Type 224-A

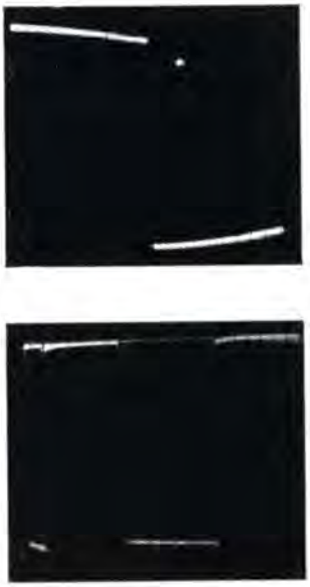


Figure 2. Response of the vertical amplifier of the Type 224-A to square-wave signals. Top oscillogram, 50 cycles per second; bottom oscillogram, 100,000 cycles per second

uniform within 30% from 20 cycles per second to 2 megacycles per second for any setting of the attenuator and gain controls. A frequency-compensated attenuator and a low-impedance gain control are used.

The probe is used in applications where a shielded signal input is necessary. When used, it introduces 4:1 attenuation of the signal, and minimizes capacitive loading of high frequencies. When not in use, it may be kept inside the removable front panel cover.

Horizontal Deflection

Signals may be applied to the horizontal deflection plates (1) through input terminals which are capacitively connected to the horizontal amplifier, or (2) through terminals which are directly connected to the deflection plates. Either balanced or unbalanced signals which do not require amplification or which contain frequency components outside the response limits of the horizontal amplifier may be directly connected to the deflection plates. The amplifier furnishes balanced output to the deflection plates; sinusoidal frequency response is uniform within 30% from 10 to 100,000 cycles per second at any setting of the attenuator and gain controls. A frequency-compensated attenuator and a low-impedance gain control are employed in this amplifier as well as in the vertical deflection amplifier.

Output voltage from the linear time-base generator may be connected by means of a switch to produce horizontal deflection, or sweep, which is linear with respect to time.

Linear Time-Base

The time-base generator furnishes recurrent sawtooth voltage, the frequency of which may be varied from 15 to 30,000 cycles per second. The direction of sweep which it produces on the cathode-ray tube is from left to right.

Synchronization of the Time-Base

The frequency of the time-base may be synchronized from (1) an internal signal which is obtained from the vertical amplifier, (2) an external signal which may be connected to the synchronizing terminal on the panel, or (3) a power-line frequency voltage obtained from the power transformer of the instrument. A switch selects any one of the three. Either polarity of signal will synchronize the sweep.

Intensity Modulation

External signals may be applied to the grid of the cathode-ray tube through a terminal provided on the panel. Positive polarity input increases beam intensity; negative polarity decreases intensity.

Positioning

The pattern may be moved to any portion of the cathode-ray tube screen by means of controls on the front panel. Three inches of positioning are available both vertically and horizontally. Positioning is available at all times, even when connections are made directly to deflection plates, provided that high-impedance or capacitive coupling is employed between the signal source and the deflection plate terminals.

Test Signal

A sine-wave voltage at power line frequency and 1.7 rms volts amplitude is available at an output terminal on the front panel. It is valuable as a test signal for many trouble-shooting applications.

SPECIFICATIONS

Cathode-ray Tube—Type 3GP-A electrostatic tube with four free deflection plates. Operated with accelerating potential of 1000 volts; deflection plates average at ground potential.

Vertical Deflection—Deflection Factor of not more than 0.1 rms volt/inch through amplifier, 0.4 rms volt/inch through probe and amplifier, and 25 rms volts/inch ±20% direct to deflection plates. Undistorted deflection with amplifier, 5 inches maximum. Sinusoidal frequency response of amplifier uniform within 30% from 20 cycles per second to 2 megacycles per second. Input impedance: to amplifier, 2 megohms in parallel with 30 μμf; to probe, 1 megohm in parallel with 20 μμf; direct to deflection plates, 10 megohms in parallel with 20 μμf. (balanced connection), and 5 megohms in parallel with 25 μμf (unbalanced connection).

Horizontal Deflection—Deflection Factor of not more than 0.7 rms volt/inch through amplifier, and 28 rms volts/inch ±20% direct to deflection plates. Undistorted deflection with amplifier, 4 inches maximum. Sinusoidal frequency response of amplifier uniform within 30% from 10 to 100,000 cycles per second. Input impedance: to amplifier, 2 megohms in parallel with 30 μμf.; direct to deflection plates, 10 megohms in parallel with 20 μμf. (balanced connection), and 5 megohms in parallel with 25 μμf. (unbalanced connection).

Linear Time-Base — Provides recurrent sweeps which may be varied in frequency from 15 to 30,000 cycles per second. Linearity of sweep within 5% at 15 cycles. Sweep direction, left to right. Synchronization from vertical signal, 0.2 inches vertical deflection; from external signal, 0.5 volt peak amplitude; or power-line frequency voltage internally obtained.

Intensity Modulation—15 volts peak amplitude provides satisfactory modulation. Positive input increases intensity; negative signal decreases. Frequency response uniform within 30% from 30 cycles to 3 megacycles per second.

Power Source—Type 224-A is designed to operate from a power-line of 115 rms volts and frequency of 50-60 cycles. Power consumption, 150 watts; fuse protection, 3 amperes.

Physical Characteristics — Instrument housed in metal cabinet provided with carrying handle and protective front cover. Overall dimensions, 14¼" (height) x 8-3/8" (width) x 15-1/8" (depth). Weight, 49 lbs.

Catalog No.	Type No.	Description	Code Word
1191	224-A	Cathode-ray Oscillograph for 115 volt, 50-60 cycles; with Type 3GP1A Cathode-ray Tube	YAIRL
1203	224-A	Same as above, with Type 3GP11A Cathode-ray Tube........	YALCA

TYPE 241
CATHODE-RAY OSCILLOGRAPH

- Vertical amplifier frequency response uniform within 30% from 20 cycles per second to 2 megacycles per second; within 50% to 4 megacycles per second
- Shielded, low-capacitance probe input to vertical amplifier
- Intensity modulation amplifier; beam blanking from either polarity of signal
- Variety of input signal combinations

FUNCTION

The Type 241 Cathode-ray Oscillograph, like the Type 224-A, is specifically intended for investigation of pulses and signals which contain high-frequency components. The important difference between the two instruments is that the Type 241 employs a 5-inch cathode-ray tube and an intensity modulation amplifier, by means of which accurately-spaced timing markers may be impressed upon the pattern or trace.

DESCRIPTION

Cathode-ray Tube

A Type 5JP-A Cathode-ray Tube is used in the Type 241. Accelerating potential of 1500 volts is divided, with about 1100 volts applied between cathode and second anode, and 400 volts between second anode and intensifier. All four deflection plates are free for direct deflection.

Vertical Deflection

Potentials to be investigated may be applied to the vertical deflection plates (1) through a terminal which is capacitively connected to the vertical amplifier, or (2) through a probe and co-axial lead which is connected to the vertical amplifier, or (3) through a pair of terminals, one of which is directly connected to one deflection plate, and one of which is capacitively connected to the other deflection plate. Either balanced or unbalanced signals may be connected to these terminals. Signals which do not require amplification, or which contain frequency components outside the response limits of the amplifier, may be connected to the deflection plates. Sinusoidal frequency response of the amplifier is uniform with 30% from 20 cycles per second to 2 megacycles per second at any attenuator setting; it is uniform within 50% to 4 megacycles per second.

The input probe provides a shielded input to the amplifier as well as a low-capacitance input which imposes negligible load upon high-frequency signals. It introduces an attenuation of 10:1 in the signal amplitude.

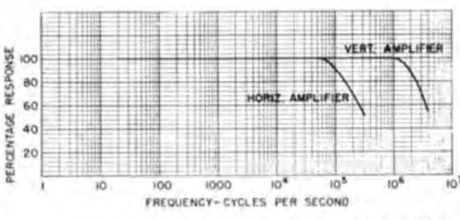


Figure 1. Frequency-response characteristic of the Type 241

Horizontal Deflection

External signals may be applied to the horizontal deflection plates (1) through a terminal which is capacitively connected to the horizontal amplifier or (2) through a pair of terminals, one of which is directly connected to one deflection plate, and one of which is capacitively connected to the other deflection plate. Either balanced or unbalanced signals may be connected to these terminals and an adjacent ground terminal. Signals which do not require amplification, or which contain frequency components outside the response limits of the amplifier, may be connected to the deflection plates. Sinusoidal frequency response of the amplifier is uniform within 30% from 5 to 100,000 cycles per second at any attenuator setting; it is uniform within 50% to 300,000 cycles per second.

Output from the linear time-base may be connected to produce horizontal deflection.

Linear Time-Base

The time-base generator furnishes a recurrent sawtooth voltage. It produces a sweep from left to right on the cathode-ray tube screen. The return-trace of the sweep may be blanked out so that it is not visible on the screen.

Synchronization of the Time-Base

The frequency of the time-base generator may be synchronized (1) from the vertical deflection signal, (2) from an externally connected signal, or (3) from a signal at power-line frequency. Either polarity of signal will synchronize the time-base.

Positioning

The pattern on the cathode-ray tube may be moved to any portion of the screen by means of controls on the front panel. Five inches of positioning are available both vertically and horizontally. These controls are effective even when direct signal connection is made to the deflection plates, provided capacitive or high-impedance coupling is used.

Test Signal Output

A sine-wave voltage at power line frequency and about 5 rms volts amplitude is available at a terminal on the front panel. It may be used as a test signal for trouble-shooting applications.

Intensity Modulation

An external signal may be connected through an amplifier to modulate the intensity of the pattern. Either polarity of signal may be used to increase or decrease intensity.

SPECIFICATIONS

Cathode-ray Tube—Type 5JP-A, cathode-ray tube with four free deflection plates. Accelerating potential, 1500 volts. Deflection plates at ground potential.

Vertical Deflection—Deflection Factor not more than 0.07 rms volt/inch with amplifier at full gain; 0.7 rms volt/inch through input probe and amplifier at full gain; 22 rms volts/inch ±20% with direct connection to deflection plates. Undistorted deflection through amplifier, more than full screen. Sinusoidal frequency response of amplifier uniform within 30% from 20 cycles per second to 2 megacycles per second; uniform within 50% to 4 megacycles per second. Input impedance to amplifier, 2 megohms parallelled by 40 μμf.; to probe, 1 megohm parallelled by 10 μμf.; to deflection plate terminals, 5 megohms parallelled by 20 μμf. (balanced input) and 5 megohms parallelled by 25 μμf. (unbalanced input).

Horizontal Deflection—Deflection Factor not more than 0.7 rms volt/inch with amplifier at full gain; 21 rms volts/inch ±20% with direct connection to deflection plates. Undistorted deflection through amplifier, more than full screen. Sinusoidal frequency response of amplifier uniform within 30% from 50 to 100,000 cycles per second; uniform within 50% to 300,000 cycles per second. Input impedance to amplifier, 2 megohms parallelled by 40 μμf; to deflection plate terminals, 5 megohms parallelled by 20 μμf (balanced input), and 5 megohms parallelled by 25 μμf. (unbalanced input).

Linear Time-Base — Provides recurrent sweeps. Sweep frequency variable from 15 to 30,000 cycles per second. Direction of sweep, left to right. Right-to-left return trace blanked out if desired. Synchronization from vertical deflection signal, power-line frequency voltage, or externally connected signal of 0.5 volt peak amplitude and either polarity.

Intensity Modulation—0.7 volts peak provides satisfactory modulation. Either polarity will brighten or blank beam.

Power Source—Type 241 is designed for operation from a power line of 115 volts at frequencies between 50 and 60 cycles. Power consumption, 160 watts; fuse protection 3 amperes.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle and protective front cover. Overall dimensions, 17-1/2" (height) x 10-3/4" (width) x 21" (depth). Weight, 65 lbs.

Catalog No.	Type No.	Description	Code Word
1192	241	Cathode-ray Oscillograph, 115 volts, 50-60 cycles; with 5JP1A Cathode-ray Tube	YAJAZ
1204	241	Same as above, with 5JP7A Cathode-ray Tube	YALDE
1205	241	Same as above, with 5JP11A Cathode-ray Tube	YALED

TYPE 248
CATHODE-RAY OSCILLOGRAPH

- Vertical amplifier frequency response uniform within 30% from 20 cycles per second to 5 megacycles per second; amplifier useful to 10 megacycles per second
- Timing oscillator to permit accurate measurement of time intervals
- Pulse output for synchroscope applications
- Selection of accelerating potential to provide either maximum intensity or deflection sensitivity
- High-vacuum sweep circuit to provide wide range of recurrent and high-speed driven sweeps
- Delay network in vertical amplifier to permit observation of entire short duration phenomena

FUNCTION

The Type 248 Cathode-ray Oscillograph is specifically designed for investigation of pulses which contain high frequency components and which may be of either recurrent or transient nature. It provides high-frequency recurrent sweeps and short duration driven sweeps, a timing oscillator which produces accurate markers on the sweeps, and a delay network to permit initiation of the driven sweep before the investigated pulse is plotted on the screen. This last feature is invaluable for the observation of extremely short pulses without losing the initial detail. Sufficient light output is available from the cathode-ray tube screen to permit observation of phenomena which have short durations and low repetition rates. The Type 248 is capable of performance ordinarily obtained with more costly, specialized oscillographic equipment, and it is also a general-purpose instrument for use in the laboratory.

A modification of the Type 248, known as Type 248-A, is available either from the factory or by conversion of an instrument which is already in the customer's possession.

DESCRIPTION

Cathode-ray Tube

Type 248 utilizes a Type 5JP-A Cathode-ray Tube. Accelerating potential is evenly divided between second anode and intensifier electrodes. Selection of either 2000 or 4000 volts overall accelerating potential may be made by means of a switch on the front panel. The lower voltage is used where deflection sensitivity is of importance and high intensity is not necessary; the higher voltage is used whenever intensity or light output from the cathode-ray tube screen is of primary concern.

A magnetic shield protects the cathode-ray tube from the effects of external magnetic fields, and a retractable light shield is provided to aid in the observation of traces on the cathode-ray tube screen.

Vertical Deflection

Signals may be applied to the vertical deflection plates (1) through a terminal which is capacitively connected to the vertical amplifier, (2) through a probe and co-axial lead which is connected to the amplifier, or (3) through a pair of terminals which are capacitively connected to the deflection plates. Those potentials which do not require amplification, or which contain frequency components beyond the response limits of the vertical amplifier are ordinarily connected to these last-mentioned terminals. They may be either balanced or unbalanced signals.

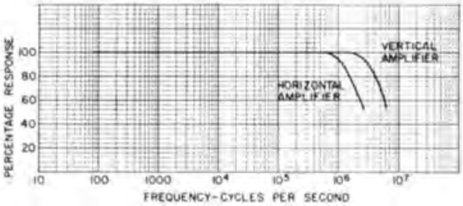


Figure 1. Frequency-response characteristic of the Type 248

The sinusoidal frequency response characteristic of the vertical amplifier is uniform within 30% from 20 cycles per second to 5 megacycles per second at any attenuator position. High-frequency compensation is such that a square-wave having a rise time as fast as 0.1 microsecond will not produce oscillation in the amplifier.

A delay network may be inserted in the vertical amplifier. It causes the vertical deflection signal to be delayed by 0.5 microsecond before it reaches the deflection plates. Since this is sufficient time to initiate the driven sweep circuits, the sweep is started in advance of the time when vertical deflection begins, and initial detail of the deflection signal is visible on the screen. If the delay circuit were not inserted, vertical deflection might occur before the sweep began, and important detail would be lost from the initial portion of the deflection signal. In cases where the deflection signal is a short duration pulse with a very fast rise time, this could mean that most of the pulse would not be visible on the screen at all.

The probe and co-axial lead provide a shielded input to the vertical amplifier. Input capacitance is low, and loading of high-frequency signals is negligible. The probe clips are insulated to protect the user in making connections to points of high potential.

Horizontal Deflection

External signals may be applied to the horizontal deflection plates (1) through a terminal which is capacitively connected to the horizontal amplifier, or (2) through a pair of terminals which are capacitively connected to the deflection plates. Those signals which do not require amplification; or which contain frequency components outside the response limits of the amplifier may be connected to these last-mentioned terminals. They may be either balanced or unbalanced signals. The sinusoidal frequency response of the horizontal amplifier is uniform within 30% from 20 cycles per second to 2 megacycles per second at any attenuator setting.

Output from the linear time-base generator may be connected by means of a switch to produce horizontal deflection.

Linear Time-Base

The high vacuum time-base generator in the Type 248 provides either recurrent or driven sweeps. When it is running under recurrent conditions, frequency of the generated sawtooth voltage may be varied from 15 to 150,000 cycles per second. It may be synchronized from (1) the vertical deflection signal, (2) from a line-frequency voltage, or (3) from an externally connected signal. An attenuator permits external synchronizing signal inputs as high as 200 volts. Direction of the sweep will be from left to right on the cathode-ray tube screen; the sweep will be at least 3 inches long even when the tube is operated with 4000 volts accelerating potential.

The time-base generator is adjusted for driven sweep operation by means of a switch. A single sawtooth cycle is generated upon initiation by a signal which may or may not be repetitive, and which does not necessarily have a constant repetition rate. Sweep durations of 5, 25, 100, or 1000 microseconds may be selected. Sweeps may be initiated at any rate up to the frequency corresponding to the sweep duration.

Figure 2. A sharp pulse displayed on the 5 microsecond sweep with no delay in vertical amplifier

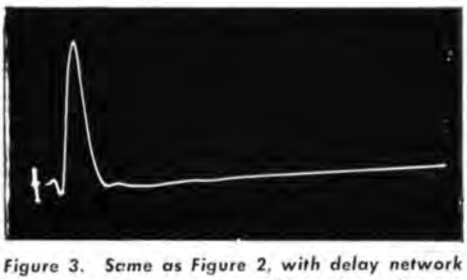


Figure 3. Same as Figure 2, with delay network inserted in vertical amplifier. Note that entire pulse is now visible, whereas without the delay network it had occurred before the sweep could get started

Figure 4. Internal timing oscillator of the Type 248 being used to provide blanked-out markers 10 microseconds apart on a square-wave signal

Intensity Modulation

The Intensity Modulation Amplifier may be used in conjunction with (1) an external signal or (2) the Timing Oscillator described below to modulate the beam intensity. Either polarity of signal will brighten or blank the beam.

A separate Beam Control circuit blanks out the return trace on recurrent sweeps, and also blanks the beam on driven sweeps except during actual sweep duration.

Timing Oscillator

An oscillator and pulse shaping circuit furnish accurate pulses at intervals of either 1, 10, or 100 microseconds. These pulses may be applied to the grid of the cathode-ray tube to produce blanked-out time marks on the trace. Time intervals along the trace may be measured with the aid of these marks. The oscillator is keyed on by initiation of the driven sweep circuit, and is turned off at the end of the sweep.

Pulse Output

The Type 248 may be used as a synchroscope since it contains a pulse generator which furnishes output pulses of both polarities. Repetition rate of these pulses is variable from 200 to 3,000 per second. An external circuit may be initiated by the pulse output, and a phenomenon produced by that circuit applied to the deflection plates of the Type 248 for observation. At the same time, the driven sweep in the Type 248 may be initiated either by the output pulse or by the phenomenon itself.

Positioning

The trace on the screen of the cathode-ray tube may be moved to any portion of the screen by means of controls on the front panel. These controls are effective regardless of connections which may be made to the deflection plate terminals. At least two inches of positioning are available both vertically and horizontally.

Test Signal Outputs

A sinusoidal voltage of power-line frequency and 3.2 rms volts amplitude at 60 cycles is available at a terminal on the front panel. It is useful as a test signal for many trouble-shooting applications.

A sawtooth voltage at sweep frequency and 75 peak-to-peak volts amplitude is available at another terminal. This is also useful as a test signal, or it may be used to produce a time-base on another oscillograph which is positively synchronized with that of the Type 248.

SPECIFICATIONS

Cathode-ray Tube — Type 5JP-A tube with four free deflection plates. Accelerating potential of either 2000 or 4000 volts.

Vertical Deflection (with 4000 volts accelerating potential)—Deflection Factor not more than 0.1 rms volt/inch with amplifier at full gain; 2 rms volts/inch through probe with amplifier at full gain; 32 rms volts/inch ±20% at deflection plate terminals. Undistorted deflection through amplifier, 3 inches. Sinusoidal frequency response of amplifier uniform within 30% from 20 cycles per second to 5 megacycles per second. Input impedance: to amplifier, 1 megohm paralleled by 40 μμf.; through probe, 5 megohms paralleled by 10 μμf.; to deflection plate terminals, 9.4 megohms paralleled by 15 μμf. (balanced), and 4.7 megohms paralleled by 25 μμf. (unbalanced).

Horizontal Deflection (with 4000 volts accelerating potential)—Deflection Factor not more than 2.75 rms volts/inch with amplifier at full gain; 37 rms volts/inch ±20% at deflection plate terminals. Undistorted deflection through amplifier, 3 inches. Sinusoidal frequency response of amplifier uniform within 30% from 20 cycles per second to 2 megacycles per second. Input impedance: to amplifier, 1 megohm paralleled by 60 μμf.; to deflection plate terminals, 9.4 megohms paralleled by 15 μμf. (balanced), and 4.7 megohms paralleled by 25 μμf. (unbalanced).

Linear Time-Base — Recurrent sweeps variable in frequency from 15 to 150,000 cycles per second. Linearity within 20% at 15 cycles. Driven sweeps of 5, 25, 100, 1000 microseconds duration. Recurrent sweeps synchronize from repetitive signal of either polarity having frequency between 15 cps and 3 megacycles per second, peak amplitude of 1 volt, duration of peak at least 0.1 microsecond. Driven sweeps initiated by signal of 1.5 volts peak amplitude of either polarity, with repetition rate up to 200,000 cycles per second, duration of initiating peaks at least 0.1 microsecond.

Intensity Modulation—External signal of either polarity blanks or brightens beam. Satisfactory modulation with 3 volts peak input between frequencies of 30 cps and 5 megacycles per second. Input impedance to amplifier, 1 megohm paralleled by 30 $\mu\mu$f.

Timing Oscillator—Blanked time-marks on trace at intervals of 1, 10, or 100 microseconds; accuracy, ±5%. Operative only with driven sweeps.

Pulse Generator—Output pulse of 100 volts peak amplitude, 0.5 microsecond duration. Repetition rate from 200 to 3000 pulses per second; both polarities available. Output impedance, 500 ohms.

Power Source—The Type 248 is designed to operate from a 115-volt power line at frequencies between 50 and 400 cycles per second. Power consumption, 550 watts; fuse protection, 10 amperes.

Physical Characteristics—The Type 248 is housed in two metal cabinets, each one provided with carrying handles. Overall dimensions of the Indicator unit: 15-3/4" (high) x 12-3/4" (wide) x 21-1/4" (deep); Power Supply: 15-3/4" (high) x 12-3/4" (wide) x 19-3/4" (deep). Weights of the two units are respectively 71 and 126 lbs.

Catalog No.	Type No.	Description	Code Word
1199	248	Cathode-ray Oscillograph for 115 volts, 50-400 cycles; with 5JP1A Cathode-ray Tube	YAJZA
1200	248	Same as above, with 5JP11A Cathode-ray Tube	YAKAB
1201	248	Same as above, with 5JP7A Cathode-ray Tube	YAKBA

TYPE 248-A CATHODE-RAY OSCILLOGRAPH

The Type 248-A is a modified version of the Type 248 Cathode-ray Oscillograph. It accommodates a 5RP-A Cathode-ray Tube and has provision for connection of an external high-voltage supply to furnish intensifier potential. The accelerating potential which may be used with the Type 248-A (up to 20,000 volts) increases the light output from the tube so that fast writing rates and short pulses with very low repetition rates can be observed and photographed. With an accelerating potential of 12,000 volts (which may be furnished using the Du Mont Type 263-A High-voltage Supply), oscillograms plotted with the fluorescent spot moving at a speed of 1.6 inches per microsecond may be photographed using an f/3.5 lens and an image reduction of 4.5 to 1. Using an f/1 lens and the same image reduction, speeds of 19 inches per microsecond can be photographed. A pulse having a one microsecond duration with a repetition rate of only 60 cycles per second can easily be observed. The Type 248-A can also be used as a projection oscillograph (by attaching the Type 2088 Projection Lens). The pattern on the screen of the tube is greatly enlarged when projected in this manner; it is therefore useful for lecture and demonstration purposes.

The Type 248-A will perform all the functions of the Type 248 in addition to the specialized ones mentioned. It will be identical to the Type 248 with the exception of (1) deflection factors and (2) the undistorted deflection available from the amplifiers. Deflection Factors depend upon the accelerating potential used on the cathode-ray tube. They will vary in a manner such as illustrated by Figure 4, page 64. Undistorted deflection will vary in an inverse manner.

Anyone who has a Type 248 instrument which he wishes to revise into a Type 248-A should contact the Instrument Division, Instrument Service Department for details. The Type 263-A High-voltage Power Supply is not a part of this revision and its cost is therefore not included.

Catalog No.	Type No.	Description	Code Word
1244	248-A	Cathode-ray Oscillograph for 115 volts, 50-400 cycles; with 5RP2A Cathode-ray Tube	YALBT
1247	248-A	Same as above; with 5RP11A Cathode-ray Tube	YALBW

TYPE 250
CATHODE-RAY OSCILLOGRAPH

- Provision for amplification of d-c and a-c signals
- Sensitive vertical deflection amplifier
- Internal calibrator for signal amplitude and deflection sensitivity measurements
- Recurrent and driven sweeps with wide range of frequencies and durations available
- Automatic beam intensity control on all driven sweeps
- Input probe for vertical amplifier
- Connection to deflection plates from front panel

FUNCTION

The Type 250 Cathode-ray Oscillograph is specifically designed to facilitate investigation and photographic recording of recurrent and transient phenomena. It has provision for amplification of potentials which contain d-c components, as well as those which contain a-c components. The linear time-base is unusually flexible in operation; automatic control of beam intensity, when driven sweep is used, prevents exposure of film except during actual sweep duration and facilitates visual observation.

A modification of the Type 250, known as the Type 250-H, is also available.

DESCRIPTION

Cathode-ray Tube

The Type 5CP-A Cathode-ray Tube is incorporated in Type 250. Overall accelerating potential of 3,000 volts is evenly divided, cathode-to-second anode, and second anode-to-intensifier.

Vertical Deflection

Signals may be applied to the vertical deflection plates (1) through a capacitively-coupled amplifier, (2) a direct-coupled amplifier, or (3) through a pair of terminals which are capacitively connected to the plates. Either balanced or unbalanced signals may be connected to these latter terminals. Signals which do not require amplification or which contain frequency components beyond the response limits of the amplifiers may be connected to the terminals. Sinusoidal response of the capacitively-coupled amplifier is uniform within 10% from 5 to 200,000 cycles per second and within 60% to 500,000 cycles per second. Response of the direct-coupled amplifier is uniform within 10% from d-c (zero frequency) to 200,000 cycles per second.

A probe and co-axial lead may be connected to the amplifier in order to provide a low-capacitance, shielded input. It imposes minimum loading upon high-frequency signals and prevents pickup which might occur in connecting leads. Probe clips are insulated so that it may be safely connected to points of high potential.

Calibrator

A voltage calibrator is incorporated in the Type 250. It is useful for (1) measuring the amplitude of an applied potential, or (2) measuring the deflection factor of the oscillograph at any particular setting of the signal attenuator controls. A switch permits connection of either the calibrator or an external signal to the vertical amplifier without disconnecting any leads.

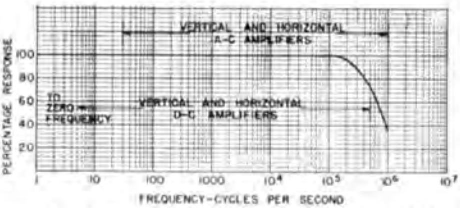


Figure 1. Frequency-response characteristic of the Type 250

Horizontal Deflection

External signals may be applied to the horizontal deflection plates (1) through a capacitively-coupled amplifier, (2) a direct-coupled amplifier; or (3) a pair of terminals which are capacitively connected to the plates. Either balanced or unbalanced potentials may be connected to these latter terminals. Sinusoidal frequency response characteristics of the capacitively-coupled and the direct-coupled amplifiers are identical to those in the Vertical Deflection circuits.

The output of the linear time-base generator may be connected by means of a switch to provide horizontal deflection which is proportional to time.

Linear Time-Base

The high vacuum linear time-base generator provides either recurrent or driven sweeps. Frequency of the recurrent sweeps is variable from 1 to 150,000 cycles per second; duration of the driven sweeps is variable from 1 second to 20 microseconds. Direction of the sweep on the cathode-ray tube screen is from left to right.

Synchronization of the Time-Base

The time-base generator may be synchronized on recurrent operation from (1) the vertical deflection signal, (2) a power-line frequency, or (3) an externally connected potential. Either polarity of signal may be used for synchronization.

The driven sweep may be initiated from (1) the vertical deflection signal or (2) an externally connected potential. Either polarity of signal may be used for initiation. The driven sweeps may be initiated at rates up to the frequency which corresponds to the sweep duration.

Automatic Beam Control

Intensity of the fluorescent spot is automatically reduced to zero when the sweep is changed to driven operation. Only during the actual duration of the sweep is the spot visible on the screen. If a camera is used to record the trace, the shutter may be opened before and after its occurrence without causing exposure of the film.

Intensity Modulation

An external signal may be connected to provide modulation of beam intensity. Timing marks may thereby be impressed upon the fluorescent trace, or certain portions of the trace may be brightened to facilitate observation of interesting details.

Positioning

A pattern or trace may be moved to any portion of the cathode-ray tube screen by means of controls on the front panel. At least 10 inches of positioning are available both vertically and horizontally.

Signal Outputs

A sinusoidal voltage at power-line frequency and 1 rms volt amplitude is available at a terminal on the front panel. It is useful as a test signal for trouble-shooting work.

A sawtooth voltage from the time-base generator is available at another terminal. It may also be used as a test signal, or it may be used to provide a time-base for another oscillograph.

SPECIFICATIONS

Cathode-Ray Tube—Type 5CP-A Cathode-ray Tube with four free deflection plates. Accelerating potential, 3000 volts.

Vertical Deflection—Deflection Factor not more than 15 rms millivolts/inch through a-c amplifier at full gain; 150 rms millivolts/inch through probe and amplifier; not more than 2 d-c volts/inch through d-c amplifier at full gain; 21 rms volts/inch ±20% direct to plates. Sinusoidal frequency response of a-c amplifier uniform within 10% from 5 to 200,000 cycles per second and within 60% to 500,000 cycles. Response of d-c amplifier uniform within 10% from 0 to 200,000 cycles per second. Undistorted deflection through either amplifier, 5 inches. Input impedance to amplifier, 2 megohms paralleled by 50 $\mu\mu$f; through probe, 4.7 megohms paralleled by 10 $\mu\mu$f.; direct to plates, 4 megohms paralleled by 20 $\mu\mu$f. (balanced connection); 2 megohms paralleled by 40 $\mu\mu$f. (unbalanced connection).

Calibrator—Furnishes square-wave amplitudes of 0.01, 0.1, 1, 10, or 100 volts peak-to-peak. Accuracy ±5%. Connected to vertical amplifier by means of a switch.

Horizontal Deflection—Deflection Factor not more than 0.7 rms volt/inch through a-c amplifier at full gain; not more than

2 d-c volts/inch through d-c amplifier at full gain; 23 rms volts/inch ±20% direct to plates. Sinusoidal frequency response of a-c amplifier within 10% from 5 to 200,000 cycles per second, and within 60% to 500,000 cycles. Response of d-c amplifier uniform within 10% from 0 to 200,000 cycles per second. Undistorted deflection through either amplifier, 5 inches. Input impedance to amplifier, 2 megohms paralleled by 40 μμf.; direct to plate 4 megohms paralleled by 20 μμf. (balanced connection); 2 megohms paralleled by 40 μμf. (unbalanced connection).

Linear Time-Base—Recurrent sweeps variable from 1 to 150,000 cycles per second. Linearity within 10% at 15 cycles. Direction of sweep from left to right. Synchronization from vertical deflection signal, power-line frequency voltage, or external signal of 0.005 rms volts amplitude.

Driven sweeps with durations variable from 1 second to 20 microseconds. Initiation from vertical signal or external signal of 0.25 volts amplitude.

Either polarity of signals will synchronize or initiate the sweeps.

Intensity Modulation—Input impedance to external signal, 47,000 ohms paralleled by 30 μμf. Amplitude of 3 volts peak provides visible modulation at medium or low intensity setting. Positive polarity decreases intensity of beam; negative polarity increases intensity.

Power Source—The Type 250 may be operated from a 50-60 cycle power line at either 115 or 230 volts. Voltage changeover switch is accessible from outside of instrument. Power consumption, 200 watts, fuse protection, 2 amperes.

Physical Characteristics—Instrument is housed in a metal cabinet provided with carrying handles. Overall dimensions, 15" (height) x 11" (width) x 19" (depth). Weight, 68 lbs.

Catalog No.	Type No.	Description	Code Word
1303	250	Cathode-ray Oscillograph, for 115 volts, 50-60 cycles; with 5CP1A Cathode-ray Tube	YALED
1304	250	Same as above; with 5CP2A Cathode-ray Tube	YALEE
1306	250	Same as above; with 5CP7A Cathode-ray Tube	YALEG
1307	250	Same as above; with 5CP11A Cathode-ray Tube	YALEH
1308	250	Cathode-ray Oscillograph, for 230 volts, 50-60 cycles; with 5CP1A Cathode-ray Tube	YALEJ
1309	250	Same as above; with 5CP2A Cathode-ray Tube	YALEK
1311	250	Same as above; with 5CP7A Cathode-ray Tube	YALEM
1312	250	Same as above; with 5CP11A Cathode-ray Tube	YALEN

TYPE 250-H CATHODE-RAY OSCILLOGRAPH

The Type 250-H is a modified version of the Type 250 Cathode-ray Oscillograph. It accommodates the Type 5RP-A Cathode-ray Tube and has provision for connection of an external high-voltage supply to furnish intensifier voltage. The higher accelerating potentials which may be used (up to approx. 15,000 volts) increase the light output from the screen of the tube so that much faster writing rates can be observed and photographed. Writing speeds can be photographed from the Type 250-H (using the Du Mont Type 263-A as an intensifier supply) which are about 10 times those which can be recorded from the Type 250 alone. Light output is also sufficient to permit use of the Type 250-H as a projection oscillograph for lecture and demonstration to large groups. For projection purposes, the Type 2088 Projection Lens may be readily attached in front of the Type 5RP-A Cathode-ray Tube.

Deflection Factors for the Type 250-H are somewhat higher than in the Type 250, depending upon the accelerating potential which is used. However, the deflection factor of the Type 5RP-A with 12,000 volts accelerating potential is only about 30% greater than the deflection factor of the Type 5CP-A Cathode-ray Tube in the Type 250 which is operated with 3000 volts.

The Type 250-H is available on order from the factory, or by modification of a Type 250 Oscillograph which is already in a customer's possession. The procedure to obtain the modification is the same as outlined for the Type 248-A, page 39.

Catalog No.	Type No.	Description	Code Word
1314	250-H	Cathode-ray Oscillograph, with Type 5RP2A Cathode-ray Tube; for operation from 115 volts, 50-60 cycles	YALEP
1316	250-H	Same as above, with Type 5RP7A Cathode-ray Tube	YALER
1317	250-H	Same as above, with Type 5RP11A Cathode-ray Tube	YALES
1319	250-H	Cathode-ray Oscillograph, with Type 5RP2A Cathode-ray Tube; for operation from 230 volts, 50-60 cycles	YALEU
1321	250-H	Same as above, with Type 5RP7A Cathode-ray Tube	YALEW
1322	250-H	Same as above, with Type 5RP11A Cathode-ray Tube	YALEX

TYPE 256-D

CATHODE-RAY OSCILLOGRAPH

- Frequency response of vertical deflection amplifier uniform within 30% to 8 megacycles per second
- Undelayed or delayed, expanded sweeps
- Delay of sweeps read directly on calibrated dial with accuracy of 0.1 per cent
- Trigger generator with variable repetition rate
- Crystal-controlled marker generator
- Trigger and timing-marker outputs
- Movable marker output

FUNCTION

The Du Mont Type 256-D Cathode-ray Oscillograph is a precision instrument specifically designed for the study of short-duration pulses, and measurement of time intervals down to a fraction of one microsecond. It is invaluable as an auxiliary unit for existing radar systems where it may be used to increase accuracy of ranging, extend the range of usefulness, provide accurate time-markers, and expanded, delayed, or undelayed sweeps, or act as a precision test instrument and calibrator.

The Type 256-D is also an exceptionally fine general-purpose test oscillograph because of its variety of sweep lengths, precision delay circuits, crystal-controlled markers, variable trigger generator, and wide-band video amplifier. Accuracy of the sweep delay is assured by circuit design, and the instrument may readily be calibrated using its own internal markers without need for auxiliary apparatus.

DESCRIPTION

Cathode-ray Tube

The Type 5CP-A Cathode-ray Tube is used in the Type 256-D. Accelerating potential is equally divided between second anode and intensifier electrodes. Focus and Auxiliary Focus controls permit adjustment for a fine, clear trace at any point on the screen.

Sweeps

Two types of sweeps are available on the Type 256-D. (1) An "A" Sweep which is defined as that which starts simultaneously with an initiating trigger. (2) An "R" Sweep which is defined as an expanded and delayed portion of an "A" Sweep.

"A" Sweeps of 4, 10, 25, 100, 1000, or 4500 microseconds duration are available; "R" Sweeps of 4, 10, or 25 microseconds may be selected. By means of sweep controls, the 100 microsecond "A" Sweep, or any 4, 10 or 25 microsecond portion of it may be displayed on the cathode-ray tube screen. The 1000 microsecond "A" Sweep, or any 10 or 25 microsecond portion of it may be displayed instead.

The "R" Sweeps may be locked to the initiating trigger so that they are no longer delayed. These undelayed sweeps are in reality short-duration "A" Sweeps. The 0-4 microsecond portion of the 100 or 1000 microsecond

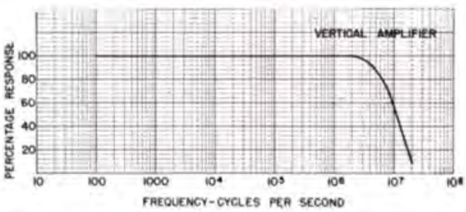


Figure 1. Frequency-response characteristic of the Type 256-D

"A" Sweeps, which are not available as "R" Sweeps, may thus be displayed.

The start of any "R" Sweep may be read directly on a calibrated dial to an accuracy of ±0.1% of the "A" Sweep duration. This means an accuracy of ±0.1 microsecond for any of the "R" Sweeps on the 100 microsecond "A" Sweep between 4 and 100 microseconds and accuracy of ±1 microsecond for the "R" Sweeps on the 1000 microsecond "A" Sweep between 5 and 1000 microseconds.

Figure 2. Oscillogram taken from the Type 256-D showing a square pulse of 1 microsecond duration after it has passed through the vertical amplifier. Note the reproduction of the extremely fast rise and fall of the pulse

Trigger Circuits

The sweeps may be triggered or initiated either from an external signal of positive or negative polarity, or from an internal Trigger Generator. Repetition rate of the internally generated trigger is variable from 80 to 2000 per second when the 100 microsecond "A" Scale is used, and from 80 to 400 per second when either the 1000 or 4500 microsecond "A" Scales are used.

Trigger output pulses of positive and negative polarities at 100 volts amplitude are available at front panel terminals whether or not internal triggering is used. When external trigger is used, repetition rate of the output triggers is the same as that of the external signal.

Markers

Timing markers are available only when the internal Trigger Generator is used. They appear on the screen of the cathode-ray tube as intensity-modulated marks, but they are also available at a terminal for use with associated equipment. Provision is made so that, when external markers are not required, intensity modulation signals may be applied to this same terminal.

It is possible to select either polarity for the markers, and also to select marker intervals of 10 or 50 microseconds. Markers are crystal-controlled, have an extremely fast rise-time, and are generated by a low impedance source.

A Movable Marker of fixed duration shows the exact portion of the 100 or 1000 micro-

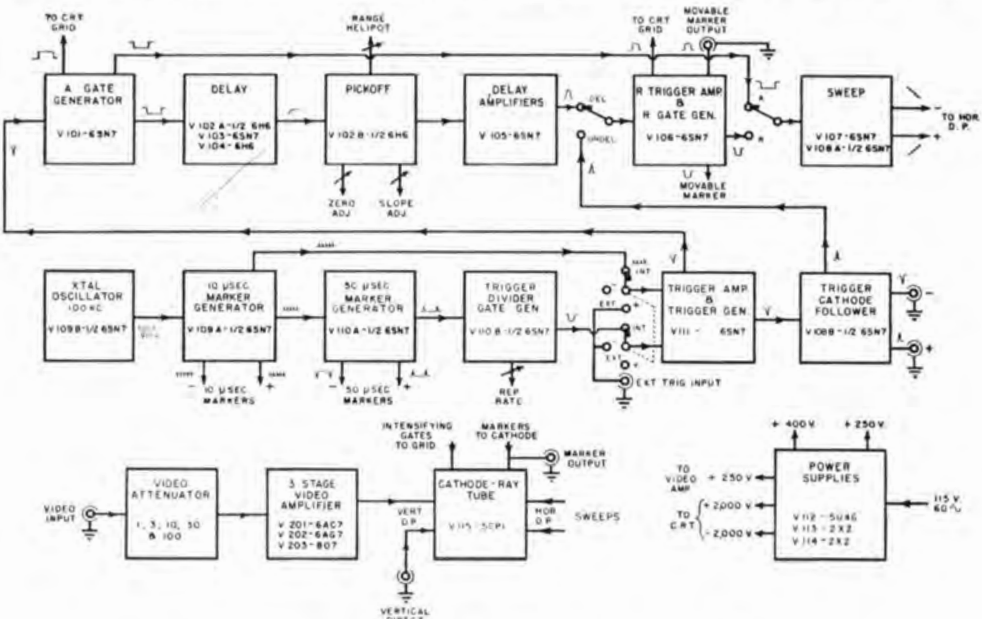


Figure 3. Block diagram of the Type 256-D Cathode-ray Oscillograph

second "A" Sweeps which will be expanded by the "R" Sweeps. The movable marker is available at all times at an output terminal. It may also be used with associated equipment to indicate which portion of their signal is being displayed on the Type 256-D.

Vertical Deflection

An incoming signal may be connected either directly to a vertical deflection plate or through a video amplifier which has a sinusoidal frequency response down only 30% at 8 megacycles per second, and 50% at 11 megacycles per second. A compensated attenuator provides reduction of 1:1, 3:1, 10:1, 30:1, or 100:1 in amplitude of the signal before it is passed through the amplifier.

Measurement of Signal Amplitudes

When a signal is connected directly to the deflection plates, the peak amplitude of that signal may be directly measured by making use of two calibration jacks on the panel of the Type 256-D. A voltmeter is connected to these jacks, and the vertical positioning control is used to move the trace vertically an amount equal to the amplitude of the signal being observed. Peak-to-peak amplitude is read from the voltmeter.

SPECIFICATIONS

Cathode-ray Tube—Type 5CP-A tube operated with total accelerating potential of 4000 volts. Unbalanced vertical deflection.

"A" Sweeps—"A" Sweep durations of 4500, 1000, 100, 25, 10, and 4 microseconds available. The 4500 μs sweep used for observing entire duty cycle operation at repetition rates above 300 per second.

"R" Sweeps—Sweep durations of 25, 10, or 4 μs. Will expand any portion of 100 μs "A" Sweep except first 4 μs. 25 or 10 μs sweeps will expand any portion of 1000 μs "A" Sweep except first 5 μs. Delay read directly on calibrated dial; accuracy, ±0.1% of full scale.

Internally Triggered Operation—Output triggers of 100 volts peak amplitude; positive or negative polarities. Trigger rise time, 0.3 μs; duration, 1.0 μs. Repetition rate variable 80-400 pulses per second on 1000 and 4500 μs "A" Sweeps; 80-2000 per second on 100 μs "A" Sweeps. Crystal-controlled timing-markers indicating intervals of 10 μs or 50 μs; either polarity available. First 50 μs marker appears 40 μs after the trigger; each subsequent one, 50 μs later. Rise time of markers, 0.25 μs; duration, 1.0 μs. Accuracy of markers, ±0.02%.

Externally Triggered Operation—Input trigger of either polarity and 15 volts peak amplitude required. Rise time at least 100 volts/μs for accurate triggering. Trigger amplifier permits operation regardless of trigger waveform. Rise time as slow as 10 volts/μs will trigger sweep, but recalibration of instrument is necessary. Repetition rate of external trigger, 0-2000 pulses per second when 100 μs "A" Sweep is used; 0-400 per second when 1000 μs "A" sweep is used. Timing markers not available.

Intensity Modulation — External signal may be connected to modulate intensity of cathode-ray beam if marker selector switch is set at position to provide for this.

Vertical Deflection — Deflection Factor direct to deflection plate, 79 d-c volts/inch ±20% through video amplifier at full gain, not more than 0.33 rms volts/inch. Positive signal produces upward deflection on screen of cathode-ray tube. Maximum input potential, 600 volts (d-c plus peak signal). Undistorted deflection, at least 3.5 inches. Input impedance to amplifier, 1 megohm paralleled by 20 μμf. Sinusoidal frequency response is down not more than 30% at 8 megacycles per second; no more than 50% at 11 megacycles per second. Pulse response as follows: The sum of rise and fall times of a 1 μs pulse, with rise and fall time of 0.01 μs, does not exceed 0.08 μs when pulse is passed through video amplifier. A 1000 μs pulse does not change vertical position of base line after the pulse by more than 10% of pulse height. Amplifier will not overload on signal less than 1 volt peak amplitude with attenuation ratio of 1:1.

Power Source—Type 256-D is designed to operate from a 115 volt, 50-60 cycle power line. Higher power-line frequency may be used but accuracy of instrument may be decreased. Power consumption 220 watts; fuse protection, 2 amperes.

Physical Characteristics — Instrument housed in metal cabinet provided with carrying handles and removable front cover. Overall dimensions, 16-1/4" (height) x 11-3/8" (width) x 26" (depth). Weight, 104 lbs.

Catalog No.	Type No.	Description	Code Word
1296	256-D	Cathode-ray Oscillograph for 115 volts, 60 cycles; 5CP1A Cathode-ray Tube	YALDW
1297	256-D	Same as above; 5CP2A Cathode-ray Tube	YALDX
1299	256-D	Same as above; 5CP7A Cathode-ray Tube	YALDZ
1300	256-D	Same as above; 5CP11A Cathode-ray Tube	YALEA

TYPE 274
CATHODE-RAY OSCILLOGRAPH

- Light-weight, portable, general-purpose oscillograph
- Varied selection of deflection plate connections
- Identical amplifiers for vertical and horizontal deflection
- Intensity-modulation provision
- Sine-wave test signal output
- Recurrent sweeps from 8 cycles to 30,000 cycles per second

FUNCTION

The Type 274 is a general-purpose oscillograph for laboratory or servicing duties. Its combination of simplicity and utility is similar to the Type 164-E, the principal differences being in the 5-inch cathode-ray tube, intensity modulation provision, and signal connection combinations provided in the Type 274. It is extremely light in weight, and is therefore easily transported and set up for operation.

DESCRIPTION

Cathode-ray Tube

A Type 5BP-A Cathode-ray Tube is used in the Type 274. Accelerating potential of 1200 volts is applied prior to deflection. A magnetic shield for the cathode-ray tube prevents spurious deflection or intensity modulation from stray magnetic fields.

Vertical Deflection

Signals may be applied to vertical deflection plates (1) through the vertical amplifier, (2) through a panel terminal which may be capacitively connected to the deflection plate, or (3) through a terminal at the rear of the instrument which is directly connected to the deflection plate. Signals which do not require amplification or which contain frequency components beyond the response limits of the vertical amplifier may be either capacitively or directly connected to the deflection plates. Sinusoidal frequency response characteristic of the vertical amplifier is uniform within 20% from 20 to 50,000 cycles per second, and within 50% to 100,000 cycles per second.

Horizontal Deflection

External signals may be applied to horizontal deflection plates (1) through the horizontal amplifier, (2) through a panel terminal which may be capacitively connected to the deflection plate, or (3) through a terminal at the rear of the instrument which is directly connected to the deflection plate. Signals which do not require amplification or which contain frequency components beyond the response limits of the horizontal amplifier may be either capacitively or directly connected to the deflection plate. Characteristics of the horizontal amplifier are identical to those of the vertical amplifier; therefore by connecting two signals, one to each of the amplifiers, relative phase between the signals may be directly determined.

Sawtooth voltage from the linear time-base generator may be connected instead of an external signal to produce horizontal deflection.

Linear Time-Base

The time-base generator furnishes a recurrent sawtooth voltage variable in frequency from 8 to 30,000 cycles per second. Direction of the sweep produced on the cathode-ray tube is from left to right.

Synchronization of the Time-Base

Frequency of the time-base generator may be synchronized from (1) the vertical deflection signal or (2) an external signal. The vertical deflection signal is obtained from the vertical amplifier; the external signal may be connected to a synchronizing terminal on the panel.

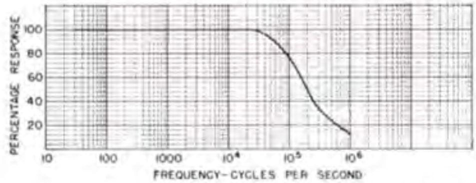


Figure 1. Frequency-response characteristic of the Type 274

Positioning

A pattern may be moved to any portion of the cathode-ray tube screen by means of controls on the panel. At least 5 inches of positioning are available both vertically and horizontally. Positioning control may be retained even when signals are connected through the rear deflection plate terminals, provided that capacitive connection or high-impedances are used between the signal source and the terminals. (Refer to March-April 1946 issue of Du Mont "Oscillographer" for discussion of connections at rear terminals.)

Test Signal Output

A sinusoidal voltage of power line frequency and 6 rms volts amplitude is available at a terminal on the panel. It is often useful as a test signal for trouble-shooting applications, or it may be connected to the synchronizing terminal to synchronize the time-base at power line frequency.

Intensity Modulation

An external signal may be connected to a terminal on the panel to provide modulation of beam intensity. An input signal of positive polarity will increase intensity; a negative polarity signal will decrease intensity.

SPECIFICATIONS

Cathode-ray Tube—Type 5BP-A cathode-ray tube. Accelerating potential, 1200 volts. Deflection plates are at ground potential.

Vertical Deflection—Deflection Factor not more than 0.65 rms volt/inch with amplifier at full gain; 18 rms volts/inch ±20% direct to plates. Sinusoidal response of amplifier at full gain uniform within 20% from 20 to 50,000 cycles per second; within 50% to 100,000 cycles per second. Input impedance to amplifier, 1 megohm paralleled by 40 μμf.; through capacitor to deflection plate, 5 megohms paralleled by 50 μμf.

Horizontal Deflection—Deflection Factor not more than 0.65 rms volt/inch with amplifier at full gain; 18 rms volts/inch ±20% direct to plates. Sinusoidal response of amplifier at full gain uniform within 20% from 20 to 50,000 cycles per second; within 50% to 100,000 cycles per second. Input impedance to amplifier, 5 megohms parallelled by 40 μμf.; through capacitor to deflection plates, 5 megohms parallelled by 60 μμf.

Linear Time-Base—Recurrent sweeps variable in frequency from 8 to 30,000 cycles per second. Sweep direction, left-to-right. Synchronization from vertical deflection signal, or external signal of 0.6 rms volt amplitude.

Intensity Modulation—Input impedance, 470 000 ohms paralleled by 45 μμf. 10 volts rms input signal provides satisfactory modulation. Positive polarity increases intensity; negative polarity decreases intensity.

Power Source—Type 274 is designed to operate from a 115 volt power line at 50-60 cycles. Power consumption, 50 watts; fuse protection, 1 ampere.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle. Overall dimensions, 14" (height) x 8-5/8" (width) x 19-3/8" (depth). Weight, 35 lbs.

Catalog No.	Type No.	Description	Code Word
1220	274	Cathode-ray Oscillograph, with 5BP1A Cathode-ray Tube; for operation from 115 volts, 50-60 cycles	YALAV
1222	274	Same as above, with 5BP11A Cathode-ray Tube	YALAX

TYPE 275-A
POLAR COORDINATE INDICATOR

- Cathode-ray Oscillograph designed specifically for investigation of mechanical devices
- Circular time-base automatically synchronized with quantity being studied
- Amplifies potentials over frequency range corresponding to the fundamental frequency produced at a speed of 120 rpm up to the 500th harmonic of 3600 rpm

FUNCTION

The Du Mont Type 275-A Cathode-ray Polar-coordinate Indicator has been developed to meet the need for electronic equipment in the field of mechanical engineering. In the past, primary emphasis in oscillograph design has been placed on the needs of the electronic engineer. This was justifiable since electronic engineers demanded oscillographic improvements to assist in achieving such electronic advances as television, radar, nuclear fission, etc. Such developments would have been impossible without the cathode-ray oscillograph.

However, there have also been many advances in the mechanical field. Diesel engines, fuel-injection systems, gas turbines, and superchargers are but a few examples. Until recently the mechanical engineer has had to rely on mechanical, rather than on electronic means for observing and evaluating the results of his efforts, or else he has been forced to use the tools of the electronic engineer, modified to fit his special needs.

Solutions to problems such as the determination of peak transient pressures in fuel-injection systems, the effect of vibration and resonance on precision mechanical linkages, and angular acceleration and torsional stresses in the crankshaft of a gasoline engine when the spark plug fires, all are vital if best performance is to be achieved in various devices. In these problems, mechanical indicators are of limited value because of their inherent inertia, and their correspondingly poor high-frequency response.

The Type 275-A Cathode-ray Polar-coordinate Indicator is ideally suited for studying these phenomena. Cathode-ray indication is inertialess, and the circular time-base shows relative positions of phenomena that take place in a given mechanical cycle with respect to some reference point in that cycle. A typical example of the use of this Indicator is shown in the oscillograms of Figure 1. These oscillograms show varying degrees of tension on the spring of the contact points of a distributor on a six-cylinder engine. Figure 1A shows exces-

A B C

Figure 1. Oscillograms taken from the Type 275-A in adjusting the spring tension on the distributor contact points in a 6-cylinder engine. Oscillogram A indicates excessive bouncing of the contact points, B indicates a moderate degree of bounce, and C corresponds to proper adjustment of the tension

Figure 2. The small two-phase generator supplied with the Type 275-A to provide a circular time-base which is automatically synchronized with the phenomenon under investigation

sive bouncing, Figure 2b shows the presence of moderate bouncing, while Figure 2c shows the proper adjustment.

DESCRIPTION

The Type 275-A is essentially a cathode-ray indicating device with a circular time-base on which the signal being studied produces a radial deflection. The intensity of the trace may be modulated simultaneously, with one or more markers, to indicate either time intervals along the time-base or to establish a reference point from which angular displacement may be measured. A calibrated polar-coordinate scale which fits in front of the cathode-ray tube enables quantitative measurements to be made. The circular time-base is derived from the two-phase sine-wave generator, shown in Figure 2, which is coupled to the device under test. Automatic synchronization of the time-base to the investigated phenomena is therefore accomplished.

Cathode-ray Tube

The Type 5CP-A Cathode-ray Tube is used to present oscillograms on a five-inch-diameter screen. This tube is available with various types of screen phosphors, each of which is designed for a specific purpose. The Type 5CP1A utilizes a green, medium-persistence screen which is suitable for all general-purpose work. The Type 5CP11A provides a short persistence blue-luminescent trace of high actinic value which is primarily used for photographic work. For visual observation of low-speed phenomena, the Type 5CP2A or the Type 5CP7A are usually employed since they provide long persistent traces.

The cathode-ray tube operates at an overall accelerating potential of 3,000 volts. This accelerating potential provides sufficient brilliance at all writing rates, under normal conditions of ambient light, to allow both visual observation and photographic recording of an oscillogram from the screen.

A shield is provided to protect the cathode-ray tube from the effects of external magnetic fields.

Circular Time-Base

It is a well-known fact that a circular trace may be obtained on any cathode-ray oscillograph by applying a sine-wave to the vertical deflection plates and another sine-wave, 90° out of phase with the first, to the horizontal deflection plates. This principle is used in the design of the Type 275-A. The required sinusoidal voltages are obtained from the two-phase sine-wave generator. Thus, as shown in Figure 3, the signal applied to each deflecting plate is 180° out of phase with the voltage on an opposite deflecting plate and 90° out of phase with the potential applied to each of the deflecting plates of the other pair.

The circular trace thus achieved is always in synchronism with the phenomenon being investigated, since the two-phase generator is driven from a shaft which is mechanically related to that phenomena.

The generator has a red dot on its shaft and another one on its case. The time when these dots are opposite each other correspond to the top-center position on the circular time-base. Connection from the generator to the Indicator is made through a connector on the Indicator cabinet. However, there is provision for connection of other sinusoidal voltages through terminals on the Indicator panel. The diameter of the circular time-base is nearly constant over generator frequencies from 0.5 to 60 cycles per second. This corresponds to rotational speeds from 30 to 3600 r.p.m. Diameter may be conveniently adjusted by means of a continuously variable control on the Indicator.

Radial Deflection

The phenomenon to be investigated with the Type 275-A may be transformed into a proportional electrical potential if it does not already exist as such. This potential is con-

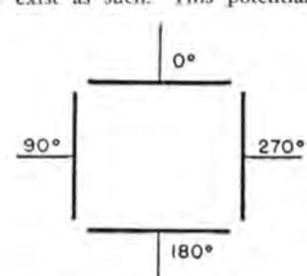


Figure 3. Diagram showing the phase relationship between the voltages applied to the deflection plates of the cathode-ray tube in producing the circular time-base

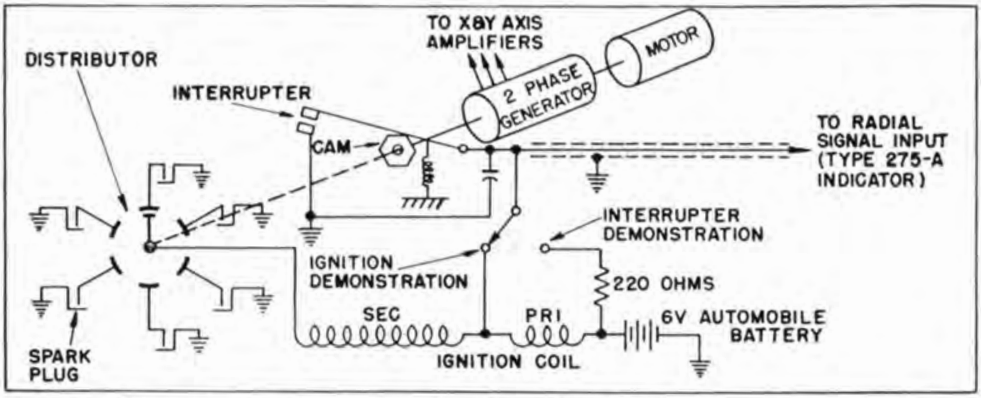


Figure 4. Diagram showing the application of the Type 275-A in adjustment and performance investigation of the ignition system of a 6-cylinder automobile engine

nected to the Indicator to produce radial displacement from the circular time-base.

The application of the Type 275-A to the analysis of the ignition system of an automobile has been accomplished in the laboratory by using the circuit of Figure 4. No special devices are required in order to produce proportional electrical potentials since the system already provides them. This set-up duplicates the automobile ignition system and permits study and adjustment of interrupter operation as well as spark plug gap adjustment. An electric motor serves to drive the interrupter, the distributor, and the two-phase generator of the Type 275-A. If the test is to be performed on an automobile, the two-phase generator can be coupled to the cam-shaft of the engine, either directly or otherwise. Figure 5 is a typical oscillogram obtained from the set-up shown in Figure 4. Each of the six separate oscillations on the circular time-base is a plot of the voltage across the coil primary as the distributor applies voltage to the various spark plugs. Interpretation of the trace enables an observer to determine whether or not each plug is firing, the length of the firing period, and from this to predict gap adjustment and condition of the plug.

The Type 275-A may be used in adjustment and timing of many different types of mechanisms. For example, in the textile industry, it is used to rapidly adjust and time looms and to improve the uniformity of the weave. Looms had previously been adjusted at low speeds by mechanics, and the accuracy of adjustment depended upon judgment and experience. There was no way to ascertain whether cloth woven on two machines would be uniform. In using the Type 275-A, the reciprocating elements of the loom operate microswitches which open and close electrical circuits to produce potentials corresponding in time to some point in the reciprocal travel.

A potential which is proportional to any reciprocal or rotary motion may also be produced by an arrangement of a potentiometer and a source of d-c voltage. The potentiometer is connected across the d-c source, and is mechanically coupled in a manner such that its center arm moves in accordance with that motion. The proportional potential appears between the center arm and one terminal on the potentiometer.

The Type 275-A may be used in dynamic balancing of machinery and in other vibration

Figure 5. A typical oscillogram resulting from the set-up shown in Figure 4. Each of the six oscillations on the circular time-base is a plot of the voltage across the coil primary at the time when the spark plugs fire. Interpretation of the oscillogram shows that plugs 2, 3, 5, and 6 are firing normally, while plug 1 is open and 4 is shorted

studies. A vibration type pick-up device may be attached, for example, to a bearing which supports a rotating shaft or wheel. Any vibration of the mechanism as it rotates will produce radial deflection from the circular time-base.

Pressure type pick-ups are also commercially available. One of these may be attached to the cylinder of a Diesel engine, for example, and used in conjunction with the Type 275-A to show the pressure vs. time variation within that cylinder.

The frequency response of the radial amplifier in the Type 275-A is uniform within 10% from 2 to 30,000 cycles per second. This frequency range corresponds, for the lower limit, to the fundamental motion of a shaft rotating at 120 r.p.m., and, for the higher limit, to the 500th harmonic of the fundamental vibration of a shaft turning at 3600 r.p.m.

The input attenuator for the radial amplifier has 10:1 and 1:1 positions, and a position at which a 60-cycle test signal is applied to the input of the radial amplifier. A continuously variable control permits adjustment of radial deflection amplitude.

Intensity Modulation

The Type 275-A has provisions for applying an external signal to the grid of the cathode-ray tube. This channel is used either to apply timing marks, so that rotational speed of the device under investigation can be determined, or to apply a reference marker from which angular displacement can be measured.

SPECIFICATIONS

Cathode-Ray Tube—Type 5CP-A electrostatic tube; overall accelerating potential, 3000 volts.

Circular Time-Base—Derived from two-phase generator furnished with the equipment. Useful circle diameter, 1 to 4-1/2 inches. Positive polarity from generator deflects beam upward or to the right.

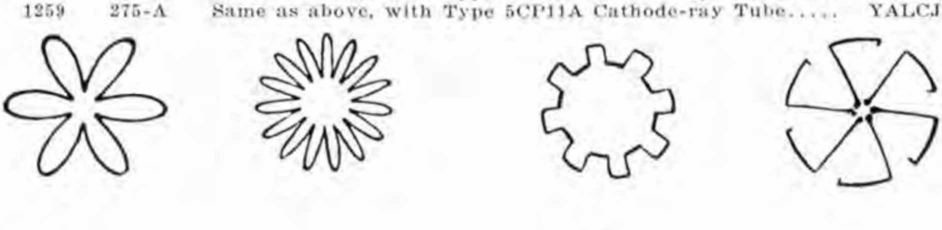
Radial Amplifier—Less than 0.4 rms volt produces deflection to center of circle. Positive input increases circle diameter. Frequency response uniform within 10% from 2 to 30,000 cycles per second. Input impedance; with 1:1 attenuation, 250,000 ohms; with 10:1 attenuation, 2.45 megohms. Input selection of external signal or 60-cycle test signal.

Intensity Modulation — Input terminal capacitively connected to cathode-ray tube grid. Input impedance, 2.2 megohms. Positive input increases beam intensity; 45 volts peak signal drives cathode-ray tube from cut-off to zero bias.

Power Source—Type 275-A is designed to operate from either a 115 or 230 volt power line; change from one to the other by means of switch. Power-line frequency, 50-60 cycles; power consumption, 100 watts; fuse protection, 1.5 amperes.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle and removable panel cover. Overall dimensions, 17" (height) x 10-1/2" (width) x 19-1/2" (depth). Weight, 65 lbs.

Catalog No.	Type No.	Description	Code Word
1250	275-A	Cathode-ray Polar-coordinate Indicator with Type 5CP1A Cathode-ray Tube; 115 volts, 50-60 cycles	YALBZ
1251	275-A	Same as above, with Type 5CP2A Cathode-ray Tube	YALCA
1253	275-A	Same as above, with Type 5CP7A Cathode-ray Tube	YALCC
1254	275-A	Same as above, with Type 5CP11A Cathode-ray Tube	YALCD
1255	275-A	Cathode-ray Polar-coordinate Indicator with Type 5CP1A Cathode-ray Tube; 230 volts, 50-60 cycles	YALCE
1256	275-A	Same as above, with Type 5CP2A Cathode-ray Tube	YALCF
1258	275-A	Same as above, with Type 5CP7A Cathode-ray Tube	YALCH
1259	275-A	Same as above, with Type 5CP11A Cathode-ray Tube	YALCJ



A B C D

Figure 6. Typical oscillograms which may be obtained on the Type 275-A Polar-Coordinate Indicator by application of sinusoidal (A and B) and square-wave voltage (C and D) to the radial deflection amplifier

TYPE 279

DUAL-BEAM CATHODE-RAY OSCILLOGROPH

- Dual-beam cathode-ray tube
- Two oscillographs in one unit —either separate or common horizontal deflection
- Multiple combinations of input connections
- Built-in voltage calibrator
- Intensity modulation channels
- Optional relay-rack mounting

FUNCTION

The Du Mont Type 279 Dual-beam Cathode-ray Oscillograph is a dual-channel instrument which employs the Du Mont Type 5SP-Dual-beam Cathode-ray Tube to permit two entirely independent oscillograms to be displayed simultaneously on a single cathode-ray tube screen.

Simultaneous oscillographic comparison of two phenomena has been the subject of research for many years. Prior to the development of the dual-beam tube, it has been accomplished (1) by utilizing an electronic switch fo: such observations, (2) by splitting the beam from a single electron gun and deflecting portions of the beam separately, or (3) by superimposing the patterns from two screens by optical means. The first two methods, however, have always required that the two signals be observed on the same time-base, and the latter method is quite cumbersome, and too elaborate for many applications. The Type 279 permits observation of the signals on separate time-bases or on a common time-base.

DESCRIPTION

Cathode-ray Tube

The Type 5SP- Cathode-ray Tube is the equivalent of two separate tubes. Its construction permits two completely independent traces to be viewed on a single fluorescent screen. Independent signals can also be used for intensity modulation of each beam. Overall accelerating potential is 4500 volts. This potential makes available a high light output from both beams.

Figure 1 shows the Type 5SP- Cathode-ray Tube and its electron gun structure. The two guns are physically separated, and an electrostatic shield prevents interaction between the deflection plates associated with each one.

Double Channels

Essentially the Du Mont Type 279 Dual-beam Cathode-ray Oscillograph is two oscillographs in one cabinet. Figure 2 shows the

Figure 1. The Du Mont Type 5SP Dual-Beam Cathode-ray Tube showing the structure of its electron guns. The two guns are physically separate and are shielded to prevent interaction between the deflection plates associated with each

***Figure 2.** Front panel of the Type 279. Some idea of the instrument's versatility may be gathered by studying the number of combinations and selections which may be made. All controls are grouped and located to provide for simple operation*

simplified front-panel layout. The beam controls for each channel are located on opposite sides of the cathode-ray tube. The remaining controls for each channel are independently grouped on two sections of the panel, and these sections are subdivided so that the vertical controls for each channel are located on the left side while the horizontal controls are on the right. Controls common to both channels are located in the center under the cathode-ray tube. The two channels, each in reality an independent oscillograph, are referred to as Channel A and Channel B, with the corresponding beam-control circuits designated as Beam A and Beam B. Channels may be used with separate or common horizontal deflection. Either continuous sweeps or single sweeps are available in each channel. Z-axis modulation may be applied to both channels simultaneously or separately. A voltage calibrator is built into the instrument so that peak-to-peak calibration voltages may be applied to either channel.

Some typical applications of this instrument are illustrated by the oscillograms of Figures

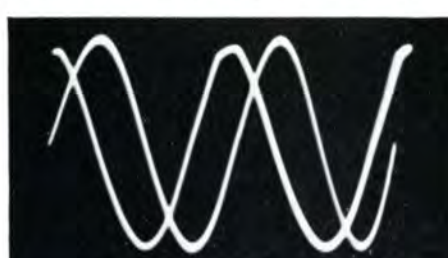


***Figure 3.** Oscillogram showing phase comparison between two sine-waves. They are plotted on a common sweep and superimposed to facilitate measurement*

Figure 4. Oscillogram showing a square-wave signal (top) and the resultant waveform after differentiation by an RC network (bottom). Both signals are plotted on a common sweep

3, 4, 5, and 6. Figures 3 and 4 show the use of a common time-base for the observation of two signals simultaneously. Figure 3 shows the comparison of phase between two sine waves of the same frequency. Figure 4 shows a square wave input as the upper trace and the output of a differentiator circuit, to which this square wave has been applied, as the lower trace.

Figure 5 illustrates the use of separate sweeps at different frequencies for observing parts of the same waveform. The complex wave obtained from the circuit of a fluorescent lamp (upper trace) is compared with an expanded portion of the same waveform (lower trace). The lower trace is plotted on a faster time-base. By properly phasing the synchronizing signal for the faster time-base, any portion of the upper signal may be observed in greater detail. Figure 6 illustrates the use of different frequencies for intensity modulating each beam. The two 60-cycle sine waves shown are modulated with frequencies of 120 cps and 480 cps, upper and lower respectively.

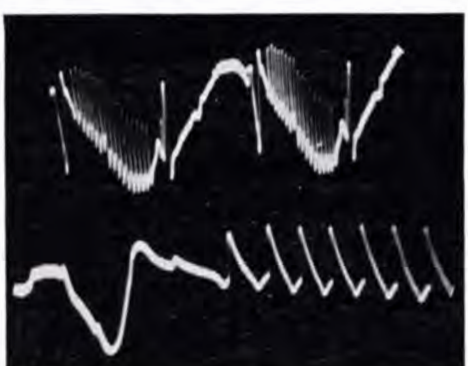


Figure 5. A complex wave-form taken from an ordinary fluorescent lamp (top) is compared with a greatly expanded portion of the same wave-form (bottom). Expansion is accomplished by plotting the lower trace on a much faster sweep

Amplifiers

Single-stage, direct-coupled, amplifiers are employed for vertical and horizontal deflection in each channel. Signals applied to the input terminals of any of the four amplifiers may be coupled to the amplifier either capacitively or conductively through a combination of stepped and variable attenuators. The stepped attenuators have three positions for each type of coupling. An additional position of the attenuator switch automatically grounds the grid of the amplifier so that signals may be left connected to the amplifier input terminals without danger of interaction when other signals are connected directly to the deflection plates. Signals may be capacitively coupled to the deflection plates, without going through the amplifier, by connecting to terminals on the back of the instrument. The positioning controls on the panel retain their functions when signals are coupled to the deflection plates in this manner.

Figure 6. Oscillogram showing intensity modulation by signals of different frequencies. At the top, a 60-cycle signal is intensity-modulated at 120 cycles per second. At the bottom, the same 60-cycle signal is modulated at 480 cycles per second

Response of the vertical amplifiers is flat to zero frequency (direct current) at the low end, and is down 30% at 200,000 cycles per second. The response of the horizontal amplifiers is flat to zero frequency at the low end, and it is down 30% at 150,000 cycles per second. Average frequency-response curves for the vertical and horizontal amplifiers are shown in Figure 7.

Beam Controls

Beam controls for adjustment of intensity, focus, and positioning are provided for each gun of the Type 5SP- Cathode-ray Tube. If only one channel of the oscillograph is being used, the beam of the other channel may be turned off by means of the intensity control. The vertical position controls permit their respective beams to be moved up or down, and thus superimposed or separated, whichever is desirable. The horizontal position controls also permit complete flexibility for control of the horizontal position of the traces of both channels.

Voltage Calibrator

A calibrating voltage may be connected, instead of an external signal, to the input of either of the vertical amplifiers so that it is attenuated in the same proportion as the external signal. The calibrator furnishes calibrated square-wave outputs at power-line frequency.

Linear Time-Base

A linear time-base generator is provided for each channel to produce continuous sweeps over the range from 2 to 30,000 cycles per second. Provision is also made for single sweeps variable in duration from 1/2 second to 300 microseconds. The time-base generators in each channel may be used independently, or the time-base of Channel A may be used as common to both channels to permit the simultaneous observation of two signals on a single time-base.

Automatic Beam Control

An automatic beam-control circuit is incorporated in each channel to increase the brightness of the beam for the duration of any single sweep. The intensity is automatically reduced to zero when the time-base is switched from continuous-sweep to single-sweep operation, and is automatically returned to its original value upon initiation of the single sweep.

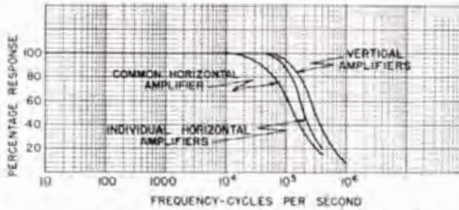


Figure 7. Frequency-response characteristic of the Type 279

Automatic beam control is of particular value in photographing single transients. If the Type 271-A Oscillograph-record Camera is used, the shutter can be opened prior to the occurrence of the transient, left open for the duration of the transient, and closed after the cycle is completed without fogging the film. The photographic technique required for making such recordings has thus been greatly simplified.

Test Signals

A sawtooth voltage, and sine-wave voltage of power-line frequency are available as test signals from terminals on the front panel. The sawtooth signal is obtained from the sweep generator of Channel A.

Mechanical Features

The Du Mont Type 279 Dual-beam Cathode-ray Oscillograph is mounted in its own metal cabinet. However, the front panel is of standard relay-rack design so that the instrument may readily be removed from its cabinet and installed in a relay rack as permanent equipment. Input terminals on both the front and rear of the instrument are easily accessible.

The bezel of the cathode-ray tube is the Du Mont Type 2501 Bezel. It permits the attachment of such accessories as the Types 271-A and 314 Oscillograph-record Cameras.

SPECIFICATIONS

Cathode-ray Tube Type 5SP- dual-beam cathode-ray tube. Accelerating potential, 4500 volts overall.

Vertical Deflection—Deflection Factor not more than 0.35 rms volt/inch or 1 d-c volt/inch through amplifiers at full gain; 29 rms volts/inch or 80 d-c volts/inch ±20% at deflection plates. Amplifier input coupling, capacitive or conductive. Input impedance to amplifiers, 2 megohms paralleled by 60 μμf; to deflection plates (balanced connection), 2 megohms parallelled by 20 μμf.; (unbalanced connection), 1 megohm parallelled by 20 μμf. Sinusoidal frequency response of amplifiers (capacitive input) within 10% from 10 to 100,000 cycles per second; (conductive input) flat to d-c (zero frequency) and within 10% to 100,000 cycles per second. Response within 30% to 200,000 cycles per second, either capacitive or conductive input.

Horizontal Deflection—Deflection Factor not more than 0.35 rms volt/inch or 1 d-c volt/inch through amplifiers at full gain;

25 rms volts/inch or 69 d-c volts/inch ±20% at deflection plates. Amplifier input coupling, capacitive or conductive. Input impedance to amplifier, 2 megohms paralleled by 60 μμf.; to deflection plates (balanced connection), 2 megohms paralleled by 20 μμf.; (unbalanced connection), 1 megohm paralleled by 20 μμf. Sinusoidal frequency response of amplifiers (capacitive input) within 10% from 10 to 70,000 cycles per second; (conductive input) flat to d-c and within 10% to 70,000 cycles per second. Response within 30% to 150,000 cycles per second, either capacitive or conductive input. For common horizontal amplifier, response is within 10% to 40,000 cycles per second, and within 30% to 70,000 cycles per second.

Linear Time-Base — Provides recurrent sweeps variable in frequency from 2 to 30,000 cycles per second. Also provides single sweeps with durations variable from 1/2 second to 300 μsec. Recurrent sweeps synchronize from external signal of either polarity and less than 0.2 volt peak amplitude, or from internal vertical-deflection signal at approx. 1/4" vertical deflection with full gain. Single sweeps initiated from external signal of either polarity and less than 5 volts peak amplitude, or from internal vertical-deflection signal at approx. 1.5" vertical deflection with full gain. Repetition rate of initiating signal up to frequency corresponding to driven sweep duration.

Provision for sweep "A" to deflect both beams simultaneously.

Intensity Modulation—Terminal for capacitive connection of external signals to cathodes of cathode-ray tube. Input impedance, 10,000 ohms paralleled by 40 μμf. Positive signal decreases intensity; amplitude of 7.5 volts peak provides satisfactory modulation.

Return-trace of recurrent sweeps blanked out. Beam blanked out on single sweeps except during sweep duration.

Calibrator—Square-wave output at power-line frequency and 0.1, 1, 10, or 100 volts peak-to-peak amplitude. Accuracy, ±5%. Calibrating voltage may be applied to either vertical amplifier.

Test Signal Outputs—Sine-wave signal at power-line frequency and approx. 2.5 rms volts amplitude. Sawtooth voltage from sweep "A".

Power Source—Type 279 is designed to operate from either a 115 or 230 volt power-line. Changeover is made by switch. Power-line frequency, 50-60 cycles; power consumption, 300 watts; fuse protection, 3 amperes.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handles. Overall dimensions, 17" (height) x 21-3/4" (width) x 22-1/4" (depth). May be mounted without cabinet in standard 19" relay-rack. Weight, with cabinet, 125 lbs; without cabinet, 86 lbs.

Catalog No.	Type No.	Description	Code Word
1386	279	Dual-beam Cathode-ray Oscillograph for 115 volts, 50-60 cycles operation; with Type 5SP1 Cathode-ray Tube	YALHR
1387	279	Same as 1386 with Type 5SP2 Cathode-ray Tube	YALHS
1390	279	Same as 1386 with Type 5SP11 Cathode-ray Tube	YALHV
1391	279	Dual-beam Cathode-ray Oscillograph for 230 volts, 50-60 cycle operation; with Type 5SP1 Cathode-ray Tube	YALHW
1392	279	Same as 1391 with Type 5SP2 Cathode-ray Tube	YALHX
1395	279	Same as 1391 with Type 5SP11 Cathode-ray Tube	YALJA

TYPE 280
CATHODE-RAY OSCILLOGRAPH

- Precise measurements of television waveforms and signals even on fractional line basis
- Wide range of calibrated sweep writing-speeds
- Video amplifier with response uniform to 10 megacycles per second
- Calibrated circuit for accurate delay of sweeps
- Type 5RP-A Cathode-ray Tube with accelerating potential adjustable to 12,000 volts
- May be used in conjunction with standard television picture-monitor to indicate portion of picture being studied.

FUNCTION

The Type 280 Cathode-ray Oscillograph is specifically designed as a television-studio and television-transmitter facility. It provides a means for precise measurement of (1) the duration and waveform of the various components contained in any portion of the composite television signal, and (2) the character of the television-picture video signal, according to FCC standards and practices. An output marker gate may be connected to a standard picture monitor in order to brighten on the monitor that portion of the picture which is being plotted on the Type 280.

It may also be used as a general-purpose, precision time-measuring oscillograph. Time intervals down to fractions of one microsecond are measured on the calibrated sweeps while longer time intervals are read from a calibrated dial. On the 1 μsec. sweep, an interval of 0.25 μsec. can be measured with an accuracy of ±0.01 μsec. With the calibrated dial, an interval of say 5 μsec. can be measured to ±0.1 μsec.

DESCRIPTION

Cathode-ray Tube

A Type 5RP-A Cathode-ray Tube is used in the Type 280. It can be operated with very high accelerating potentials and yet maintain good deflection sensitivity. Power supplies in the Type 280 furnish 2000 volts to the second anode, and provide 5000 to 10,000 volts for the intensifier electrodes. Overall acceleration is therefore variable from 7000 to 12,000 volts; it may be adjusted to the value which produces the optimum combination of light output and deflection sensitivity for any particular application of the instrument.

Vertical Deflection

An incoming signal may be applied to the vertical deflection plates through a video amplifier. Sinusoidal frequency response of this amplifier is uniform within 30% from 10 cycles per second to 10 megacycles per second. Either high-impedance or 75 ohm input may

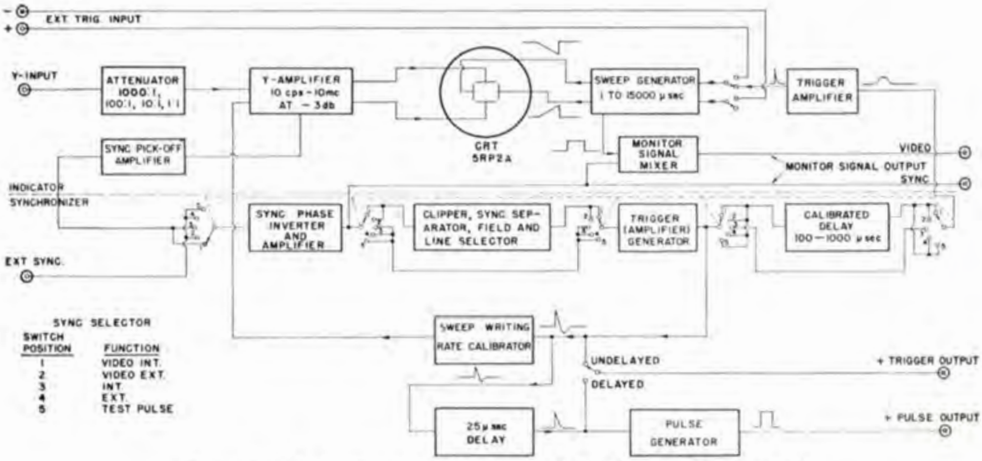


Figure 1. Block diagram of the Type 280 Cathode-ray Oscillograph

be selected, the latter to match the standard studio video-line. A probe which is provided may be used as a high-impedance, shielded input for the video amplifier.

A stepped-attenuator, which is provided to reduce signal amplitudes, has a position which inserts a positive-peak-clipping circuit. This allows full-scale expansion of negative polarity signals, such as television synchronizing pulses, in order that they may be studied in great detail.

Time-Base

A driven-type linear time-base generator produces horizontal deflection on the screen of the cathode-ray tube. Sweep durations from 1 microsecond to 15,000 microseconds are available; excellent linearity is assured over this entire range.

Sweep Calibrator

In order to calibrate the time-base writing speed, a sine-wave oscillator which oscillates at some exact frequency is connected to produce vertical deflection. Oscillator frequencies corresponding to 10, 1, or 0.2 μsec. per cycle may be selected, and time-base speed determined by measuring the number of cycles which occur in a given horizontal distance on the screen of the cathode-ray tube. Once the time-base writing speed in inches per microsecond is known, time intervals may be accurately measured directly from the screen.

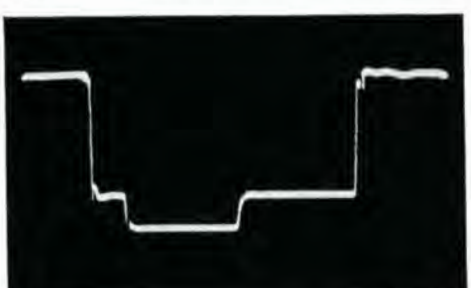


Figure 2. Horizontal synchronizing and blanking pulses from a composite television signal as displayed on the Type 280

Figure 3. A vertical synchronizing pulse showing the horizontal equalizing pulses

Synchronization of the Time-Base

The time-base may be initiated from the following sources:

(a) Internal Video Signal

This video signal is obtained from the vertical deflection amplifier. A Video Synchronizing Dissector circuit in the Type 280 derives synchronizing voltage from this composite video signal, such that the time-base may be initiated at a time corresponding to any horizontal synchronizing pulse or equalizing pulse in either or both of the fields in the television-picture

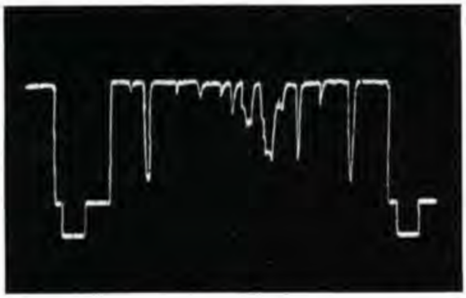


Figure 4. Oscillogram of the wave-form of one horizontal line from a television picture showing the video signal and the horizontal synchronizing and blanking pulses at each end of the line

frame. Thus any particular horizontal line in the picture may be selected for investigation.

The synchronizing voltage from the Dissector circuit is passed through a Calibrated Delay circuit which permits precise adjustment of the sweep-start to any time, within the Delay range, following the particular pulse selected by the Dissector. Together, the Dissector and Calibrated Delay enable not only the selection of a particular line, but selection of any portion of that line, to be plotted on the time-base of the Type 280.

Video signals of either polarity may be used to provide synchronization.

(b) External Video Signal

The only difference here is that the composite video signal is applied to a synchronizing terminal on the Type 280 instead of being obtained from the vertical amplifier.

Figure 5. The leading edge of a horizontal synchronizing pulse as plotted on the 1 microsecond sweep of the Type 280. Expansion of the pulse amplitude is accomplished by using the positive-peak-clipping circuit

(c) Internal Signal

This signal, which is not a composite video signal, is obtained from the vertical amplifier. It directly synchronizes or initiates the Trigger Generator, which in turn initiates the Time-base Generator directly.

(d) External Signal

This signal is connected to the external synchronizing terminal on the Type 280 just as was the External Video Signal. It synchronizes or initiates the Trigger Generator, and the trigger produced is passed through the Calibrated Delay circuit before going to the Time-base Generator. The sweep-start may therefore be delayed up to 1000 microseconds with respect to the trigger.

Whenever the Calibrated Delay is used, a direct-reading dial on the Type 280 indicates the amount of delay introduced (time of sweep-start).

(e) Direct

Terminals are provided on the Type 280 so that either polarity of triggering voltage may be applied directly to the Time-base Generator.

Output Trigger

Low-impedance output from the Trigger Generator is available at a terminal on the

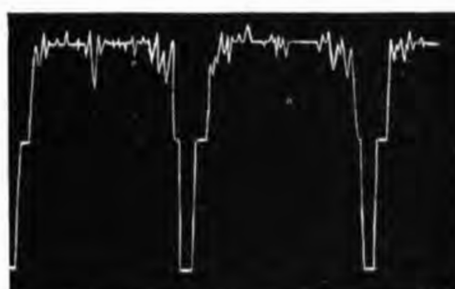


Figure 6. Wave-form of two horizontal lines with horizontal synchronizing pulses expanded by use of the clipping circuit

panel. It has positive polarity, and may be either undelayed so that it corresponds with the start of the Calibrated Delay, or delayed by 25 microseconds from this time. Extremely fast rise-time makes it suitable for triggering of external circuits. The delayed trigger is valuable for this purpose since it allows the Type 280 sweep to get under way before the external circuit is initiated. Effectively then, the range of the Calibrated Delay with respect to that external circuit extends from minus 25 to plus 1000 microseconds.

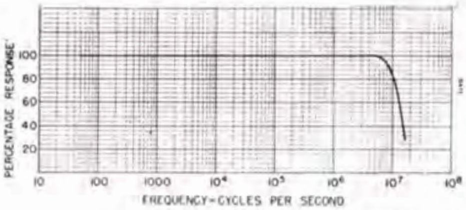


Figure 7. Frequency response characteristic of the Type 280

Output Pulse

A Pulse Generator in the Type 280 furnishes a low-impedance output pulse which may be used for testing the characteristics of, or triggering of external circuits. It is a flat-topped pulse of short duration and variable amplitude, delayed 25 microseconds from the start of the Calibrated Delay. An output cable and pulse amplitude control is furnished.

SPECIFICATIONS

Cathode-ray Tube—Type 5RP-A high-voltage cathode-ray tube. Accelerating potential variable, 7,000 to 12,000 volts.

Video Amplifier—Deflection Factor dependent upon accelerating potential. Not more than 0.1 rms volt/inch through amplifier at full gain and 12,000 volts acceleration; not more than 2 rms volts/inch through probe under same conditions. Sine wave response—down 30% at 10 megacycles per second. Pulse response—with a 1 μsec. pulse rising to 90% of peak amplitude in .02 μsec., rise time not more than .045 μsec. between 10% and 90% amplitude. Input impedance to amplifier terminals, 2.2 megohms paralleled by 25 μμf, or 75 ohms. Input impedance to probe, 5 megohms paralleled by 10 μμf. Undistorted deflection available, at least 2 inches with 12,000 volts acceleration. Input attenuation—3 steps of 100:1, 10:1, 1:1, plus variable of 10:1. Additional 20:1 by input probe. Maximum input potential, 400 volts (d-c plus peak signal).

Linear Time-base—Driven sweep durations variable from 1 to 15,000 μsec. in 4 inches of sweep length. Sweep direction, left to right; linearity, within 5% for all durations. May be triggered at rates up to 0.75 of the frequency corresponding to the sweep period.

Synchronization of Time-base—

a. Composite Television Signal—

(1) Method—Internal from video amplifier or from external synchronizing input at 75 ohms impedance or .47 meg. and 40 μμf.

(2) Polarity—positive or negative.

(3) Features—

(a) Field and line selector permits selection of any line in either or both interlaced fields to start sweep.

(b) Sweep is synchronized to within ±.02 μsec. of the selected line synchronizing pulse.

(c) Repetition rate set at frame or field rate by field selector.

(d) Calibrated delay (see below) delays sweep start with respect to a particular line synchronizing pulse selected by line selector.

(4) Sensitivity—

(a) Internal (from video amplifier) —.75 inch deflection provides sufficient synchronizing signal.

(b) External—1 volt peak-to-peak required.

b. General purpose internally through video amplifier and internal trigger generator.

(1) Repetition rate of trigger—120 to 2500 cps, or driven by video input signal.

(2) Repetition rate of external signal to which internal trigger generator can be synchronized—120 cps to 50,000 cps.

(3) Sweep delay—approximately 0.2 μsec.

(4) Sensitivity—±.25" deflection, minimum.

c. General purpose externally with delayed sweep and through internal trigger generator.

(1) Repetition rate of trigger—120 to 2500 cps or driven by external signal.

(2) Repetition rate of external signal to which internal trigger generator may be synchronized—120 cps to 50,000 cps.

(3) Sweep delay—through calibrated delay, 4 to 100 μsec. or 7 to 1000 μsec., (see below).

(4) Sensitivity—±.5 volts peak.

d. Direct driven sweep.

(1) External signal required—pulse type waveform. Positive or negative polarity increasing to 90% of full amplitude in 1 μsec. or less and 10 volts or more in amplitude.

(2) Sweep delay.
From positive trigger—.1 μsec.
From negative trigger—.04 μsec.
(Time measured between 10% amplitude points of trigger and fast sweep sawtooth).

Calibrated Sweep Delay

a. Ranges—100 μsec. and 1000 μsec.

b. Minimum Delay—4 μsec. or less on 100 μsec. range; 7 μsec. or less on 1000 sec. range.

c. Accuracy—±.1% of full scale on either range beyond minimum delay.

d. Time indication—direct-reading dial.
e. Repetition rate limitation—100 μsec. range—2500 cps max.; 1000 μsec. range—400 cps max.

Sweep Calibration

a. Method—sinusoidal vertical deflection (approx. 1 inch).
b. Time intervals available—0.2, 1, 10 μsec.
c. Accuracy—±1%.
d. Duration of calibrating signal—approx. 1200 μsec.
e. Start of calibrating signal—coincident with start of calibrated sweep delay.

Output Trigger

a. Polarity—positive only.
b. Source—internal trigger generator.
c. Delay—0 or approximately 25 μsec. with respect to start of calibrated delay.
d. Amplitude—approximately 50 volts.
e. Rise time—10% to 90% of peak amplitude—0.5 μsec. or less.
f. Output Impedance—200 ohms or less.

Output Test Pulse

a. Polarity—positive only.
b. Duration—1 μsec. ±10%.
c. Rise and fall time between 10% and 90% of peak—not more than .02 μsec.
d. Amplitude—variable from 0 to 20 volts.
e. Output impedance—pulse is available at end of a 3-foot coaxial cable terminated with 75 ohms.
f. Delay—approximately 25 μsec. with respect to start of calibrated delay.

Power Source—Type 280 is designed to operate from a 115 volt, 50-60 cycle power line. Power consumption, 690 watts; fuse protection, 10 amperes to input and individually in each power transformer.

Physical Characteristics—Instrument mounted in rack supplied with rubber-tired casters. Side and rear panels removable. Overall dimensions, 60" (height) x 20-3/4" (width) x 22" (depth). Weight, 287 lbs.

Catalog No.	Type No.	Description	Code Word
1275	280	Cathode-ray Oscillograph for 115 volts, 50-60 cycles; with 5RP2A Cathode-ray Tube	YALDA
1278	280	Same as above, with 5RP11A Cathode-ray Tube	YALDD
1378	280	Cathode-ray Oscillograph for 230 volts, 50-60 cycles; with 5RP2A Cathode-ray Tube	YALHJ
1381	280	Same as above; with 5RP11A Cathode-ray Tube	YALHM

TYPE 288 CATHODE-RAY OSCILLOGRAPH

The Type 288 is a version of the Type 280 Cathode-ray Oscillograph. It employs the Type 286 High-voltage Power Supply instead of the Type 308; overall accelerating potential for the Type 5RP-A Cathode-ray Tube is variable from 20 to 27 kilovolts as compared to 7 to 12 kilovolts in the Type 280.

As a result, pattern brightness will be increased by a factor of 1.5 to 2 times that obtainable in the Type 280, while deflection sensitivity will be reduced some 25% to 35%, depending upon the accelerating potential used.

The Type 288 will perform the same functions as the Type 280, but it will also provide the additional brightness necessary for observation and photography of pulses and transients which have exceptionally low repetition rates and short durations.

Catalog No.	Type No.	Description	Code Word
1347	288	Cathode-ray Oscillograph ,with Type 5RP2A Cathode-ray Tube for 115 volts 50-60 cycle operation	YALFY
1350	288	Same as above, with Type 5RP11A Cathode-ray Tube	YALGE

TYPE 281

CATHODE-RAY INDICATOR

- Type 5RP-A Multi-band Cathode-ray Tube
- Electronically-regulated second anode and positioning voltages permit accurate quantitative measurements
- Provision for use of external high-voltage intensifier supply for cathode-ray tube as well as built in power supply
- Direct and capacitive connections to all deflection plates
- Provision for connection of external deflection amplifiers and time-base generator
- Intensity modulation channels
- May be used as projection oscillograph and for high-speed photographic recording

FUNCTION

The Du Mont Type 281 Cathode-ray Indicator is designed specifically to operate the Type 5RP-A high voltage cathode-ray tube. It is a basic instrument containing the cathode-ray tube, power supplies to furnish potentials for it, and controls to vary intensity, focus, and position of the trace on the screen.

This instrument fulfills three important requirements:

(1) It makes available an indicator capable of exploiting the full capabilities of the Du Mont Type 5RP-A cathode-ray tube, since it may be used in conjunction with external high-voltage intensifier supplies[1], or as a self-contained unit.

(2) It makes available a basic instrument invaluable to those whose oscillographic needs are too specialized or too advanced to be satisfied by standard, commercially-available equipment. For example, it may be used for high-tension studies such as surge testing of power distribution transformers and cables, and studies of lightning and other discharges. Heretofore, commercially-available equipment almost invariably incorporated linear time-base generators, whereas a logarithmic time-base is often more suitable for surge testing. The Type 281 makes possible the use of any type of time-base generator that the application may require.

(3) It makes available an indicator capable of displaying single transients containing writing speeds as high as 210 cm/μsec. (85 in./μsec.) when referred to standard conditions.[2]

Figures 1 and 2 offer a means of comparison between the photographic writing speeds obtainable with the Type 281 Indicator operating at two different overall accelerating potentials, 8000 volts and 29,000 volts. (The Type 286 High-voltage Power Supply is utilized to operate this instrument at an overall accelerating potential of 29,000 volts.) The maximum writing speed of the first cycle in each oscillogram is 32 cm/μsec. (13 in./μsec.), while the maximum writing speed of the tenth cycle is 8.7 cm/μsec. (3.5 in /μsec). It should be noted that these are unretouched oscillograms; some detail has been lost in the reproduction process. Furthermore, these photographs were made with a camera which employs an f/3.5 lens. An f/1.0 lens is capable of recording writing speeds 12 times as fast.

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1 The Du Mont Type 286 High-voltage Power Supply, a 25 kv. regulated, rectified radio-frequency power supply, has been designed expressly as an external supply for use with the Type 281 Indicator.

2 The standard conditions to which photographic writing speeds are referred are given in the following definition. Maximum photographic writing speed is defined as the maximum writing speed of the luminescent spot which will yield a negative density of 0.1 above fog, using a lens speed of f/1.0, a high-sensitivity photographic emulsion, an object:image ratio of 1:1, and with development in a high-contrast developer.

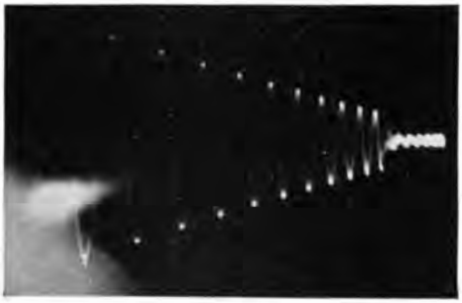


Figure 1. Unretouched oscillogram of a high-speed transient photographed from the Type 281 operated with an accelerating potential of 8,000 volts. Photograph made with a Du Mont Type 271-A Oscillograph-record Camera having a lens speed of f/3.5. Writing speed in the first cycle of the transient is 13 inches per microsecond; in the 10th cycle 3.5 inches per microsecond

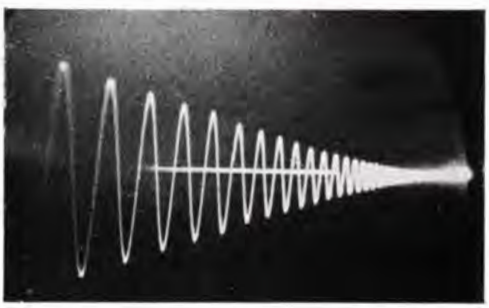


Figure 2. Unretouched oscillogram of the same transient as in Figure 1 photographed from the Type 281 operated at an accelerating potential of 29,000 volts (using Type 286 High-voltage Power Supply). Note the difference in intensity between comparable cycles on the two oscillograms

From experimental data collected to date, it has been calculated that the average value[3] of the maximum photographic writing speed obtainable with the Type 281 Cathode-ray Indicator, using the Type 286 High-voltage Power Supply as an auxiliary is 825 cm/μsec. or 330 in./μsec.

Figure 3 illustrates the use of the Type 286 High-voltage Power Supply with the Type 281 Cathode-ray Indicator. The two units may either be rack mounted, Figure 3A, or their cabinets may be fastened together, Figure 3B.

DESCRIPTION

Cathode-ray Tube

The Du Mont Type 5RP-A High-voltage Cathode-ray Tube is the result of a long research program aimed to overcome the oscillographic problems encountered when high values of accelerating voltage are used. The multi-band, post-deflection intensifier rings of the Type 5RP-A provide the following advantages over other cathode-ray tubes operating with comparable beam currents:

(1) Ordinary deflection amplifiers may be used with the Type 5RP-A because its deflection sensitivity with high accelerating potentials is reasonably similar to those found in low-voltage tubes.

(2) Insulation requirements for the cathode-ray tube heater transformer are similar to those for low-voltage tubes.

(3) Physical size and voltage rating of coupling capacitors to grid and cathode of the tube are reasonable.

(4) Small spot size allows great resolving power.

Figure 3. The Du Mont Type 281 and Type 286 are designed so that they may be used together or as separate instruments. When used together, they may be mounted in a standard relay-rack (Fig. 3A) or fastened together in their cabinets (Fig. 3B)

3 Average, rather than absolute maximum values are given to allow for normal manufacturing tolerances and variations in photographic technique. Higher values than those stated herein may be obtained under optimum conditions.

(5) Sufficient light output from the screen enables direct projection of patterns.

(6) Photographic recording at speeds equal to those obtained with continuously-evacuated cold-cathode tubes, and with less auxiliary equipment and lower accelerating potentials.

A comparison of a non-intensifier type of cathode-ray tube with the 5RP-A is shown in Figure 4. Curves a and b indicate the moderate increase in the deflection factor of the Type 5RP-A cathode-ray tube, resulting from an increase in the potential applied to the stepped-intensifier rings. Curve c indicates the increase in the deflection factor of a similar non-intensifier-type cathode-ray tube resulting from an increase in the potential applied to the second anode.

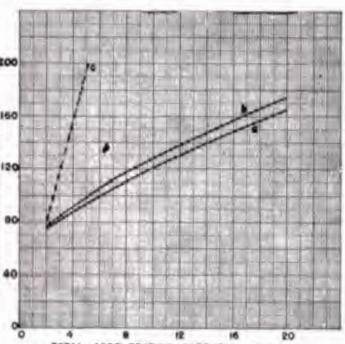


Figure 4. Deflection Factor as a function of total accelerating potential, comparing a non-intensifier type cathode-ray tube with the Type 5RP-A. (a) deflection plates nearer the electron gun in Type 5RP-A (vertical deflection in Type 281). (b) deflection plates nearer the screen in Type 5RP-A (horizontal deflection in Type 281). (c) non-intensifier cathode-ray tube with E_{b2} varied

Vertical and Horizontal Deflection Circuits

Optimum flexibility is assured in the operation of the Type 281 since connections to each of the deflection plates are readily available. Capacitive coupling to the deflection plates is made through terminals on the front panel. Direct connection to deflection plates is made through terminals on a recessed panel in the top of the cabinet.

The capacitors which are used for capacitive coupling of the signal to the deflection plates have sufficient voltage rating to withstand input potentials as high as 3,000 rms volts. This value of input voltage would produce more than twice full-screen deflection even at 30,000 volts total accelerating potential.

Figure 5 is the top view of the Type 281 Cathode-ray Indicator. Note the accessibility of the deflection plate terminals for direct connections, and the fact that short, direct leads may be used.

Figure 5. Top view of the Type 281 with cabinet removed. Note accessibility of deflection plate terminals for direct connections

Intensity Modulation Circuits

A terminal connected to the control grid of the 5RP-A provides a high-impedance input for beam-blanking or timing signals, and a terminal connected to the cathode provides a low-impedance input for similar functions. Both connections are capacitively coupled and may be used simultaneously. For example, an intensifying pulse equal in duration to the time-base may be applied to the grid, and a circuit, the output of which is proportional to the rate-of-change of signal voltage, may be connected to the cathode. These potentials will control the beam intensity as a function of the writing rate, and will prove especially valuable in photographic recording.

To protect the 5RP-A against screen burns when there is no signal applied to the deflection plates, a manually-operated beam switch, located on the front panel, is used to control the grid bias. Since the grid is either 2000 or 4000 volts[4] negative with respect to ground (the chassis of the instrument), this beam switch operates a relay which, in turn, biases the grid below cut-off. No high-voltage connections are made to the switch on the panel.

Power Supplies

To further increase the flexibility of the Type 281 Indicator, a switch is available on the front panel to permit the operation of the Type 5RP-A cathode-ray tube at either 4000 or 8000 volts overall accelerating potential. The pre-deflection accelerating voltage is electronically regulated so that it is not affected by power-line voltage changes or by beam current changes in the cathode-ray tube. Quantitative

4 See section on power supplies.

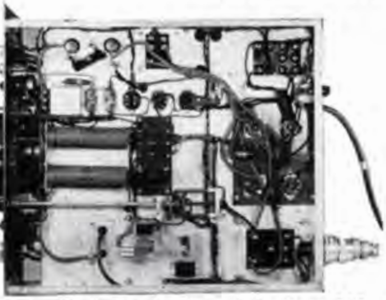


Figure 6. Underneath view of the Type 281. The location of all components has been carefully designed

measurements may therefore be made without continuous calibration of deflection factor. In addition, the self-contained positive supply may readily be disconnected from the intensifier rings, and a positive external supply connected instead. This operation consists merely of transferring a strap from the self-contained power supply to the high-voltage input jack on the rear of the Type 281.

A low voltage supply furnishes balanced positioning potentials to the deflection plates of the cathode-ray tube. A trace may be moved to any portion of the screen by means of panel controls. The supply is regulated to prevent power-line voltage variations from affecting the spot position.

Mechanical Construction

Flexibility is also enhanced by the type of construction utilized for this instrument. Although the Type 281 Cathode-ray Indicator is basically designed for relay-rack mounting, it is supplied with its own dust-proof cabinet so that it may be used as a portable instrument if required. The cathode-ray tube is mounted to provide adequate insulation for the high accelerating potentials used; a calibrated scale is permanently attached in front of the screen. Provision is made for attaching auxiliary equipment such as the Type 2088 Projection Lens or Type 271-A Camera.

Figure 6 shows the wiring of circuits and placement of parts that have been carefully engineered to meet the problems presented by the high potentials. The high-voltage terminal for connection to the Type 286 High-voltage Power Supply, for operation of the cathode-ray tube at 29,000 volts total accelerating potential, is located at the rear of the instrument so that it does not interfere with any controls or connections on the panel.

SPECIFICATIONS

Cathode-ray Tube—Type 5RP-A multiband tube with four free deflection plates. Deflection plate pairs average at ground potential. Accelerating potential 4000 or 8000 volts using internal power supplies; up to 29,000 volts using external positive intensifier supply.

Vertical and Horizontal Deflection Circuits—Deflection Factor dependent upon accelerating potential (refer to Figure 4 in text). Input impedance to terminals on front panel, 2 megohms paralleled by 30 μμf. (balanced); 1 megohm paralleled by 40 μμf. (single-ended). Input impedance to top terminals, 5 μμf (balanced); 10 μμf (single-ended).

Intensity Modulation—Terminals capacitively coupled to grid and to cathode of cathode-ray tube. Input impedance to grid, 0.5 megohm paralleled by 50 μμf; to cathode, 4700 ohms paralleled by 60 μμf. Cut-off bias of 5RP-A tube with 2000 volts on second anode, —60 volts ±50%; with 4000 volts on second anode, —120 volts ±50%.

Power Supplies—2000 volt negative supply regulated within ±2% for variations in load from 0 to 1 milliampere, and for power-line variations of ±10%. 4000 volt negative supply regulated within ±2% for loads of 0-2 milliamperes, and power-line variations of ±10%.

Positioning voltages, +400 and —400 volts, regulated so that ±10% line voltage change does not move spot more than 0.1 inch in any direction, regardless of position on the screen.

Power Source—Type 281 is designed to operate from a power-line at either 115 or 230 volts. Changeover is made by switch at rear of instrument. Power-line frequency, 50-60 cycles; power consumption, 100 watts; fuse protection, 1 ampere.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handles. Overall dimensions, 12-1/4" (height) x 20-3/4" (width) x 20-1/2" (depth). Provision for mounting without cabinet in standard 19" relay-rack. Weight with cabinet, 120 lbs., without cabinet, 90 lbs.

Catalog No.	Type No.	Description	Code Word
[5] 1280	281	Cathode-ray Indicator for 115 volts, 50-60 cycles; with Type 5RP2A Cathode-ray Tube	YALDF
[6] 1283	281	Same as 1280 with Type 5RP11A Cathode-ray Tube........	YALDJ
[5] 1324	281	Cathode-ray Indicator for 230 volts, 50-60 cycles; with Type 5RP2A Cathode-ray Tube	YALEZ
[6] 1327	281	Same as 1324 with Type 5RP11A Cathode-ray Tube........	YALFC

5 Recommended as the general-purpose screen type.
6 Recommended as the screen type for photographic work in which the writing speed of the Type 5RP2A, used in conjunction with Du Mont Type 216-H blue filter, is inadequate.

DU MONT AUXILIARY CATHODE-RAY INSTRUMENTS

TYPE 185-A
ELECTRONIC SWITCH

- Makes possible simultaneous observation of separate traces on a single cathode-ray tube
- Provides "chopping" of a d-c signal to make it suitable for transmission through an a-c circuit
- Furnishes a square-wave output voltage of variable frequency and amplitude

FUNCTION

The Type 185-A Electronic Switch and Square-wave Generator is a portable instrument which makes possible simultaneous observation of two recurrent patterns on the screen of a single cathode-ray oscillograph. The relative positions may be varied so that the patterns are superimposed or else separated from each other by a desired amount. Direct comparison of amplitudes, waveforms, frequency, and phase relationships is thereby readily accomplished. Two Type 185-A's operated in tandem permit three patterns to be viewed simultaneously; three Type 185-A's may be connected so that four separate patterns can be seen. The latter arrangement is particularly useful for investigation of polyphase power systems and equipment.

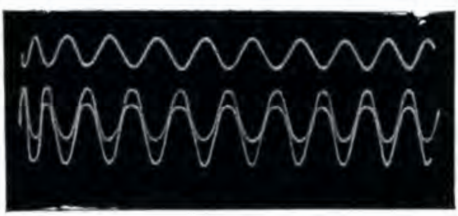


Figure 1. Operation of two Type 185-A instruments in cascade will permit the simultaneous study of three separate signals. In this particular oscillogram, the signals have been displaced from each other by means of the balance controls

There are direct-coupled amplifiers in the Type 185-A which are alternately operative and inoperative at a rate determined by the switching frequency. The instrument is therefore effective for "chopping" a d-c signal, making it suitable for transmission through the a-c amplifiers which are generally found in cathode-ray oscillographs. When the output of the Type 185-A is connected to an oscillograph, one channel may be used to establish a reference level while the other channel carries the d-c signal to be investigated. Qualitative as well as quantitative information concerning the d-c signal may be obtained in this manner.

A square-wave voltage of variable frequency and amplitude is available at the output terminals for use as a test signal in studying the transmission characteristics of vacuum-tube amplifiers and other circuits.

DESCRIPTION

The two signals to be investigated are connected to separate vacuum-tube amplifiers through the input terminals of the Type 185-A; a multivibrator circuit in the instrument generates a square-wave voltage which alternately blocks these amplifiers. The amplifier output circuits are connected so that the output of

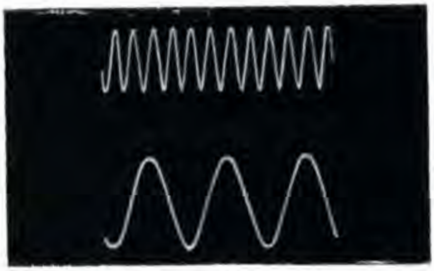


Figure 2. By adjustment of the balance control on the Type 185-A Electronic Switch, two patterns on the screen of the cathode-ray tube may be displaced with respect to each other to facilitate separate, detailed study of each

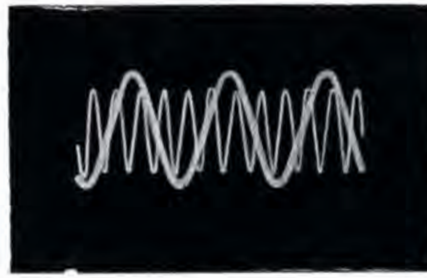


Figure 3. Two signals of frequencies f and 4f as obtained on a cathode-ray oscillograph using a Type 185-A Electronic Switch. These signals are superimposed on each other to permit a more direct comparison

the Type 185-A is composed of first one signal and then the other; the rate of switching from one to the other is variable by means of front panel controls. This rate is sufficiently rapid so that (1) the combined output may be connected to the amplifier of a cathode-ray oscillograph, and (2) the two signals appear simultaneously on the screen of the cathode-ray tube.

Frequency response characteristics of the signal amplifiers in the Type 185-A are adequate to allow satisfactory operation of instruments in tandem, thus providing additional channels for signal amplification.

Operation as a square-wave generator is accomplished by using the instrument with no signal inputs. Amplitude and frequency of the square-wave are variable by means of controls on the front panel.

SPECIFICATIONS

Switching Rate — Continuously variable, 10 to 2000 times per second.

Signal Amplifiers—Sinusoidal frequency response at full amplifier gain uniform from d-c (zero frequency) to 5000 cycles per second; down not more than 25% at 25,000 cycles per second. Maximum gain, 10 times. Continuously variable attenuator with negligible phase distortion to 25,000 cycles per second. Input impedance, 100,000 ohms. Maximum input at greatest attenuation, 150 rms volts; with no attenuation, 2.5 rms volts at balance, and 1.5 rms volts at maximum unbalance.

Output impedance 50,000 ohms. Maximum signal output at balance, 75 volts peak-to-peak. Voltage gain between output terminals and deflection plates of cathode-ray tube should not exceed 5 times.

Square-wave Generator—Frequency continuously variable, 10 to 500 cycles per second. Rise time of square-wave, 25 microseconds at 500 cycles. Maximum square-wave, output, 30 volts peak-to-peak.

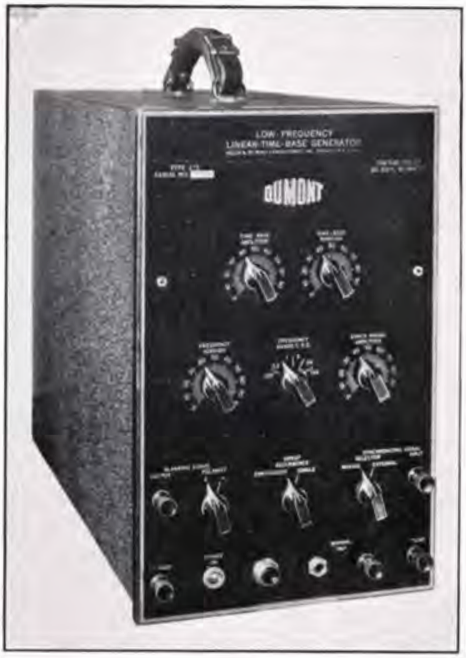
Power Source—Type 185-A is available for operation from either 115 or 230 volt power, whichever is specified. May be changed from one to the other by changing connections to primary of power transformer. Power line frequency, 40-60 cycles, power consumption, 30 watts; fuse protection, 1 ampere.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle. Overall dimensions, 11-3/4" (height) x 7-3/8" (width) x 13" (depth). Weight, 17 lbs.

Catalog No.	Type No.	Description	Code Word
1072	185-A	Electronic Switch and Square-Wave Generator; 115 v., 40-60 cycles	YAUIF
1073	185-A	Same as above, for 230 volts	YAURN

TYPE 215

LOW FREQUENCY LINEAR TIME BASE GENERATOR



- Recurrent sweep frequencies from 0.2 to 125 cycles per second
- Driven sweep durations from 8 milliseconds to 5 seconds
- Balanced sawtooth voltage output up to 400 volts peak-to-peak amplitude
- Extremely good linearity on all sweep ranges
- Return-trace blanking pulse output of either positive or negative polarity

FUNCTION

The cathode-ray oscillograph may be used to investigate the variation with respect to time of any quantity that can be converted into an electrical potential proportional to itself. To accomplish this investigation, however, there must be applied to one pair of deflection plates in the oscillograph a potential which varies in a manner directly proportional to time. It is the function of the Type 215 Low-frequency Linear Time-base Generator to furnish such a potential which can be used to produce a time-base much more nearly linear (with respect to time) and at much lower frequencies than those available from time-base generators incorporated in most commercially available oscillographs.

By connection of the Type 215 output to the horizontal deflection plates of an oscillograph, investigation of very low-frequency phenomena is readily accomplished. Such phenomena are often encountered in vibration studies, stress and strain measurements, and in rotating mechanisms. They may be either recurrent or transient in nature.

DESCRIPTION

The circuits of the Type 215 generate a recurrent, sawtooth-shaped voltage continuously variable in frequency from 0.2 to 125 cycles per second. This range corresponds to rotating speeds from 12 to 7500 r.p.m., clearly illustrating that machinery operating from very low to high speeds may be studied. The sawtooth voltage is made to rise in linear fashion at all frequencies by use of compensating circuits.

The output sawtooth voltage from the Type 215 is at zero d-c potential (balanced about ground) so that it furnishes a symmetrical deflection in producing a time-base, and does not disturb the focus of the oscillograph with which it is used. Amplitude of the output may be varied by a control on the panel. When it is used in conjunction with any Du Mont Oscillograph, the Type 215 will produce a horizontal deflection which may be expanded to the equivalent of a time-base approximately 15 inches in length. D-c positioning voltages which are also balanced about ground are available at the output terminals. They provide a positioning range of at least 10 inches on all

Du Mont oscillographs. Positioning of the time-base on the cathode-ray tube screen is determined by a panel control on the Type 215.

The frequency of the recurrent sawtooth voltage may be synchronized from an external signal connected to a synchronizing terminal on the Type 215 front panel.

An output pulse which is derived from the steep side (return time) of the sawtooth voltage is provided at terminals on the front panel. Either a positive or negative polarity pulse output may be selected by means of a switch. The negative polarity pulse may be applied to the grid of the cathode-ray tube upon which the time-base is produced. It serves to blank out the beam during the return-time of the sweep, since a trace produced during this time might tend to make the pattern on the oscillograph confusing to an observer. If the amplitude of the negative pulse is not sufficient to blank the beam, the positive polarity output may be selected, and a stage of amplification inserted between the pulse output terminal and the grid of the cathode-ray tube.

A switch on the panel of the Type 215 stops the recurrent sawtooth oscillation and adjusts the circuit for driven or single-sweep operation. In this condition, a single sawtooth cycle is generated each time an initiating signal is introduced. The initiating pulse may be applied to the Type 215 either by manual operation of an external switch, or by connecting a transient signal to be studied to the synchronizing terminals.

SPECIFICATIONS

Time-Base Output—Linear sawtooth voltage output available to provide either recurrent or driven (single) sweeps. Recurrent frequency variable from 0.2 to 125 cycles per second; driven sweep duration variable from 0.008 to 5 seconds. Maximum output, 400 volts peak-to-peak balanced about ground potential.

Positioning Output—D-c positioning voltages balanced around ground potential available at output terminals. Positioning range, 300 volts.

Synchronization of Time-Base—Recurrent sweeps synchronized by external signal. Driven sweeps initiated either manually or by positive external signal. An amplitude of 1 volt peak to 5 volts peak is adequate to synchronize or initiate the sweeps at all settings of sweep frequency controls on the Type 215.

Blanking Pulse Output—Positive or negative polarity at approx. 25 volts peak amplitude. Repetition rate determined by frequency of recurrent sweep.

Power Source—Type 215 may be operated from either 115 or 230-volt power. Change from one to the other by means of a switch. Power line frequency, 40-60 cycles, power consumption, 50 watts; fuse protection, 1 ampere.

Physical Characteristics—The instrument is housed in a metal cabinet provided with carrying handle. Overall dimensions, 14-1/4" (height) x 8-13/16" (width) x 19-1/2" (depth). Weight, 35 lbs.

Catalog No.	Type No.	Description	Code Word
1189	215	Low-Frequency Linear Time-Base Generator; for 115 or 230 volts, 40-60 cycles	YAGOK

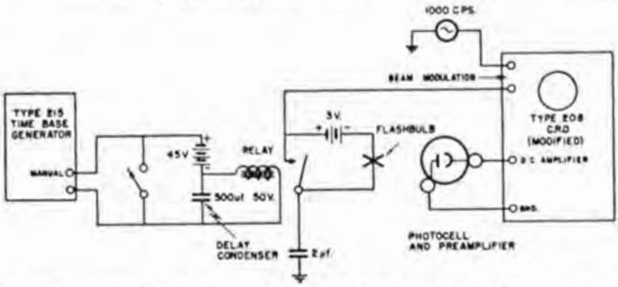


Figure 1. A circuit which demonstrates how the Type 215 may be used in making measurements on flash bulb characteristics. Closing of the battery switch triggers the single (driven) sweep of the Type 215, and the delay condenser begins to charge. When the potential across the condenser reaches a sufficient value (in approximately 1/30 second), the relay is closed and the flash bulb is fired. A photo cell pick-up converts the light from the bulb into a proportional electrical potential which can be plotted on the screen of the cathode-ray oscillograph. A 1000 cycle signal generator modulates intensity of the cathode-ray beam to produce timing-markers on the pattern.

TYPE 263-A
HIGH-VOLTAGE POWER SUPPLY

- Output variable from 5,000 to 10,000 volts
- Direct-reading output meter
- No danger from high-voltage shock
- No damage from accidental short circuits
- Shielded output circuit

FUNCTION

The Type 263-A High-voltage Power Supply is a source of high potential particularly useful in conjunction with a cathode-ray oscillograph. Connection of its output to the intensifier electrode of the cathode-ray tube provides a greater overall accelerating potential than is normally furnished by the power supplies in the oscillograph, and makes possible a considerable increase in light output from the fluorescent screen. This light output is a primary requirement where the oscillograph is to be employed in the investigation of high speed transients or pulses having very low repetition rates, especially when photographic recordings are to be made or the fluorescent trace is to be projected.

Unfortunately in ordinary cathode-ray tubes, intensifier potential cannot be increased much above twice the second anode voltage without introducing serious distortions in deflecting properties. For this reason Du Mont has developed the 5RP-A series of tubes which are so designed that the intensifier may be operated at a potential as high as 10 times that of the accelerator.

Oscillographs such as the Types 248-A and 250-H, which utilize the 5RP-A cathode-ray tube, also employ the Type 263-A High-voltage Power Supply as an external source of intensifier potential. In addition, because of its small size and light weight, the Type 263-A may be used almost anywhere to furnish high potentials and small currents. There is practically no danger from shock as opposed to a conventional high-voltage supply and no damage will be done even if the output is accidentally shorted.

DESCRIPTION

The Type 263-A provides a positive d-c potential output which may be varied by means of a control on the panel from 5000 to 10,000 volts; it will furnish currents up to 200 microamperes. The high voltage is obtained by rectification and filtering of the output from an RF oscillator. A direct-reading meter on the front panel indicates the output potential; a length of shielded cable and connector are provided for attachment to the output connector on the panel of the Type 263-A.

SPECIFICATIONS

Output Characteristics—Voltage positive with respect to ground, negative terminal connected to chassis. Potential variable from 5,000 to 10,000 volts at currents up to 200 microamperes. Output varies not more than 20% from zero to 200 microamperes external load. Ripple voltage on output not more than 0.5% of d-c output voltage.

Power Source—Type 263-A is designed for operation from a 115 volt power line at 50-60 cycles. Power consumption, 100 watts; fuse protection, 1 ampere.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handle. Overall dimensions, 10-7/8" (height) x 8-1/8" (width) x 14-3/4" (depth). Weight, 24 lbs.

Catalog No.	Type No.	Description	Code Word
1206	263-A	High-voltage Power Supply for 115 volts, 50-60 cycles......	YALAA

TYPE 308 HIGH-VOLTAGE POWER SUPPLY

The Type 308 is electrically similar to the Type 263-A High-voltage Power Supply but it is designed for mounting in a standard 19" relay-rack. The perforated metal cover prevents radiation from interfering with the performance of adjacent units. The high-voltage output is available at a connector on the rear of the chassis where it is out of the way of all panel controls. A four-foot length of shielded output cable and connector are furnished with the instrument.

Overall dimensions of the Type 308 are 10-1/2" (height) x 19" (width) x 8" (depth). Weight is 18 lbs.

Catalog No.	Type No.	Description	Code Word
1270	308	High-voltage Power Supply; for 115 volts, 50-60 cycle operation	YALCT

TYPE 264-A
VOLTAGE CALIBRATOR

- Direct means for calibrating any cathode-ray oscillograph or measuring amplitude of any applied signal
- Not necessary to disconnect input to oscillograph while calibration is made
- Small size, simple operation

FUNCTION

The Type 264-A Voltage Calibrator is a simple, inexpensive instrument which can be used in conjunction with any cathode-ray oscillograph, and is small enough to fit on top of most. It provides a convenient method (1) for measuring the amplitude of a signal which is applied to the oscillograph, or (2) for determining deflection factor of the oscillograph at any given setting of amplifier gain controls.

DESCRIPTION

Output of the Calibrator is a square-wave signal the amplitude of which is variable from 0 to 100 volts peak-to-peak. Amplitude of the square-wave may be read directly from a calibrated dial and multiplier switch.

When the Type 264-A is used with a cathode-ray oscillograph, the signal to be investigated is connected to its input terminals, while its output terminals are connected to the input of the oscillograph. The multiplier switch on the Calibrator selects either the signal or square-wave voltage for application to the oscillograph. No leads need be disconnected or reconnected to permit calibration.

To measure the amplitude of the signal, it is only necessary to (1) apply that signal to the oscillograph, (2) note the deflection which it produces on the screen, (3) apply Calibrator output to oscillograph without disturbing oscillograph controls, (4) adjust Calibrator square-wave amplitude to produce same deflection as signal, (5) read amplitude of square-wave from dial and multiplier on Calibrator panel. (6) This amplitude is the peak-to-peak signal amplitude.

To determine the deflection factor of an oscillograph, (1) set the oscillograph gain and attenuation controls at some position, (2) ap-

Figure 1. Signal voltage is passed through the Voltage Calibrator to the Vertical Input of the Cathode-ray Oscillograph. The signal voltage appears on the screen.

Figure 2. Same as Figure 1 except that the OUTPUT MULTIPLIER switch has been turned to the X.1 Position resulting in the calibration voltage appearing on the screen.

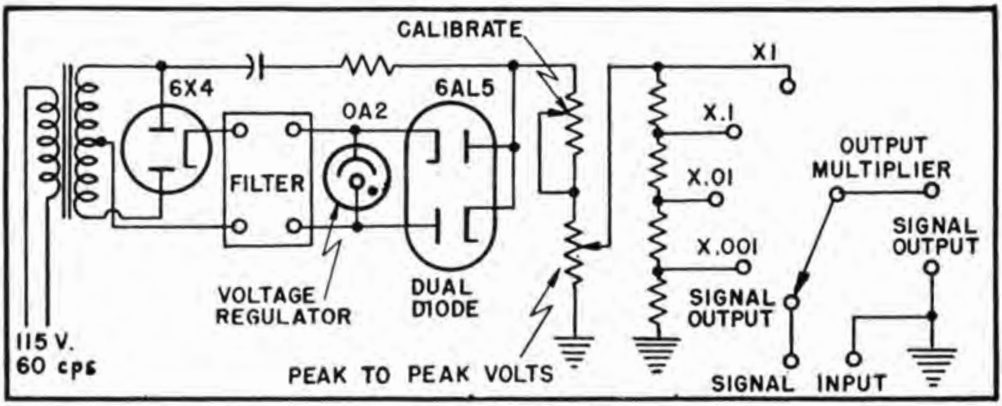


Figure 3. Simplified Schematic Circuit Diagram for the Type 264-A Voltage Calibrator.

ply the Calibrator output and note deflection which it produces. Deflection Factor is the quotient of the Calibrator square-wave amplitude divided by the number of inches deflection produced, and is expressed in peak-to-peak volts per inch.

SPECIFICATIONS

Electrical Characteristics—Output square-wave at power-line frequency, with amplitude variable from 0-0.1 volt, 0-1 volt, 0-10 volts, or 0-100 volts. Accuracy of output dial reading, ±5% of full scale on each range (including power line voltage variations of ±10%). Input impedance to signal, 20 μμf.

Power Source—Type 264-A is designed to operate from either a 115 or 230* volt power line at 50-60 cycles. Power consumption, 20 watts; fuse protection, 1/2 ampere.

Physical Characteristics — Instrument enclosed in metal case. Overall dimensions, 4-1/2" (height) x 8" (width) x 5-3/4" (depth). Weight, 5 lbs.

Catalog No.	Type No.	Description	Code Word
1240	264-A	Voltage Calibrator for 115 volts, 50-60 cycles................	YALBP
*1241	264-A	Same as above, for 230 volts, 50-60 cycles..................	YALBQ

*Note: This catalog item will be available about July, 1948.

TYPE 271-A
OSCILLOGRAPH-RECORD CAMERA

- Specifically designed to make oscillographic recordings
- Mounting provided to fit standard cathode-ray equipment
- Easily attached and removed —correct focus assured at all times
- Time, bulb, or fixed exposures
- Provision for observing pattern during recording

FUNCTION

The Type 271-A Oscillograph-record Camera eliminates the major problems involved in obtaining permanent records from the screen of a cathode-ray oscillograph. There is no necessity to use tripods, to work in the dark, or to be satisfied with make-shift apparatus and mediocre results. This instrument is the first commercially-available, low-priced camera, specifically designed to make oscillographic recordings. It has been stripped of all details which become superfluous when an ordinary still camera is used for this purpose, but adequate features have been incorporated to make it perform its prime function conveniently and completely. The camera is invaluable in the study of transients or non-repetitive phenomena where visual observation will not suffice. It can also be used to make photographs of steady-state phenomena appearing on the screen of any standard five-inch cathode-ray oscillograph.

The light-proof hood of the Type 271-A Oscillograph-record Camera clamps to the bezel which is provided on many commercial cathode-ray instruments. Where no such bezel has been provided, the Type 2501 Bezel furnished with the Type 271-A Camera may be attached permanently to the front panel of the cathode-ray oscillograph, and the camera then clamped on. Since the camera can be attached or removed quickly, the cathode-ray oscillograph with which it is employed can be used for more than one purpose. Furthermore, the hood of the camera may be used alone as a light shield, under conditions where ambient light makes visual observation of the cathode-ray trace difficult.

DESCRIPTION

The Type 271-A is shown in Figure 1. The split clamp at the front of the camera is a separate, removable part which clamps firmly to the bezel on the front panel of the oscillograph. The cylindrical body or hood, which is edged with a rubber ring, passes through the clamp and bears against the face of the cathode-ray tube, automatically establishing the correct focal distance for the camera.

It is equipped with a coated f/3.5 lens, and a shutter calibrated for Time, Bulb, and 1/30 sec. exposure. It is designed to use any stand-

Figure 1. Clamping Ring. The body of the Type 271-A Camera passes through the clamping ring to bear against the face of the cathode-ray tube. No adjustment of focus is necessary. The rubber edge provided on the body of the camera prevents the possibility of scratching or otherwise damaging the face of the cathode-ray tube.

Figure 2. Convenient Disassembly. For the adjustment of shutter speeds, lens speeds, and for reloading, the camera may be simply removed from the light hood to which it clamps securely with a bayonet lock and spring detent. The camera body, exclusive of the mounting clamp and hood, may be removed from the oscillograph to leave the hood to serve as a convenient light shield.

ard 35 mm. film cartridge, so the film may be processed with commercially-available developing and printing equipment. A peep-hole is provided at the back of the camera to permit adjustment of the oscillograph before a record is taken. This peep-hole also permits visual monitoring of the records during exposure without danger of fogging the film. A sliding closure for the peep-hole makes the camera housing completely light-tight.

MAXIMUM PHOTOGRAPHIC WRITING SPEEDS

The theoretical maximum photographic writing speed obtainable from a given set of equipment is defined as the maximum writing speed of the luminescent spot which will yield a negative density of 0.1 above fog, using a lens speed of f/1.0, a high sensitivity photographic emulsion, an object:image ratio of 1:1, and with development in a high-contrast developer.

The maximum photographic writing speeds which can be recorded with the Type 271-A Oscillograph-record Camera from Du Mont cathode-ray oscillographs are listed in Table 1. The speed specified is that of the fluorescent spot on the cathode-ray tube screen. Among the factors determining the maximum photographic writing speed of the luminescent spot which can be photographed from the screen of a cathode-ray tube are: lens speed, type of photographic emulsion, type of screen phosphor employed, spot brightness, object:image ratio, and development techniques employed. In general, the highest speeds will be obtained by the use of a P11 screen phosphor and a fast, orthochromatic film.

The writing speeds shown in Table 1 assume high-contrast development of high-sensitivity negative emulsions such as Eastman Super XX, Agfa Triple-S Ortho, Eastman 5211 or Eastman 5244. These data are based upon the brilliance obtained from average cathode-ray tubes with P11 phosphors, operated at the accelerating potentials which are available in the oscillographs listed.

By stopping down the lens of the Type 271-A Camera, writing speeds slower than those shown may be photographed. The method for determination of the proper exposure for any writing speed is described in the operating instructions for the Type 271-A Camera and in the Du Mont bulletin entitled, "Cathode-ray Tube Screens and their Characteristics," Form 629. This bulletin is available upon request.

TABLE I

				Average Photographic Writing Speed with P11 Screen	
		Maximum Accelerating Potential Volts			
Du Mont Oscillo-graph. Type No.	Tube Type	E_{b2}	E_{b3}	Inches Per Microsecond	Kilometers Per Second
208-B	5LP11-A	1,120	1,400	.04	1
213-A	5LP11-A	1,000	2,000	.15	4
241	5JP11-A	1,100	1,500	.04	1
247	5CP11-A	1,550	3,000	.4	10
247 with 263-A	5RP11-A	1,550	11,550	4.9	125
248	5JP11-A	2,000	4,000	.63	16
248-A with 263-A	5RP11-A	2,000	12,000	8.6	220
250	5CP11-A	1,700	3,200	.47	12
250-H with 263-A	5RP11-A	1,700	11,700	4.6	170
274	5BP11-A	1,000	1,000	.02	0.5
275-A	5CP11-A	1,500	3,000	.4	10
280	5RP11-A	1,900	11,900	7.8	200
288	5RP11-A	1,900	19,000	11.8	300
281	5RP11-A	4,000	8,000	7.1	180
281 with 263-A	5RP11-A	4,000	14,000	17.7	450
281 with 286	5RP11-A	4,000	29,000	27.5	700

SPECIFICATIONS

Photographic Characteristics—Lens speed of f/3.5; iris diaphragm to allow variation to f/16. Shutter calibrated for time, bulb, or 1/30 second exposures. Fixed-focus; object to image ratio approximately 4.5 to 1. Uses any 35 mm. roll film in standard cartridge.

Physical Characteristics—Max. diameter of mounting clamp, 6 inches. Max. diameter of hood at center, 4-3/4 inches. Overall length, 13-1/2 inches; weight, 4-1/2 lbs.

Max. inside diameter of clamp ring, 5-1/2 inches; minimum inside diameter, 5-3/16 inches.

Catalog No.	Type No.	Description	Code Word
1216	271-A	Oscillograph-record Camera, including mounting bezel....	YALAR
1215	2501	Mounting Bezel, only, for Type 271-A Oscillograph-record Camera	YALAP

Unlock

Insert Spool

Thread Film

Take Up Loose Film

Close and Lock

Advance Film Thru 4 Frames

Set Counter

Figure 3. Loading Sequence for the Type 271-A Camera

TYPE 286
HIGH-VOLTAGE POWER SUPPLY

- Source of high-voltage variable from 18,000 to 25,000 volts
- Electronic regulation of output
- Safe, simple operation
- Portable instrument or permanent mounting in standard relay-rack

FUNCTION

The Type 286 High-voltage Power Supply is a rectified radio-frequency type of power supply with regulated output. It is intended primarily as an intensifier supply for high-voltage cathode-ray tubes, but it may be used wherever a variable high-voltage source is called for, and current required is not great.

The Type 286 has several advantages over conventional types of power supplies.

(1) Accidental contact with the high voltage is less dangerous because very little power is stored in the filtering circuits.

(2) No damage will result if the output is short-circuited.

(3) It is much lighter because the transformer core is air instead of iron, and because the filtering circuits are simpler and smaller.

***Figure 1. Top View of Chassis.** The simplicity of this high voltage power supply and its comparatively light weight both result from the use of a rectified, high-voltage, radio-frequency signal to supply the output power.*

DESCRIPTION

All controls are located on the front panel. They include a primary-power switch, a high-voltage switch, and a control which varies the output potential between 18,000 and 25,000 volts. A direct-reading voltmeter indicates the output potential. Only the primary-power and plate-supply switches need be operated to turn the supply on or off.

The circuit consists of an r-f oscillator and associated power supply, a step-up transformer as part of the oscillator circuit, a voltage-doubler rectifier system, a high-voltage filter, and output-voltage regulator. The regulator maintains a constant output potential even with large changes in power-line voltage and external current requirements. The arrangement of the components has been carefully designed to allow for the high potentials which are present.

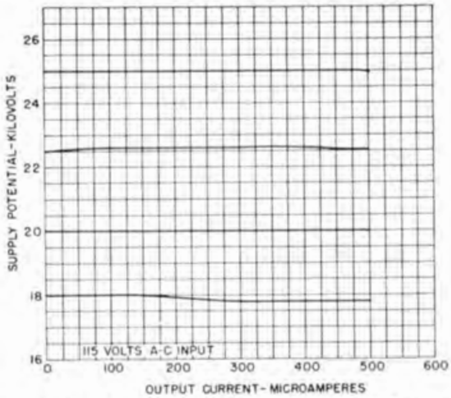


***Figure 2. Output Potential versus Load Current.** The regulation of the Type 286 power supply is provided to adapt the instrument particularly for use as a source of third-anode potential for high-voltage cathode-ray tubes.*

Adequate shielding is provided to permit use of this instrument in close proximity with sensitive amplifiers and cathode-ray tubes. The high-voltage output cable is located at the back of the Type 286 where it is out of the way of the panel controls.

Although the Type 286 is basically designed for relay-rack mounting, it is furnished with its own dust-proof cabinet, and can be used as a portable instrument. Provision is also made to fasten the cabinet conveniently to that of the Du Mont Type 281 Cathode-ray Indicator to combine them into a single instrument. Refer to Figure 3, page 63.

SPECIFICATIONS

Output Characteristics—Regulated, high-voltage variable from 18,000 to 25,000 volts. Positive with respect to ground (chassis of instrument). Power-line voltage variation of ±10%, or external current change from 0-500 microamperes, produces not more than 5% variation in output voltage at any initial output setting. Accuracy of output meter, ±2% of full scale.

Power Source—Type 286 is designed to operate from either a 115 or 230 volt power-line; changeover by means of switch on instrument. Power-line frequency, 50-60 cycles; power consumption, 200 watts; fuse protection, 1-1/2 amperes.

Physical Characteristics—Instrument housed in metal cabinet provided with carrying handles. Overall dimensions, 12-1/4" (height) x 20-3/4" (width) x 20-1/2" (depth).

Provision for mounting without cabinet in standard 19" relay-rack. Weight with cabinet, 90 lbs; without cabinet, 60 lbs.

Catalog No.	Type No.	Description	Code Word
1285	286	High-voltage Power Supply for 115 volts, 50-60 cycles.....	YALDL
1286	286	High-voltage Power Supply for 230 volts, 50-60 cycles......	YALDM

TYPE 314
OSCILLOGRAPH-RECORD CAMERA

Figure 1. The Type 314 Oscillograph-record Camera mounted on a Du Mont Cathode-ray Oscillograph.

- Moving-film or single-frame recording
- Mounting on any 5-inch oscillograph provides correct focal distance and does not interfere with oscillograph controls
- Calibrated, variable film speed
- Provision for remote control
- Simultaneous viewing and recording

FUNCTION

The Type 314 Oscillograph-record Camera is designed for both continuous recording and single-frame exposures. It is quickly and easily attached to any 5-inch oscillograph, and does not interfere with the oscillograph controls. Furthermore, correct centering and focusing are automatically accomplished in the mounting, and the camera need not ordinarily be used in a darkened room or with a tripod or other cumbersome equipment.

This camera fulfills a long-standing need for a general-purpose, easy-to-use camera to record phenomena from the screen of a cathode-ray tube. In the fields of electricity and electronics, physics, biology, physiology, mechanics, hydraulics, geology, and acoustics, to name a few, innumerable occasions arise where it is necessary to obtain permanent records which can be studied at convenient times or which must be maintained for reference purposes.

Some phenomena such as starting characteristics of motors and fluorescent lamps, sound reverberations, cylinder pressures in engines, etc., are transient in nature and occur so rapidly that visual study is impossible. Single-frame exposures may be made of these. Other phenomena, such as welding currents, oscillator frequency drift, line-voltage fluctuation, radioactive emission, pressure variation, mechanical vibration, and acoustical reflection, all occur over relatively long time intervals so that continuity would be lost in visual observation. Continuous, moving-film recordings are best-suited for these studies.

Whenever changing, related phenomena are plotted simultaneously, as on a multiple-beam cathode-ray tube, continuous recording enables determination of exact phase and amplitude relationships at all times as no other means could accomplish. From the film record, accurate quantitative as well as qualitative measurements may be obtained.

DESCRIPTION

General

The Type 314 uses either standard 35-mm. roll film or paper in the form of 35-mm. perforated rolls. It is equipped with a motor drive and electronic speed control for moving-film recording. This control is calibrated in inches per minute and in inches per second. A shutter on the camera is used in making single-frame exposures. It provides either "time" or "bulb" exposures as well as speeds up to 1/400 second. An interlock prevents operation of the camera in the continuous-run position unless the shutter is open.

The camera is available with either an f/2.8 or an f/1.5 lens. All other conditions being equal, the f/1.5 lens will record writing rates about 4 times as fast as are possible with the f/2.8 lens.

A viewing port in the optical system makes possible simultaneous viewing and recording without fogging the film.

Moving-Film Recording

Three general methods may be used to obtain moving-film recordings with the Type 314. The first utilizes the motion of the film as a time-base and records along the length of the film. The phenomenon to be recorded is connected to the oscillograph to produce deflection at right angles to the motion of the film. Since the film moves vertically in front of the cathode-ray tube, this means that the signal must either be connected to the horizontal amplifier of the oscillograph, or to the vertical amplifier, with deflection plate connections interchanged so that horizontal deflection is produced. On many Du Mont oscillographs, deflection plate connections may be changed by a strap and terminal arrangement at the rear without removing the oscillograph from its cabinet. On other oscillographs, the same result can be achieved by reversing connections internally, or by rotating the cathode-ray tube 90 degrees. It is ordinarily preferable to use the vertical amplifier of the oscillograph because of its greater sensitivity and wide-band frequency response. However, in some cathode-ray oscillographs where vertical and horizontal amplifiers are identical, there is no preference. This method is entirely satisfactory for relatively slow or medium-speed phenomena, since the speed

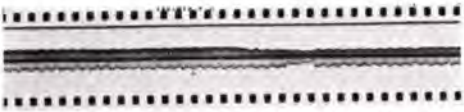


***Figure 2.** Continuous recording showing typical power-line voltage fluctuations. Voltage peaks have been clipped and amplified in order that variations may be more clearly seen. Motion of the film provided the time-base for this recording.*

***Figure 3.** Continuous motion recording of starting current in a synchronous motor under load. Current is switched from starter winding as motor builds up torque. Timing markers are unnecessary since each cycle represents 1/60 second. Motion of film provides time base.*

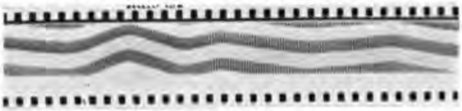


***Figure 4.** Continuous recording made with Type 314 Camera to show frequency drift of an oscillator. Successive sweeps of the oscillograph are plotted across the width of the film. Sweep synchonized at 60 cycles per second; oscillator output is applied to modulate intensity of the cathode-ray beam. Frequency drift indicated by modulation occurring in different portions of sweep cycles.*

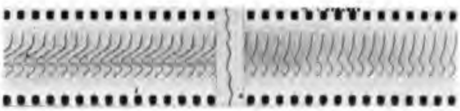


***Figure 5.** Continuous recording of biological process showing action potential of frog's sciatic nerve in response to electrical stimulation at a repetition rate of 60 per second. (Courtesy of Dr. H. Grundfest, Columbia Medical Center, New York). Both oscillograph sweep and film motion were used to record across the film.*

which can be recorded is limited by the film speed and resolution of the film. Frequencies up to about 10,000 cycles per second can be handled by this method with the film speeds available in the Type 314.

The second method utilizes both the oscillograph sweep and film motion to record each successive sweep across the width of the film. With this method the film need travel only at a rate sufficient to separate the sweeps; the only limitation on the speed which can be recorded in this manner is the maximum photographic writing speed of the oscillograph itself.

The third method is useful in photographing phenomena which have frequency components at the beginning much higher than occur thereafter. A single sweep on the oscillograph, connected to move the fluorescent spot in the same direction as the film motion, may be used to spread out the initial portion of the phenomenon over a greater length of film. When the sweep is finished, the film motion alone provides the time-base.

Single Exposures

The shutter is used for this application of the camera. It is normally operated manually, but remote operation is possible. Film advance after single exposures is accomplished by a manually

Figure 6. Front view of Type 314 Camera showing the lens, the manually operated lever for film advance after single exposures, the footage indicator which shows the exposed film length, and the push-pull knob on the side to actuate the clutch.

operated lever provided with an adjustable stop which can be set to advance the film from 1/4 of a standard 35 mm. frame to double frame height—approx. 5 to 39 mm. If many exposures are to be made at more or less regular intervals, the film may be driven continuously at low speed by using the variable-speed motor drive.

Film Speed

The rate of film movement is determined by adjustment of the electronic control unit. Speed may be varied over a 60 to 1 range by means of this control, and may be read from a calibrated dial. In addition, a clutch is provided to insert an additional 60 to 1 ratio between the motor and driving sprocket. To actuate the clutch, there is a knob on the side of the camera which may be shifted while the motor is in operation. It is therefore possible to increase or decrease film speed almost instantaneously (less than 0.01 second) by a factor of 60.

Timing Light

A neon timing light in the camera may be used to record timing-marker spots along the edge of the film, thus providing a permanent record of actual film speed and a means of making time measurements on the recorded signal. A voltage to operate this light may be connected at a pair of terminals on the speed control unit. Power-line voltage, or almost any a-c or intermittent source will serve to operate the light.

Film Length

The film chamber of the Type 314 takes standard 100-foot Daylight Load spools of 35-mm. film, but an adapter plate will be available which may be attached to the camera and which will accommodate a 1000-foot 35-mm. film magazine. A footage indicator on the camera shows the number of feet of film which are exposed.

Mounting

A periscope arrangement is provided to permit mounting the camera on top of an oscillograph where it does not interfere with operation of the controls. A rubber ring on the periscope fits against the face of the cathode-ray tube to exclude all light and at the same time to provide automatic centering and focus. The periscope and mount attach to bars, which are fastened to the oscillograph by a snap-lock arrangement for quick installation or removal. Various spacers are provided to allow for variation in tube location (with respect to the top of the cabinet) on different oscillographs. An adjustable bracket is provided for proper location with respect to the tube face.

Once the spacers are in place, and the bracket adjusted for a particular oscillograph, they may be left permanently so that the camera can be instantly attached at any time. Additional mounting kits may be obtained for other oscillographs with which the camera is to be used. Only four small holes need be drilled in the top of the oscillograph and, because of the adjustments provided, accurate location is not necessary.

The electronic control unit is connected to the camera by a cable, and therefore may be mounted in any convenient location.

The Type 314 can also be used with a tripod or other mount instead of on top of an oscillograph. For this reason, a raised index point is provided on the front of the camera from which the focal distance may be measured.

Data Record

A lucite disc is provided upon which data concerning the recording may be written with an ordinary pencil. This disc with the written data may be snapped on the periscope, illuminated, and photographically recorded by single-frame exposure just before a continuous recording is made. Information concerning the recording then appears directly on the film. There is no chance that it might be misplaced or mistakenly connected with another recording.

A switch on the electronic control unit provides illumination of the disc. Connections are such that the motor drive will not operate while the disc is illuminated.

Remote Control

Terminals on the Electronic Control Unit permit connections of the motor-control circuit to some external control circuit for automatic operation of the camera when desired. A standard electrical release for the camera shutter can be obtained for remote electrical operation if desired, or for tripping the shutter for single exposures by means of the phenomenon to be recorded.

SPECIFICATIONS

General—Complete assembly consists of 35 mm. roll film camera with lens and shutter, Electronic Film Speed Control Unit, Periscope Cone, Mount, Cables, and Data Card Unit.

Film Speed—Variable from 1 inch to 3,600 inches per minute.

Exposure Capacity—Single exposures up to double-frame length. Continuous exposures up to 100 feet with internal magazine; 1,000 feet with external magazine.

Recording Time—With 100-foot reel, 20 seconds to 20 hours. With 1,000-foot reel, 3-1/3 minutes to 8-1/3 days. Timing marks recorded along edge of film.

Lens and Shutter—50 mm. coated f/2.8 lens in Rapax No. 2 shutter (f/1.5 lens optional). Shutter provides "time" or "bulb" exposures in addition to calibrated speeds of 1 to 1/400 second.

Film Record—Recording across film if oscillograph sweep is used; along length of film if film motion provides sweep. Oscillograph may be viewed while camera is recording.

Data Record—Data can be recorded at the beginning or end of each run.

Physical Characteristics—Approximate dimensions of Camera: 7½" x 9⅛" x 11½"; Electronic Control: 5" x 10" x 9¼"; Periscope and Mount Assembly: 5½" x 11⅝" x 21½".

Approximate weight of Camera: 16¼ lbs.; Electronic Control, 10¾ lbs.; Periscope and Mount, 6 lbs.

Power Source—Type 314 operates from 115 volt power line at frequency of 50-60 cycles. Power consumption, 135 watts.

Catalog No.	Type No.	Description	Code Word
1217	314	Oscillograph-record Camera, with f/2.8 lens in Rapax No. 2 shutter; 115 volts, 50-60 cycles	YALAS
1366	314	Same, with f/1.5 lens in Rapax No. 3 shutter	YALGV

Average Exposure Guide for the Du Mont Type 314 Oscillograph-Record Camera

WITH STATIONARY PATTERN OF TEN SINE WAVE CYCLES ON SCREEN MEDIUM INTENSITY SETTINGS

E. K. Penatomic-X Film **D-76 Developer—14 Minutes**

For E. K. Type 1115 Paper—use twice the listed exposure

For E. K. Super XX, Linagraph Ortho or Linagraph Pan and SD-19a Developer, use ¼ of the listed exposure or two diaphragm stops higher

Du Mont Oscillograph, Type No.	Cathode-ray Tube	Accelerating Voltage	Exposure		
			Diaphragm Setting	Seconds Time or Bulb	Sweep Frequency cps.
208-B	5LP11A	1,400	5.6	1	15- 30,000[2]
213-A	5LP11A	2,000	2.8 or 1.5	2 or 1	15- 30,000[3]
241	5JP11A	1,500	5.6	1	15- 30,000[2]
247	5CP11A	3,000	8	½	60- 30,000[2]
247-A+263-A	5RP11A	11,550	16	½	60- 30,000[2]
248	5JP11A	4,000	11	½	60-100,000[2]
248-A+263-A	5RP11A	12,000	16	½	60-100,000[2]
274	5BP11A	1,000	4	1	60- 30,000[2]
275-A	5CP11A	3,000	8	1	1-60
280	5RP11A	11,900	16	½	30[4]
288	5RP11A	19,000	16	½	30[4]
281	5RP11A	8,000	16	½	60[2]
281+263-A	5RP11A	14,000	16	¼	60[2]
281+286	5RP11A	29,000	16	¼	60[2]

NOTES:

1. To obtain approximate exposures for other screen types, multiply by the following factors: P1—3 times, P2—5 times, P5—2 times, P7—2 times.
2. For slower sweep speeds than those given, decrease the exposure proportionately.
3. For 100% modulated sine wave envelope.
4. For shorter sweeps increase the exposure proportionately.

Average Single Transient Recording Speeds of Du Mont Cathode-Ray Oscillographs with the Du Mont Type 314 Oscillograph-Record Camera
with f/2.8 or f/1.5 Lens

Using E. K. Linagraph Ortho, Linagraph Pan and SD-19a Developer—17 Minutes

For E.K. Super XX-Developed in SD-19A, maximum photographic writing speeds will be approx. 1/2 the given values.

Du Mont Oscillograph, Type No.	Cathode-ray Tube	Maximum Accelerating Potential Volts		Maximum Photographic Writing Speed, Vmax, with P11 Screen			
		Eb_2	Eb_3	In. per Micros'e'd		Centim'ts/Micros'e	
				f/2.8	f/1.5	f/2.8	f/1.5
208-B	5LP11A	1,120	1,400	0.08	0.32	0.2	0.8
213-A	5LP11A	1,000	2,000	0.314	1.25	0.8	3.2
241	5JP11A	1,100	1,500	0.08	0.32	0.2	0.8
247	5CP11A	1,550	3,000	0.8	3.2	2.0	8
247-A+263-A	5RP11A	1,550	11,550	10	40	25	100
248	5JP11A	2,000	4,000	1.26	5	3.2	12.8
248-A+263-A	5RP11A	2,000	12,000	17.3	69	44	176
274	5BP11A	1,000	1,000	0.04	0.16	0.1	0.4
275-A	5CP11A	1,500	3,000	0.08	3.2	2	8
280	5RP11A	1,900	11,900	15.7	63	40	160
288	5RP11A	1,900	19,000	23.6	95	60	240
281	5RP11A	4,000	8,000	14.2	57	36	144
281+263-A	5RP11A	4,000	14,000	35.4	142	90	360
281+286	5RP11A	4,000	29,000	70	270	176	685

1. These maximum photographic writing speeds are referred to the face of the cathode-ray tube, and are defined as the highest writing speeds of the fluorescent spot which can be photographed under the given conditions of accelerating potential, type of cathode-ray tube screen, film material and processing procedure with the Type 314 Oscillograph-Record Camera.

   The figures are based on a minimum usable photographic density of 0.1 above film fog. These recording speeds may be obtained with an average cathode-ray tube of the type given in the table, when using fresh film stock and processed in a high emulsion-speed developer as indicated above. There are various techniques for increasing film speeds and a deviation of as much as ±100% from the figures given, may be obtained depending on the age of the cathode-ray tube and the actual processing procedure.

   For further details concerning maximum writing speeds and exposure determination, see the section on Screen Characteristics.

2. *Determination of Exposure for Slow Speed Transients or Continuous Motion Recording*

   As mentioned above, the writing speeds listed would yield photographic recording densities of about 0.1 above fog. At slower writing speeds, proportionately higher densities will be obtained. However, because of the film latitude and wide range of usable recording densities, overexposure will usually not be obtained until the writing speeds are less than 1/10 that of listed values. For recording writing speeds less than 1/10 the maximum, the effective exposure may be decreased either by:

   (a) stopping down the lens aperture

   (b) turning down the brightness control of the cathode-ray oscillograph, or *preferably*

   (c) using a slower speed, fine grain film such as E.K. Panatomic X, developed in a standard developer such as D-76.

3. *Repetitive Transients*

   Decrease the exposure proportionately to the repetition rate increase above 1 per second.

4. The maximum photographic writing rates specified above represent the limitations of the particular cathode-ray tube used, at the operating voltages available in the oscillograph. These figures do not pertain to any frequency limitations of the oscillograph amplifiers since such specifications are included in the regular oscillograph instruction manual.

DU MONT
CATHODE-RAY ACCESSORY EQUIPMENT

TYPE 189 MOVABLE TABLE

DESCRIPTION

In a laboratory, it is often convenient to be able to move instruments and other equipment from place to place as a unit without disturbing connections and without having to consume valuable work-bench space. The Type 189 Movable Table fulfills just such a need. It is constructed of welded, cold-rolled steel capable of supporting heavy weights, and is provided with large, rubber-tired, swivel casters which move easily and noiselessly along the floor.

The large table top at standard work-bench height provides an area of more than 600 square inches, ideal for accommodation of an oscillograph, signal generators, meters, and similar instruments. A lower shelf only a few inches from the floor is a handy space for carrying auxiliary units such as power supplies. The big drawer underneath the top surface may be used to store and transport tools, test leads, and notebooks.

SPECIFICATIONS

Physical Characteristics — Width 20-1/4 inches, depth 32-1/4 inches, height 30-3/4 inches. Weight, 78 lbs.

Catalog No.	Type No.	Description	Code Word
1156	189	Movable Table	YEFEC

TYPE VP-5 VIBRATION PICK-UP

DESCRIPTION

The Type VP-5 is used to transform a mechanical vibration into a proportional electrical potential suitable for producing deflection on a cathode-ray oscillograph. The potential produced is proportional to the acceleration which the Pick-up receives when it is attached to a vibrating body, and is therefore proportional to the product of vibration amplitude and square of the vibration frequency. An approximate relation for the response, before resonance is approached, is given by the expression, $V = KAf^2$, where V is generated potential, K is a constant determined by pick-up sensitivity, A is the amplitude and f is the frequency of the vibration.

At a given frequency, the amplitude of the generated potential is directly proportional to the amplitude of motion, and the frequency will be the same as that of the vibration, if the latter is a simple harmonic motion. If it be complex, however, (not simple harmonic) the harmonics will be magnified in a manner determined by the response curve of the pick-up.

There are no moving parts to actuate the crystal. The vibratory motion, which the case receives by contact with a vibrating body, causes the crystal element to bend because of its inertia. Large vibration amplitudes cannot damage the Pick-up; the maximum amplitude which may be observed is determined by the manner in which the pick-up is applied to the vibrating body.

The Type VP-5 is useful in applications such as dynamic balance of rotary devices, determination of vibration in beams and other structural members, and in general wherever vibrations are to be investigated using a cathode-ray oscillograph.

SPECIFICATIONS

Response: Frequency response approximately square-law to 3000 cycles per second

Sensitivity: 30 rms volts per 0.001 inch motion at frequency of 500 cycles per second

Vibration Axis: Perpendicular to large face

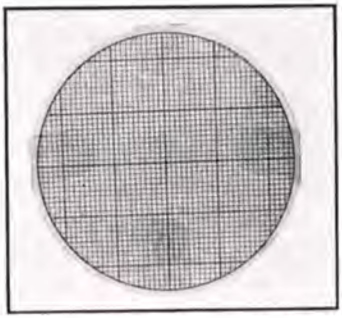
Grid Resistor: 5 megohms (recommended)

Output Impedance: Capacitive: 0.005 μf. at 23° C.; 0.0015 μf. at 40°C. Resistive: in excess of 10 megohms

Physical Characteristics: Diameter, 3 inches; depth, 1-1/2 inches; length of prod, 8-5/8 inches. Weight of crystal unit alone, 7 oz.; unit and prod, 11 oz.

Catalog No.	Type No.	Description	Code Word
1079	VP-5	Vibration Pickup	YAYMA

TYPE 216 SCALES AND FILTERS



The Type 216 Calibrated Scales provide convenient means for making both relative and quantitative measurements with a cathode-ray oscillograph. They are fastened in front of the cathode-ray tube screen by four celluloid tabs which are equally spaced around their circumference, and which grip the sides of the tube. They may be quickly removed when not required.

The Type 216-A (3 inch) and Type 216-C (5 inch) are of clear celluloid with black calibration lines. Calibration is made 10 x 10 lines to the inch with tenth lines accentuated. These scales are supplied as standard equipment with many Du Mont oscillographs.

The Type 216-D Scale (5 inch) is of clear celluloid with a logarithmic decrement calibration along one ordinate. It is used principally in making measurements on oscillatory systems.*

The Type 216-E Scale (5 inch) is logarithmically calibrated along one ordinate so that direct measurement of the Q of oscillatory systems may be made.*

The Type 216-F Scale (5 inch) is calibrated from 0 to 360 degrees in polar coordinates. It is useful in measuring such quantities as radiation patterns from light sources or from antennae; it is also supplied with the Type 275-A Polar-coordinate Indicator.

The Type 216 Filters are 5-inch discs of colored plexiglass designed to fit between the screen of a cathode-ray tube and any of the Calibrated Scales. They are extremely useful, for example, with the P2 and P7 cathode-ray tube screens, which have different color fluorescent and phosphorescent characteristics. There they provide for visual separation of initial screen excitation from the excitation which remains due to persistence characteristics of the screen.

The Type 216-G filters out everything except green light.

The Type 216-H filters out all except blue light.

The Type 216-J filters out all light other than amber.

The Type 216-K is a green, translucent scale designed for use with 5-inch cathode-ray tubes. It is calibrated in polar coordinates and reads from 0 to 720 degrees in a clockwise direction. The zero degree line is normally at the top of the scale.

* Refer to Du Mont "Oscillographer," Mar.-Apr. 1945, for more information concerning the Logarithmic Decrement and Q Scales.

Catalog No.	Type No.	Description	Code Word
1129	216-A	Three-inch Calibrated Scale	YECYA
1128	216-C	Five-inch Calibrated Scale	YECUD
1130	216-D	Five-inch Decrement Scale	YECYB
1131	216-E	Five-inch Q Scale	YECYC
1132	216-F	Five-inch Polar-coordinate Scale	YECYD
1133	216-G	Five-inch Green Filter	YECYE
1134	216-H	Five-inch Blue Filter	YECYF
1135	216-J	Five-inch Amber Filter	YECYG
1136	216-K	Calibrated, polar coördinate, green-translucent scale, 0-720° clockwise	YECYH

TYPE 276 VIEWING HOOD

This black rubber hood may be easily fitted to any equipment which uses a 5-inch cathode-ray tube. It improves pattern contrast on the tube screen by reducing ambient light level, and is shaped so that it can completely shield the eyes of an observer, producing darkened-room conditions under any circumstances.

In addition to its use wherever unfavorable ambient light conditions exisit, the Type 276 is also used for viewing on a cathode-ray tube screen fast writing speeds which would not be visible with less favorable contrast. Overall length of the hood is 10-1/2 inches.

Catalog No.	Type No.	Description	Code Word
1210	276	5-inch Viewing Hood	YALAM

TYPE 277 MICROPHONE

This crystal microphone has a high output impedance and may be directly connected to the input circuits of cathode-ray oscillographs. No pre-amplifiers are necessary. Its response is uniform in all directions; its frequency response characteristic is uniform over the entire audio range. The Type 277 is furnished with a stand 15-1/2 inches high, and with a 7-foot length of single conductor, shielded output cable plus connector.

It is particularly useful with a cathode-ray oscillograph in acoustical investigations, noise study, for demonstration purposes, and wherever else it is necessary to translate acoustic into electrical energy.

SPECIFICATIONS

Output Impedance: Greater than 500,000 ohms

Output Level: At 1000 cycles, —0.05 db. below 1 volt per bar effective sound pressure

At 1000 cycles, 31.6 millivolts for 10-bar sound pressure

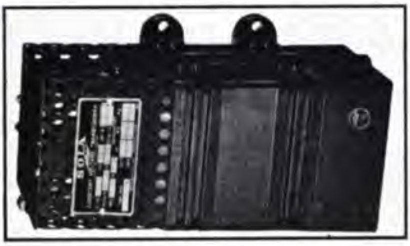
Frequency Response: Uniform up to 10,000 cycles per second

Directional Response: Circular at audio frequencies

Weight: 1-7/8 lbs. (including stand)

Catalog No.	Type No.	Description	Code Word
1212	277	Microphone	YALAO

TYPE 283 CONSTANT-VOLTAGE TRANSFORMER



A constant-voltage transformer is recommended whenever cathode-ray equipment must be operated from power lines where large voltage variations may interfere with performance.

Most Du Mont oscillographs are designed to perform satisfactorily on lines with as much as ±10% voltage variation, but greater fluctuations may produce depositioning of the pattern and objectionable modulation of beam intensity.

The Type 283 is designed for operation from a 60-cycle, single-phase power source. It delivers a constant secondary potential of 115 rms volts for input variations between 95 and 125 rms volts. Maximum output rating is 250 volt-amperes. Overall dimensions are 11-1/2" depth by 6-15/16" height x 6-5/16" width; shipping weight is 30 lbs.

Catalog No.	Type No.	Description	Code Word
1214	283	Sola C-V Transformer	YALAQ

TYPE 2088 PROJECTION LENS

DESCRIPTION

- Projection of patterns from cathode-ray tube screens
- Image sizes up to 12 feet square
- Quickly attached to or removed from Du Mont equipment

FUNCTION

The Type 2088 Projection Lens is designed for the primary purpose of projecting patterns from cathode-ray tube screens. In this capacity, it is invaluable for lecture and demonstrations to large groups. It is intended to be used in conjunction with the Type 5RP-A Cathode-ray Tube, since this tube alone is capable of the light output suitable for projection. All Du Mont equipment utilizing the Type 5RP-A is designed so that the Projection Lens may be easily attached.

DESCRIPTION

General

Type 2088 is a two-element, symmetrical, objective lens with a relative aperture of f/3.3 and focal length of 7.7 inches. It can project an area up to 3 inches by 3 inches from a cathode-ray tube screen to distances beyond 8 feet, producing a projected area approximately 12 feet square. Axial light transmission of the lens is about 85%.

Lens Mounting

Four threaded holes are provided in the front panel of Du Mont instruments which are designed or adapted to accommodate the Type

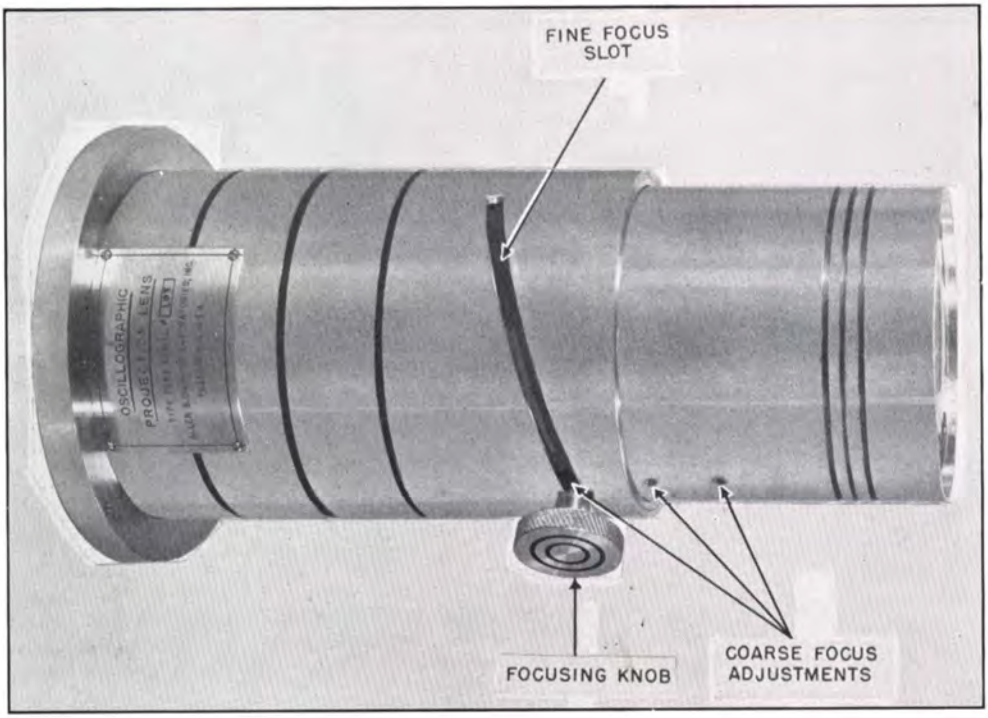
5RP-A Tube and the Type 2088 Projection Lens. Four screws are supplied with the Lens to secure it in proper position in front of the cathode-ray tube.

Focus Adjustment

A sliding focus knob on the barrel of the Lens permits convenient, precise focusing once the oscillograph and the projection screen are set up. The pattern on the cathode-ray tube may be electrically focused by adjusting the oscillograph controls while looking through the Lens.

NOTE

The image on the projection screen is reversed with respect to the pattern as viewed directly on the cathode-ray tube. It may be necessary, when non-symmetrical patterns are projected, to reverse the image by reversing the deflection plate leads on the oscillograph. If a reflective type of projection screen is used, it is only necessary to transpose the vertical deflection plate leads; if a transmissive screen is used, it is necessary to transpose both sets of leads.



Catalog No.	Type No.	Description	Code Word
1249	2088	Projection Lens	YALBY

TYPE 2501 BEZEL

The Type 2501 Bezel is intended for mounting on a panel in front of any 5-inch cathode-ray tube. Its protruding flange is designed to accommodate the Type 271-A Camera. Mounting holes are spaced so that the Type 2501 and the Type 2088 Projection Lens are interchangeable on the panel.

The Bezel is formed from sheet iron and has a durable, dull black finish. The maximum overall diameter is 6-5/8 inches; protrusion from the panel is 1-3/16 inches.

The Type 2501 is supplied as standard equipment on Du Mont Types 250, 250-H, 256-D, 275-A, 279, 280, 281, and 288 Cathode-ray Oscillographs. It is also supplied with the Type 271-A Camera.

Catalog No.	Type No.	Description	Code Word
1215	2501	Mounting Bezel (for Type 271-A)	YALAP

TYPE 2502 MAGNETIC SHIELD

This Shield is designed for use with the Type 5RP-A series of cathode-ray tubes. It is fabricated from mu-metal, a material which has most excellent magnetic properties. It completely shields the tube from the effects of stray magnetic fields, and it allows access to the terminals on the sides of the Type 5RP-A.

Catalog No.	Type No.	Description	Code Word
1382	2502	Mu-metal Shield for Type 5RP-A Cathode-ray Tube	YALHN

TYPE 2503 MAGNETIC SHIELD

Similar to the Type 2502 but designed to fit the Type 5SP- series of cathode-ray tubes.

Catalog No.	Type No.	Description	Code Word
1383	2503	Mu-metal Shield for Type 5SP- Cathode-ray Tubes	YALHO

TYPE 2504 STEP-DOWN TRANSFORMER

This transformer is designed to operate from 50-60 cycle, single-phase, 230-volt power. It delivers 115 volts and has a maximum output rating of 250 volt-amperes. There is a power cord and plug for making the 230-volt connection; 115 volt output is available from a standard receptacle on the case.

Catalog No.	Type No.	Description	Code Word
1384	2504	250 va. Step-down Transformer	YALHP

TYPE 2505 STEP-DOWN TRANSFORMER

This is similar to the Type 2504 except that it has a maximum output rating of 1000 volt-amperes.

Catalog No.	Type No.	Description	Code Word
1385	2505	1000 va. Step-down Transformer	YALHQ

TYPE 2511 SPARE MOUNTING KIT

This Kit, which is to be used in conjunction with the Type 314 Oscillograph-record Camera, consists of spacing bars, spacers, and the hardware for fastening these to the top of any 5-inch cathode-ray oscillograph. It is advisable to permanently install one of these Mounting Kits on each oscillograph with which the Camera is to be used so that it may be quickly attached at any time. One set of spacing bars and spacers are furnished with the Type 314.

Catalog No.	Type No.	Description	Code Word
1371	2511	Spare Mounting Kit for Type 314 Oscillograph-record Camera	YALHA

TYPE 2512 MOTOR DRIVEN PROCESSING UNIT

This Unit consists of two spools which will accommodate up to 100-feet of 35 mm film, a steel tank into which the spools fit, and a small, synchronous-inductor driving-motor. The spools and driving gear are attached to the tank cover-plate, but the spools are easily removed for loading and unloading of the film. Developer solution may be added to the tank or poured out through a solution spout without removing the cover-plate, which is held in place by spring-type clamps. The solution spout is light-baffled so that no light can enter the tank. The driving motor is placed on top of the cover plate. It turns the spools at a steady rate until the film is wound completely upon one of them, at which time it automatically reverses direction to rewind the film on the other reel. A time of approximately 1 minute is required to wind 100-feet of film from one spool to the other. The spools can be cranked by hand if the motor drive is not used.

Catalog No.	Type No.	Description	Code Word
1372	2512	Motor-driven Processing Unit for 35 mm; for operation from 115 volts, 50-60 cycles	YALHB

TYPE 2513 STAINLESS STEEL TANK

This Tank is for use with the Motor-driven Processing Unit, and is similar to the one supplied with the Unit except that it has no solution spout.

Catalog No.	Type No.	Description	Code Word
1374	2513	Extra Stainless-steel Tank, plain, without solution spout for use with Type 2512 Processing Unit..................	YALHE

TYPE 2514 PORTABLE DRYING RACK

This is an all-metal rack which will hold up to 200 feet of 35 mm film. A motor drive turns the Rack slowly, moving the film past a heating unit consisting of four infra-red lamps. A film squeegee is provided to remove excess moisture from the film as it is wound onto the rack. Clamps on the Rack hold the ends of the film in place. A re-winding spool is also provided for winding the film from the rack after drying is complete.

The Type 2514 may be folded up when it is to be transported or is not in use. A carrying case is furnished with it for this purpose.

Catalog No.	Type No.	Description	Code Word
1375	2514	Portable Drying Rack, motor-driven; for operation from 115 volts, 50-60 cycles	YALHF

DU MONT CATHODE-RAY TUBES

GENERAL INFORMATION
CHOICE OF TUBES FOR CERTAIN APPLICATIONS
SCREEN PHOSPHOR DESIGNATIONS
VISUAL OBSERVATION OF PATTERNS
PHOTOGRAPHIC RECORDING OF TRACES
GRID CHARACTERISTICS
OPERATING NOTES
USE OF CHARACTERISTIC SHEETS
INSTALLATION NOTES
TELEVISION PICTURE TUBES

CATHODE-RAY TUBES

INTRODUCTION

The cathode-ray tube, a two dimensional indicating device capable of plotting one quantity as a function of another and free from inertia effects, has become a most important instrument by means of which electrical phenomena may be observed and measured. As used in the cathode-ray oscillograph, it is of immeasurable value to engineers and technicians since it makes possible instantaneous observation of the variations of one phenomena with respect to another. In addition to oscillographic applications, the cathode-ray tube has become the medium for reproduction of television pictures, the essential indicating device in radar, and the indicator in innumerable other applications.

The cathode-ray tube is not as new a device as might be supposed from its increased use in recent years. In fact, the first device in which an electron stream in a sealed tube was focused on a fluorescent screen to produce a movable fluorescent spot was built by Braun in 1897. The introduction of the hot cathode in 1905, the application of gas focusing (now generally abandoned), improvements in cathode design, the use of a negative grid, general improvement in the "electron gun", improvements in the fluorescent screen, and the development of suitable auxiliary circuits, gradually brought the cathode-ray tube to its present form.

MODERN CATHODE-RAY TUBES

An outline drawing of a modern high-vacuum electrostatic focus and deflection cathode-ray tube is shown in Figure 1. A heater element (2) mounted within a cathode sleeve (3) operates to heat the oxide coating on the end of this sleeve and cause electron emission. The electric field produced by the control electrode or grid (4), and the preaccelerating electrode (connected internally to the accelerating electrode) (5) acts to draw the electrons emitted from the cathode into a narrow beam having a minimum cross-section in the vicinity of the grid.

From this point the electron beam diverges until it reaches the region of the focusing electrode (6) where the electric fields set up by the combination of the end of the preaccelerating electrode, the focusing electrode, and the accelerating electrode cause the beam to converge so that when it reaches the fluorescent screen (14) it again has a minimum cross-section. This action is analogous to the action of optical lenses on light, and it may be said that the minimum beam cross-section in the vicinity of the grid is focused onto the screen by the electron lens formed by the fields between the focusing electrode and the preaccelerating and accelerating electrodes.

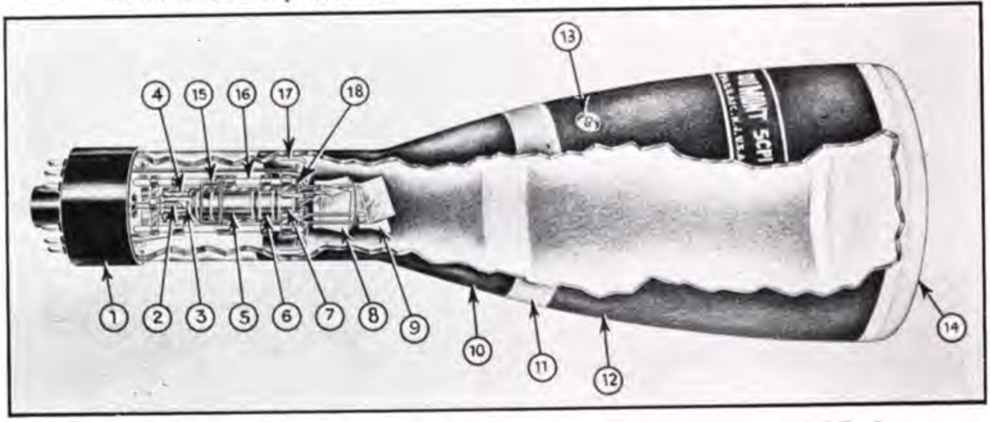


Figure 1. An example of a cathode-ray tube with electrostatic focusing and deflection

1. ***Base***
2. ***Heater***
3. ***Cathode***
4. ***Control Electrode Grid (G)***
5. ***Pre-accelerating Electrode (connected internally to A_2)***
6. ***Focusing Electrode (A_1)***
7. ***Accelerating Electrode (A_2)***
8. ***Deflection Plate Pair (D_3D_4)***
9. ***Deflection Plate Pair (D_1D_2)***
10. ***Conductive Coating (connected internally to A_2)***
11. ***Intensifier Gap***
12. ***Intensifier Electrode (A_3)***
13. ***A_3 Terminal***
14. ***Fluorescent Screen***
15. ***Getter***
16. ***Ceramic Gun Supports***
17. ***Mount Support Spider***
18. ***Deflection Plate Structure Support***

The control electrode is ordinarily operated at a negative potential with respect to the cathode, and the beam current (and therefore the brightness of the spot) is varied by varying this bias potential. This potential difference is of the order of 50 volts. The focusing electrode usually operates at a lower voltage than the accelerating electrode, and it is by variation of this focusing electrode voltage (which is usually about 500 volts for 2000 volts accelerating potential) that the spot is properly focused on the screen. The entire beam forming structure is known as the "electron gun."

After leaving the gun, the electron beam passes between the plates of the deflection-plate pair (8) and then between the plates of the pair (9). A potential difference applied between the plates of the pair (8) produces an electric field which deflects the electron beam in a direction perpendicular to the plane of those plates. Similarly, a potential applied between the plates of pair (9) results in deflection of the beam in a direction produced by plate pair (8). Thus it is possible to control the position of the spot on the screen by two potentials applied to the two sets of deflection plates.

The intensifier electrode (12), a Du Mont development, is operated at a higher voltage than the accelerating electrode. This intensifier electrode serves to further accelerate the electrons in the beam subsequent to deflection. The deflection sensitivity of the beam varies inversely with the potential applied to the accelerating electrode, which potential, measured from cathode, determines the velocity of electrons in the deflection-plate region. However, the brilliance of the fluorescent trace produced by the electron beam increases with increase in accelerating potential. A compromise must therefore be made between brilliance and deflection sensitivity. With the intensifier-type cathode-ray tube, the necessity for compromise is greatly reduced, since the beam may be deflected at a low accelerating electrode potential and then further accelerated after deflection by a higher potential applied to the intensifier electrode.

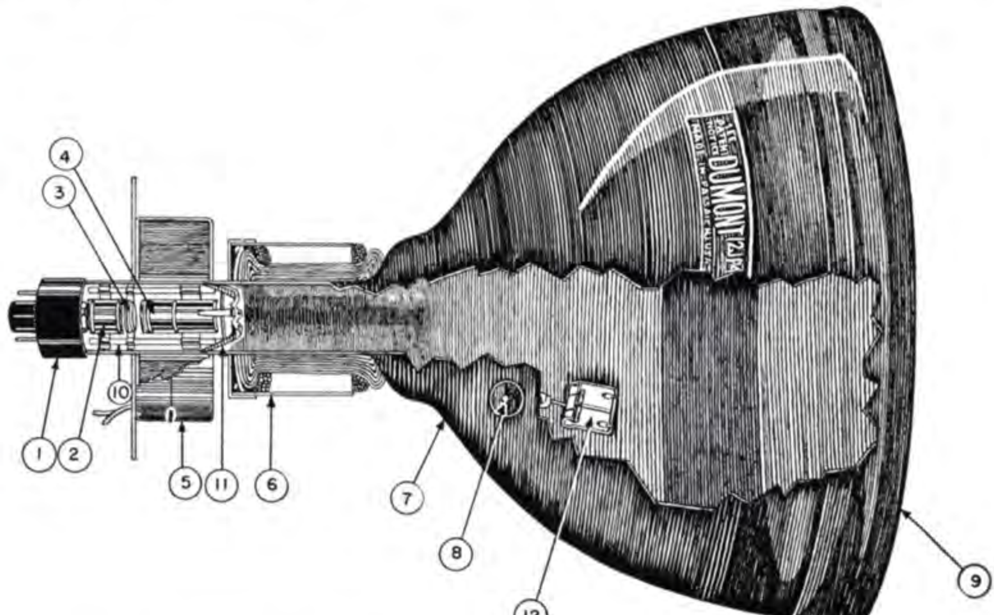


Figure 2. An example of a cathode-ray tube with magnetic focusing and deflection

1. ***Base***
2. ***Control Electrode (G_1)***
3. ***Screen Grid (G_2)***
4. ***Accelerating Electrode (A)***
5. ***Focusing Coil***
6. ***Deflection Yok3***
7. ***Anode Conductive Coating***
8. ***Anode Terminal***
9. ***Fluorescent Screen***
10. ***Ceramic Gun Support***
11. ***Mount Support Spider***
12. ***Getter***

It will be noted that in the cathode-ray tube just described, focusing and deflection of the beam are both accomplished by electrostatic fields. It is also possible to use magnetic fields for either focusing or deflection or both.

An outline drawing of a typical magnetic focus and deflection cathode-ray tube is shown in Figure 2. As in the case of the electrostatic tube, a heater element mounted within a cathode sleeve operates to heat the oxide coating on the end of this sleeve and cause electron emission. As in the case of the electrostatic tube, electrons emitted from the cathode are drawn into a narrow beam having a minimum cross-section in the vicinity of the control electrode (2), the beam diverges after leaving the cross-over and, continuing to diverge passes through the screen grid (3) which is operated at a fixed positive potential (usually about 250 volts), and then passes through the accelerating electrode (4) which accelerates the electrons to their final velocity. The beam continues to diverge (though it is made somewhat less divergent in passing through the electrostatic field between the screen grid and accelerating electrode) until it reaches the axial magnetic field produced by the focusing coil (5). This magnetic field acts on the beam, in a manner analagous to the action of a lens on a light beam (insofar as the final result is concerned), to cause the beam to converge after leaving the magnetic field, and arrive at the screen with a minimum cross-section.

After passing through the focusing coil, the beam passes through the deflection yoke (6), which contains two pairs of coils that produce two mutually perpendicular magnetic fields, both of which are perpendicular to the beam. Each of these fields deflects the beam in a direction perpendicular to its lines of flux by an amount which varies with the field intensity, the intensity in turn being varied by the current flowing through the corresponding coil pair. Thus, the position of the spot on the screen can be controlled by means of two currents applied to the two pairs of deflection coils.

It will be noted that the particular magnetic tube described, which is typical of most commercial magnetic types, differs from the electrostatic tube previously described, in that the role played by the preaccelerating electrode in the electrostatic tube, insofar as the formation of the beam in the vicinity of the grid and crossover is concerned, is played by a screen grid (3) which is connected to a fixed positive potential. The use of such a separately connected screen grid, the potential of which can be held constant regardless of the potential applied to the accelerating electrode, has the advantage of making it possible to operate the tube over a wide range of accelerating potential, depending upon the requirements of the application, without greatly changing the grid control characteristic of the tube.

Other types of gun structures are possible. Many electrostatic focus tubes have only a grid, a long focusing electrode, and an accelerating electrode. In this case the focusing occurs as a result of the field between focusing electrode and accelerating electrode. Magnetic focus tubes have been made with only a control grid and accelerating electrode. In some magnetic tubes, the accelerating electrode has consisted merely of a conductive coating on the glass neck of the tube.

As previously mentioned, it is possible to use electrostatic focus and magnetic deflection. Magnetic focus is not used to any extent with electrostatic deflection, because it would be very inconvenient to center the beam between the deflection plates.

Electrostatic deflection cathode-ray tubes are used in practically all oscillographic applications and in most other applications where operation over a wide range of deflection frequencies is necessary. The use of electrostatic deflection is advantageous in such applications because it is much more practicable to produce deflecting voltages over wide ranges of frequencies, than to produce deflecting currents over wide ranges of frequencies in the inductive circuits presented by deflecting coils. Magnetic deflection is advantageous where the deflection frequencies are fixed, and maximum intensity, minimum tube length, and minimum distortion of the spot as a result of deflection are desired. Magnetic focus has the advantage, in magnetic deflection tubes, of simplifying tube construction for applications when high beam currents are required (as in television picture tubes). Electrostatic focus has the advantage, in magnetic deflection tubes, of imposing less stringent high voltage power supply regulation requirements, and of simplifying the external equipment by eliminating the need for the focusing coil with its centering adjustments, etc. The power supply regulation does not need to be as good because, by obtaining the focusing electrode voltage from a bleeder across the accelerating voltage power supply, the focusing electrode voltage will vary in proportion to the accelerating voltage, and the tube will therefore not go out of focus if the accelerating voltage varies slightly.

CONSIDERATIONS INVOLVED IN THE CHOICE AND USE OF CATHODE-RAY TUBES FOR OSCILLOGRAPH AND SPECIAL APPLICATIONS

In choosing a cathode-ray tube for any particular application, points which should be considered are the type of screen to be used, the operating potentials which can be supplied conveniently or economically, the spot size and intensity required, the deflection sensitivity required, and the importance of deflection-plate or grid capacitance. Some of these factors are interdependent, and compromises must usually be made.

Operating Potentials, Spot Size, Intensity, Deflection Sensitivity

In most applications, high deflection sensitivity, high intensity, small spot-size, and minimum operating potentials are desirable. Since there are several conflicting factors involved, compromise is usually necessary. In general, intensity and spot size must be considered together. With a given tube, the spot size decreases and brilliance improves with increasing accelerating voltage, but the deflection sensitivity decreases. Furthermore, high accelerating voltages are in themselves undesirable from the standpoint of economy and simplicity in equipment. The particular application will, therefore, determine the tube to be used and the conditions of its operation. Where maximum intensity and minimum spot size are most important, high accelerating voltages are indicated. Where maximum deflection sensitivity is the most important requirement, lower accelerating potentials should be used. For applications where a maximum deflection sensitivity and a maximum brilliance are required, intensifier-type cathode-ray tubes should be used, since a high final accelerating potential can be used with a minimum of effect on the deflection sensitivity. The intensifier-type cathode-ray tube also simplifies the power supply problem for a given overall accelerating potential by reducing the maximum voltage for which the power supply must be insulated from ground.

Deflection-plate Capacitances

For applications where high frequency potentials are supplied to the deflection plates, minimum deflection-plate lead lengths and capacitances are essential. For such applications, special high-frequency cathode-ray tubes are made in which the leads are brought from the deflection plates directly to terminal caps on the neck of the cathode-ray tube opposite the plates. In this way the total effective capacitance between two plates of a deflection-plate pair can be lowered to two or three micro-microfarads.

SCREENS

The screen is the part of the cathode-ray tube where the energy of the electron beam is transformed into useful light output. Particular attention has, therefore, to be given to the proper choice of the screen material according to the desired application.

Standard Du Mont cathode-ray tubes are available with 6 types of screens, referred to as P1, P2, P4, P5, P7, and P11. These screens satisfy the requirements of practically all applications. A brief description of the various screen types and their applications is given in the following paragraphs, and the principle characteristics of each screen type are shown on individual characteristic sheets. It must be kept in mind, however, that the data given in the characteristic sheets is average data; characteristics may vary considerably with individual tubes.

P1 Screen

The Type P1 screen produces a green trace of medium persistence and is well suited for general-purpose, visual oscillographic work. It is quite efficient, and bright traces can be obtained with comparatively low accelerating voltages. The spectral distribution of the light produced is in the region of high sensitivity of the human eye, resulting in good contrast even when the tube is illuminated by external daylight or incandescent lighting. For photographic purposes, satisfactory results may be expected in the recording of recurrent phenomena and slow speed transients where blurring is not a limitation. By increasing the accelerating voltage on the tube, both visual and photographic efficiency may be increased many times.

P2 Screen

The P2 screen produces a bluish-green fluorescent trace with a long persistent yellow phosphorescence. This phosphorescence is useful for visual observations of transient signals, and very low frequency recurrent signals. With this type of screen a pattern can be observed for a period ranging from a fraction of a second to several minutes after it has been produced, depending upon the writing rate of the spot, the accelerating potential, the level of the ambient light, and the dark adaption of the observer.

Since the fluorescent light output is many times that of the phosphorescence, the P2 screen is also useful for observation and photography of the short persistence fluorescent trace only. In applications where it is desired to attenuate the long persistence phosphorescence, a blue filter (Du Mont catalog No. 1134-A or equivalent) may be used.

Because of the dual-purpose feature of the Du Mont P2 screen, and because of its relatively high resistance to burning at high voltages and currents, this screen type is recommended for use in the Type 5RP-A and other high voltage oscillograph tubes.

For additional data on this screen type the reader will please refer to the paragraphs "Visual Observation of Transients", and "Photographic Recording with Cathode-ray Tubes."

P4 Screen

The Type P4 screen is generally used for television applications. Its fluorescence appears white to the eye; color composition is chosen in such a way that even over long periods of observation, a minimum of fatigue will be caused. Its persistence is well balanced so as to minimize flicker effects and to give, nevertheless, clear pictures of fast-moving objects.

P5 and P11 Screens

Two general types of blue screen materials are available commercially for photographic work. These screens are the tungstate type P5 and the sulphide type P11.

The general characteristics of the P5 and P11 screens may be compared as follows: Both screens are of the short persistence blue fluorescent type and of high photographic actinity, the main difference being the considerably higher photographic and visual efficiency of the P11 screen, and the shorter persistence of the P5 screen.

The above data indicates that the use of the P11 screen is advantageous for all still photographic applications, particularly of high speed phenomena, and for continuously moving film recording up to the limit where persistence produces blurring of the picture (approximately 200 kc/sec). The use of the P5 screen is recommended only for high speed, continuous-motion picture recording at speeds above the limit at which blurring occurs with P11 screens. The P5 screen can be used above 200 kc/sec. without blurring. Detailed characteristics of the P5 and P11 screen are given on the accompanying characteristic sheets.

P7 Screen

The type P7 screen produces a blue fluorescent trace with a long persistent yellow phosphorescence. It is useful for visual observations of transient signals and very low frequency recurrent signals. With the P7 screen, as with the P2 screen, a pattern can be observed for a period ranging from a fraction of a second to several minutes after it has been produced, depending upon the writing rate of the spot, the accelerating potential, and the level of the ambient light. The P7 screen has higher persistent light output than the P2 screen for the lower writing rates, and has the further advantage that the large difference in color between the initial fluorescent light and the persistent light makes it possible to filter out the initial bright "flash" by means of a yellow filter such as the Wratten #15.

Comparison of the Essential Characteristics of P5 and P11 Screens

Property	P11	P5
* Relative photographic efficiency (Eb = 4000 V, Ib = 50 μa)	5	1
* Relative visual efficiency	3.3	1
Persistence time for energy drop 50%	10 μsec.	5 μsec.
Persistence time for energy drop 1/e	18.6 μsec.	7.2 μsec.
Persistence time for energy drop 10%	116 μsec.	15.2 μsec.
(Eb = 4000 V; Ib = 50 μa, 1 cm. spot)		
Limit recording frequency for continuous-motion film camera (blurring limit)	200 kc./sec.	>200 kc./sec.
Spectral Range	3550-6100A	3400-6100A
Maximum	4350A	4300A
Film type recommended:	Orthochromatic	Orthochromatic

* These figures are based upon screen efficiency curves determined from measurements on a stationary 50-line raster. They are not necessarily the same as may be obtained under high-speed transient conditions, where the screen does not have time to build up to its maximum efficiency.

Low and Medium-Speed Transients

Figure 3 shows tube brightness required for the visual observation of low or medium-speed single transients with P1, P2, and P11 screens at various writing speeds. These data are approximate for observation from a close distance in darkness, with dark adapted eyes, and for pulsed-grid operation. The brightness is measured on 2" x 2", 50-line raster by means of an illumination meter with a filter having a color transmission corresponding to the color response of the human eye. The signal is applied to the tube, which is first biased beyond cutoff, and the grid pulsed to the same level at which the brightness measurement was made. The limit writing speed corresponds to a signal which, under these conditions, can just be recognized. In the case of sinusoidal transients, the limit writing speed corresponds to the writing speed of the spot at the x-axis crossover point. In making such measurements, the peaks of the sine wave are usually masked off to avoid the illusion of seeing the complete pattern when only the points of minimum writing speed are actually visible.

The following examples illustrate the use of this graph. A sinusoidal transient of 3 mc/sec and 3 cm peak-to-peak amplitude has to be observed. From the nomograph, Figure 11, we find the corresponding writing speed at 28 cm/μsec. On our graph, Fig. 3, we locate P1 brightness of 15 Ft. L. which may be obtained on a Type 241, 247, 248, 250, or 280 Cathode-ray Oscillograph.* As a second case, let us take a single pulse which rises to a peak amplitude of 2 inches or 5 cm in 1 microsecond. This corresponds to a writing speed of 5 cm/μsec or 2 inches/μsec. On our graph we find 2.8 Ft. L. (P1), 2.6 Ft. L. (P2), or 0.9 Ft. L. (P11). These brightness levels can be obtained on all Du Mont oscillographs but only those types which have automatic beam control or permit grid-pulsing and have sufficient amplifier bandwidth would be used to study such transients.

Visual observation of single transients is facilitated by the use of long-persistent screens such as the P2 and P7. The P2 and P7 screen data sheets in this manual, giving curves of persistence versus signal writing rate at various voltages (and constant current) show the rela-

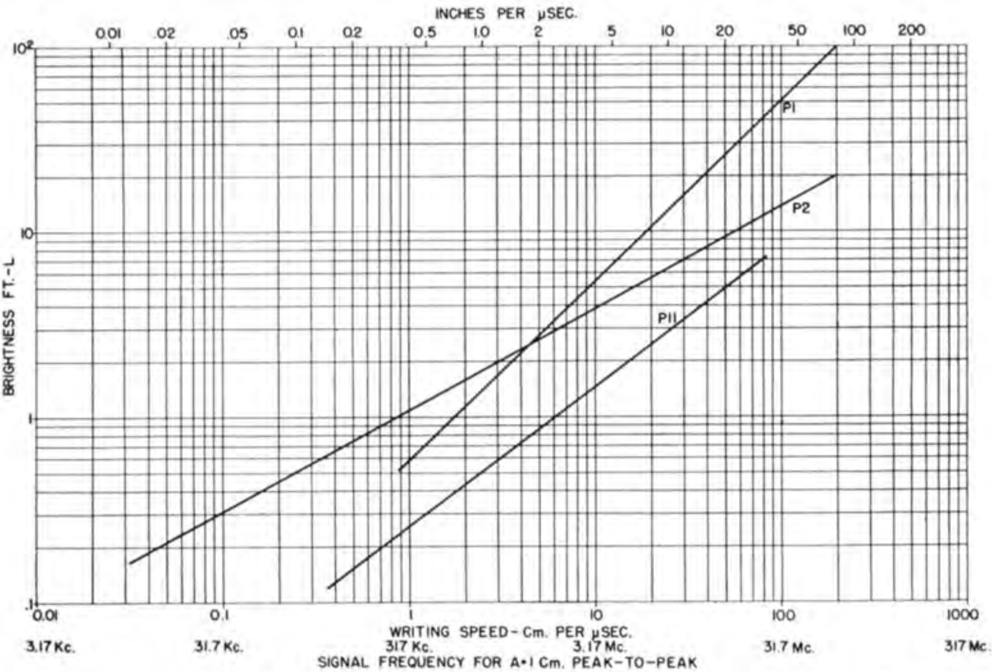


***Figure 3.** Graph showing limit writing speeds vs. screen brightness for visual observation of single transients on P1, P2, and P11 screens*

* Discussion of means for determining brightness values obtainable with standard oscillographs is given on page 109.

tive merits of the two screen types. It is apparent from these curves that the P7 screen gives better results at low writing rates and that the P2 screen gives better results at high writing rates. It is also apparent that the useful persistence time increases with increasing accelerating voltage. These curves were obtained experimentally with an ambient illumination of 0.1 ft.-candle on the tube face (corresponding to semi-dark laboratory conditions). It must be kept in mind that the useful persistence time depends to a large extent on the amount of ambient light which is present. In absolute darkness, an increase of persistence time by a factor of 10 to 20 may be expected, while with higher ambient light levels, a shortening of persistence time occurs.

High-Speed Single Transients

The curves of Figure 3 should *not* be extrapolated to very high writing speeds and brightness levels since they are based upon brightness data obtained under steady raster conditions and relatively low beam currents and accelerating potentials. Extremely high brightness levels may be obtained with the new 5RP-A high-voltage tubes, but the visual efficiencies of the different phosphors do not remain relative as the accelerating potentials and writing speeds are increased. This is due partly to shifts in the color spectrum of the light output at high voltages, and to the different thermal effects upon the screen at higher spot writing speeds. With very high-speed transient excitation of the screen, the light build-up may not be rapid enough to allow the phosphor to reach its maximum efficiency at the same instant that the beam current reaches its peak value.

The P2 screen will allow the observation of considerably higher speed transients than the P1 or P11 screen under these conditions.

PHOTOGRAPHIC RECORDING WITH CATHODE-RAY TUBES

General Considerations

Photography of cathode-ray tube patterns has been mentioned briefly in connection with fluorescent screens, but there are further special considerations involved when cathode-ray tube patterns are to be photographed. Photography of the stationary patterns produced on the cathode-ray tube screen by recurrent signals may be affected very easily since the camera shutter may be left open as long as is necessary to obtain the required negative density. In such cases the brilliance of the trace is comparatively unimportant, since the camera shutter need only be left open for a relatively long period when the brilliance is low. With some types of signals (such as square-waves) where the writing rate over various portions of the cycle changes greatly, with resultant large variations in brightness over different parts of the pattern, it may become necessary to over-expose the brighter parts of the pattern in order to obtain satisfactory recording of the less intense portions.

It is in the photography of transient patterns, however, that the most careful attention must be paid to writing rates and film requirements.

Recording by Means of Continuous-Motion Cameras

There are two methods applicable to photographic recording of transient signals—a moving film method, and a stationary film method. The former method (usually called continuous-motion recording) is preferable when the duration of the individual signal is longer than that of the longest sweep available on the oscillograph, or when it is desirable to expand a transient in its entirety for more accurate study. For example, figures (4) and (5), are recordings of the same phenomenon, that of the starting-current characteristic of a synchronous motor. The oscillogram in Figure 4 was made by a single exposure on stationary film, with a Du Mont Type 271-A Oscillograph-record Camera and using a very slow oscillograph sweep. The oscillogram of Figure 5 was made on continuously-moving film with a Du Mont Type 314 Oscillograph-record Camera. It is obvious that while Figure 4 provides a good overall record for qualitative study, the expanded oscillogram of Figure 5 is preferable where an accurate quantitative analysis is necessary.

In the continuous-motion method of recording, several techniques are possible, any of which may be used with the Type 314 Oscil-

Figure 4. ***Single exposure photographic recording of the starting-current characteristic of a synchronous motor.***

Figure 5. Moving-film recording of the same starting-current characteristic as is shown in Figure 4.

lograph-record Camera. In the first method, the spot on the cathode-ray tube is deflected by the signal along one axis only, and the time-axis is provided by the motion of the film in the direction perpendicular to the spot deflection. This method has certain limitations. In order to obtain sufficient resolution on ordinary film, the recording of a 100 kc/sec signal, for instance, would require a film speed of at least 50 ft/sec. This method leads to considerable film consumption and is therefore recommended only for the recording of low and medium-frequency signals.

In cases where it is necessary to provide a recording monitor for signals occurring completely at random over long periods of time, a continuous-motion recorder is of course mandatory. The Type 314 Camera, for example, may be used at its lowest speed to record continuously for a period of 8-1/3 days.

A second method of continuous-motion recording which has advantages in many cases, is to use a driven sweep on the cathode-ray oscillograph and to move the film perpendicularly to the direction of the sweep at a speed determined by the repetition rate of the sweep and the amplitude of the recorded signal. This makes it possible to obtain recordings of very high frequencies or of very short pulses with a relatively small amount of film, and it facilitates the analysis of the pictures. Both methods may be compared on Figure 6 which shows at the top a recording by method 1 and, at the bottom, a recording by method 2. Both recordings are of the same signal. This photograph was obtained by running the same film strip twice through the camera, exposing each time only part of it. Obviously, in this case, the second method gives a much clearer picture of what is happening on a considerably shorter length of film. The necessary film speed may be determined from the formula:

$$S = \frac{f_s h}{M}$$

where S is the minimum necessary film speed
f_s is the repetition rate or frequency of the sweep
h is the peak-to-peak amplitude (referred to the cathode-ray tube screen) of the signal which is imposed on the sweep
M is the object:image ratio of the camera*

The film speed S, will just be sufficient to separate the signals of optically-reduced amplitude h/M (referred to the film plane). When the signal has only a positive or only a negative amplitude, as in Figure 6, h may be taken as the peak value of this amplitude. The recording of Figure 6 (bottom) was made at a higher speed than the calculated value of S in order to provide plenty of separation between successive sweeps. For example, the frequency of the sweep was 60 cycles per second, the amplitude of the pulse on the cathode-ray tube screen was 0.5 inches, and the object:image ratio of the Type 314 Camera, with which the recording was made, is equal to 6:1. Therefore the minimum film speed,

$$S = \frac{60\ (0.5)}{6} = 5$$

inches per second is required to separate these signals. In recording certain types of phenomena by this method the pattern may be such

Figure 6. A double-exposed strip showing two methods of recording by means of continuous-motion film. The first method (top) records along the length of the film making use of the film motion as the time-base. The second method (bottom) utilizes both film motion and oscillograph sweep to record successive sweeps across the width of the film.

* The pattern on the cathode-ray tube screen is considered the "object", and the pattern projected on the film plane by the camera lens is considered the "image". The ratio of object:image is usually a reduction ratio.

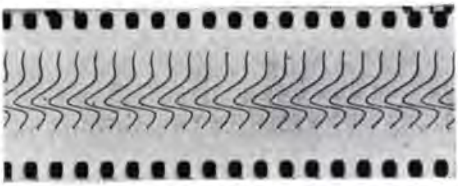


Figure 7. Continuous-motion recording illustrating the "inter-lace" which is possible with certain types of signals. A slow film speed is employed in plotting sweeps across the film width.

that it is possible to allow the successive signals to appear inside one another or "interlace" as is shown in Figure 7. A much slower recording speed than S is then permissible.

A third method of continuous-motion recording is in use. By combining the motion of the oscillograph sweep and the motion of the film, a time-base which is faster or slower (depending upon the direction of each motion) than is possible by either of the other methods can be obtained. For example, suppose it is desired to record a phenomenon which has extremely rapid variations at the beginning, and then a slow rate of change for its duration. Obviously, the resolution of the high-speed portion would require a high film speed (using method 1) unnecessary in recording the slow change portion. A great deal of film would therefore be wasted. Using method 3, the driven sweep of the cathode-ray oscillograph, initiated by the rapid transient, rapidly deflects the spot in the same direction as the motion of the film; the spot remains fixed in position and is not blanked out at the end of the sweep. By the use of an exponential sweep, the speed of which is asymptotic to film speed, discontinuities in the time-base are avoided. However, some method of time indication, recorded directly on the film, is mandatory to achieve the proper time perspective when studying the recording. A system of recording a time-marker track along the edge of the film, as is provided by the Type 314 Oscillograph-record Camera, is suitable. Summing up then, the time-base for the rapid transient is provided by the sum of the optically-reduced sweep-speed (transferred to the film plane) and the speed of the film. The time-base for the slow rate-of-change portion is provided by the film motion alone.

For all recordings by means of continuous-motion cameras, regardless of the method used, only short-persistence screens can be employed to avoid blurring of the film by afterglow. The seriousness of this effect is shown by Figure 8, which represents the recording of a 60 cps signal on a medium-persistent P1 screen. For comparison, the recording of a 1000 cps signal on a short-persistent P11 screen may be seen on Figure 9. No blurring can be observed on this recording.

Extremely high recording speeds may be obtained with limited film consumption by means of the so-called "drum camera." This camera contains a cylindrical drum on the circumference of which a strip of film or sensitive paper is fastened. The drum is driven to full speed, then the shutter opens for one revolution, while the signal is simultaneously applied to the cathode-ray tube.

Exposure

The necessary exposure may be found in much the same way as for still pictures, and will be described in the section on, "Photography with Still Camera."

Film and Processing

For the photogrpahy of low and medium-speed phenomena, excellent results are obtained from such films as Eastman Kodak Panatomic-X and Super XX developed in D76. However, when the recording of high-speed transients is undertaken, film emulsions of extremely high speed are necessary. The best films for such work are Eastman Linagraph Pan (5244) and Linagraph Ortho (5211), available in 35 mm. size. There are several principal methods of increasing the film emulsion speed.*

Figure 8. Continuous-motion recording of a 60-cycle sine wave signal from a P1 cathode-ray tube screen. The blurred effect is caused by the persistence of the screen material.

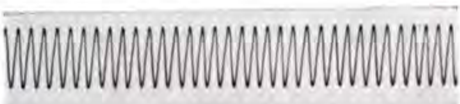


Figure 9. Continuous-motion recording of a 1000-cycle sine wave from a P11 screen which has a short-persistence characteristic. Note the clarity of the recording as compared to Figure 8.

* See "Methods of Increasing Film Speed" by H. A. Miller, R. W. Henn, and J. I. Crabtree; The Journal of the Photographic Society of America, November 1946, Vol. 12, No. 10.

1. Prolonged development in a high emulsion-speed developer, to the point where chemical fog becomes objectionable.

2. Hypersensitizing the film before exposure by bathing, exposure to vapor, or exposure to light.

3. "Latensification", by bathing between exposure and development.

4. Intensification after development.

Of these, the first method is the least difficult to control and is generally used at the Allen B. Du Mont Laboratories. The best developer to use with the Eastman 5244 and 5211 films is Eastman Kodak SD-19a. The development time is prolonged until optimum contrast is obtained between image and background fog. Fifteen minutes at 68° F has been found satisfactory. Other films that give good results are Ansco Triple S Ortho and Triple S Pan developed in Agfa 73.

Photography with Still Camera General Considerations

The density of the photographic picture recorded on the film must be unaffected by external light. Therefore, the exposures are made with oscillograph and camera in darkness, or by using a light-tight shield between both, as in the case of the Du Mont Types 271-A and 314 Cameras. In the recording of transients, background light due to extraneous signals and stray electron excitation of the screen should be eliminated as much as possible in order to avoid masking of the signal, although in some cases a certain amount of stray, uniformly distributed light may serve to hypersensitize the film as mentioned previously.

Overexposure, by a spot or sweep line, can be avoided by the use of single or driven sweeps and automatic beam-blanking circuits, so that the beam is on only when the signal occurs, thus leaving the screen dark before and after passage of the transient.

Determination of Exposure

The light output necessary to obtain a photographic recording of sufficient density (d = 0.1 above fog) depends on the color of the screen material used, its light output, the maximum writing speed of the signal, the lens aperture, and the sensitivity of the photographic material, including the development procedure. The effective exposure also depends on the object-to-image ratio; it increases with increasing reduction of the picture size. The following data is to facilitate the determination of correct exposure and the choice of suitable equipment. Several practical examples are given in illustration.

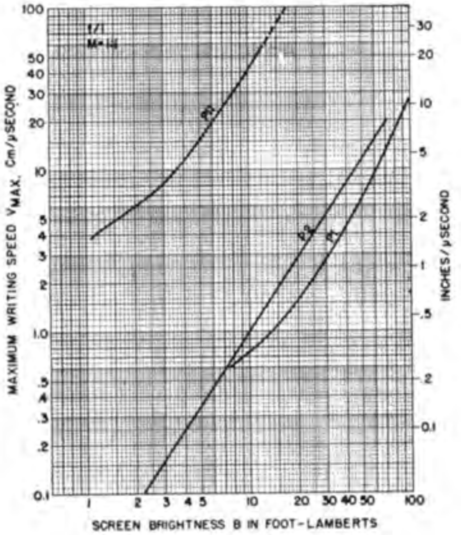


Figure 10. Graph showing the relation between maximum photographic writing speeds and screen brightness for three different cathode-ray tube screen materials. (Note: P11 brightness is visual brightness as measured with eye-corrected cell)

The maximum photographic writing speed, V_{max}, is the maximum speed of the luminescent spot which produces a recording of density equal to 0.1 above fog at object-to-image ratio M = 1:1, with a lens aperture of f/1, on a high-sensitivity emulsion developed with a high emulsion-speed developer. Figure 5 shows the maximum writing speed as a function of brightness for different screen materials. These values were experimentally determined for high emulsion-speed films such as E.K. Linagraph Pan, Linagraph Ortho and Ansco Triple S-Ortho.

If different film material is used, the values must be corrected by a correction factor. More details concerning the method which was used may be found in the paper, "Photographing Patterns on Cathode-ray Tubes" by R. Feldt, ELECTRONICS, February, 1944, and reprinted by Du Mont under the title, "Maximum Photographic Writing Rates of Commercial Cathode-ray Tubes."

The brightness values found on Figure 10 may be translated into corresponding voltage and current data from the efficiency characteristics of the screen on the characteristic sheets. It can be found, for instance, from the P1 data that a P1 tube operated on a Type 247 Cathode-ray Oscillograph with a total accelerating voltage of 3000 volts may yield an average light output of 8 Ft. L at a beam current of 10 μa. The corresponding V_{max} is (from Figure 10) .06 cm/μsec. To determine brightness values in the absence of a suitable illumination meter, it is sufficient to measure the intensifier current by connecting a microammeter between the intensifier lead and intensifier terminal (danger, high voltage), or, in first approximation, use the minimum brightness and current data given in the tube specifications.

The nomograph, Figure 11, gives the relation between signal frequency and amplitude and maximum speed for sinusoidal traces. This nomograph is based on the formula $2\pi fA$; where f is the signal frequency in cycles per second and A is one-half the peak-to-peak amplitude of the signal. The formula $2\pi fA$ gives the writing speed of the spot at the axis-crossover point due to the sinusoidal signal velocity only, and is an approximation of the true writing speed. The exact writing speed is a vector sum of the signal speed and sweep speed. However, when the sweep speed is considerably less than that of the signal (about 0.1 the signal speed) the formula and nomograph are sufficiently accurate for general use.

For example, suppose the pattern is a sinusoidal signal of 1 megacycle per second frequency and 2 inches peak-to-peak amplitude, with a sweep length such that about 10 cycles appear on the screen. The signal then has a maximum writing speed of about 6.3 inches per microsecond. Once the maximum writing rate of the signal is known, the required tube brightness may be determined from Figure 10. It is advisable to divide the maximum by 2 in order to have a sufficient margin of safety allowing for variations in film sensitivity and development procedure, or in order to obtain higher densitv than 0.1. Since the graph, Figure 10, is plotted, for f/1 and M = 1:1, corrections must be made for other lens apertures or object-to-image ratios. This may be done by means of nomograph, Figure 12, for determining writing speed in terms of lens aperture, f, object-to-image ratio, M, and maximum writing speed, V_{max}. It is well known that the amount of effective exposure is inversely proportional to the square of the f number of a lens. If, instead of an f/1 lens, an aperture of f/2 is used, onlv one-quarter of the previous light quantity reaches the film, and the maximum writing rate obtainable is reduced to $\frac{V_{max}}{4}$.

The relation

$$V^1 = \frac{V_{max}}{f^2}$$

is given in this nomograph by linking the scales V_{max}, V^1 and f. If, for instance the maximum writing speed for f/1 is 10 cm/μsec, and an f/3.5 lens is to be used as in the case of the Type 271-A Camera, the writing speed decreases to

$$\frac{V_{max}}{12.25} = \frac{10}{12.25} = 0.82 \text{ cm}/\mu\text{sec.}$$

This is shown by the dotted line which links the 3 scales. The same nomograph also shows the relation between writing rate and object-to-image ratio M. When the picture size decreases, the available quantity of light is concentrated on a smaller area and the exposure increases. This is explained by the equation

$$V = \frac{4\ V_{max}}{f^2 \left(1 + \frac{1}{M}\right)^2},$$

where V is the writing rate at any object-to-image ratio M. The limit conditions are for $M = 1$, $V = \frac{V_{max}}{f^2}$

for M = (infinite reduction of picture size)

$$V = \frac{4\ V_{max}}{f^2}$$

This means that for extreme reduction of the picture size the effective exposure may increase by a maximum factor of 4. The corrections to be made for various object-to-image ratios can be read on the scales V, V^1, and M. Going back to the previous example, V^1 was found to be 0.82 cm/μsec for f/3.5 and M = 1. Suppose M = 4.5:1, V becomes 2.2 cm/μsec according to the dotted line which links M = 4.5:1 and V = 0.82 cm/μsec. This is a practical example of a calculation for the Type 271-A Camera which has a maximum aperture of f/3.5 and object:image ratio of M = 4.5:1.

Practical Examples for the Calculation of Exposure for Low and Medium-Speed Transients

Suppose it is desired to record a sine-wave transient having a peak-to-peak amplitude of approximately 6 cm (A = 3 cm) and a frequency f = 5 kc. The tube may have a P11 screen with a raster brightness of 2 Ft. L. From Figure 10, V_{max} is determined to be 6 cm/μsec for d = 0.1. Half of this speed is taken in order to provide a margin of safety as explained above, so V_{max} = 3 cm/μsec.

NOMOGRAPH RELATING AMPLITUDE, FREQUENCY, AND MAXIMUM WRITING SPEEDS FOR SINUSOIDAL TRACES

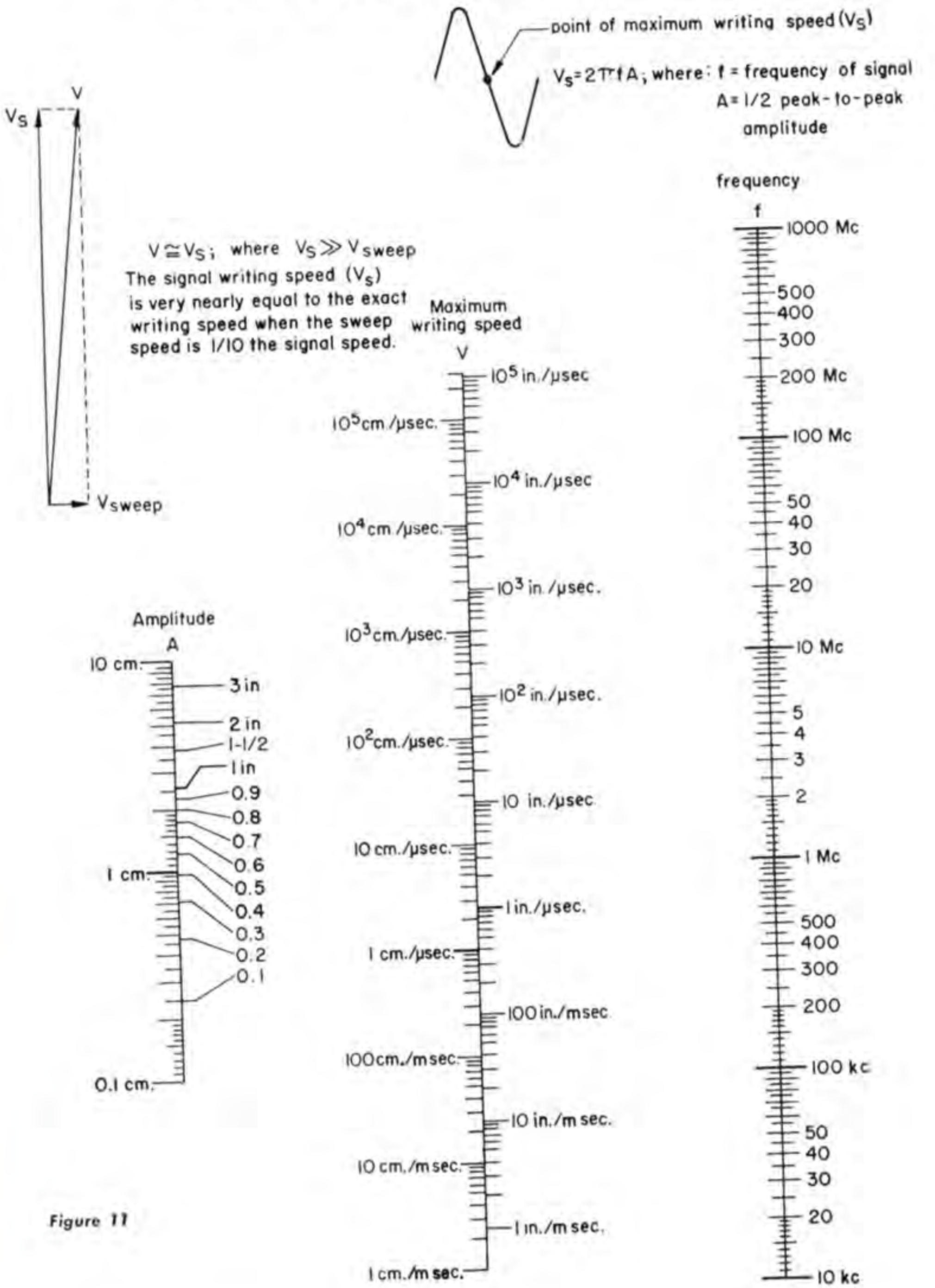


Figure 11

1μsec. = 1 microsecond = 1/1,000,000 second.
1 msec. = 1 millisecond = 1/1000 second.

1 Mc = 1 megacycle per second = 1,000,000 cps.
1 kc = 1 kilocycle per second = 1000 cps.

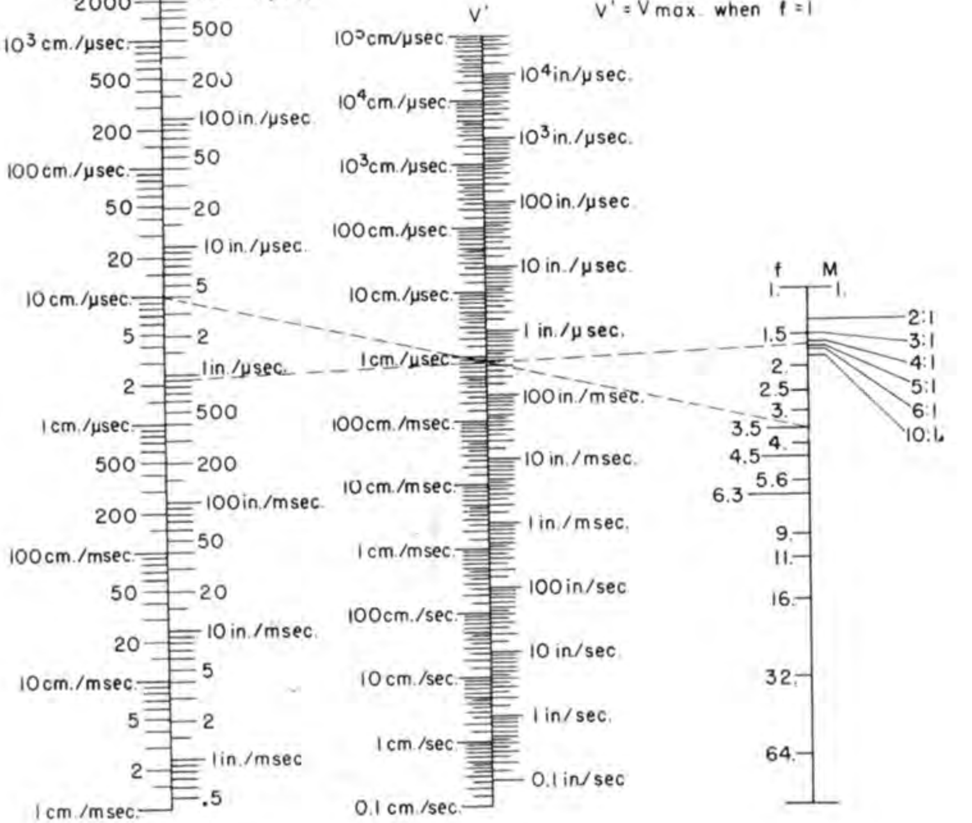
Frequency range may be extended below 10 kc or above 1000 Mc by applying a suitable factor.

NOMOGRAPH FOR DETERMINING WRITING SPEED IN TERMS OF LENS APERTURE f, OBJECT-IMAGE RATIO, & MAXIMUM WRITING SPEED

$$V = \frac{4\,V_{max.}}{f^2\,(1+\frac{1}{M})^2} \qquad V' = \frac{V_{max.}}{f^2}$$

f = lens aperture at infinity.
M = optical object-to-image ratio
$V_{max.}$ = maximum writing speed at f = 1 & M = 1
V' = writing speed at any aperture f.
V = writing speed at object: image ratio M, and aperture f.

V' = V when M = 1
V' = $V_{max.}$ when f = 1

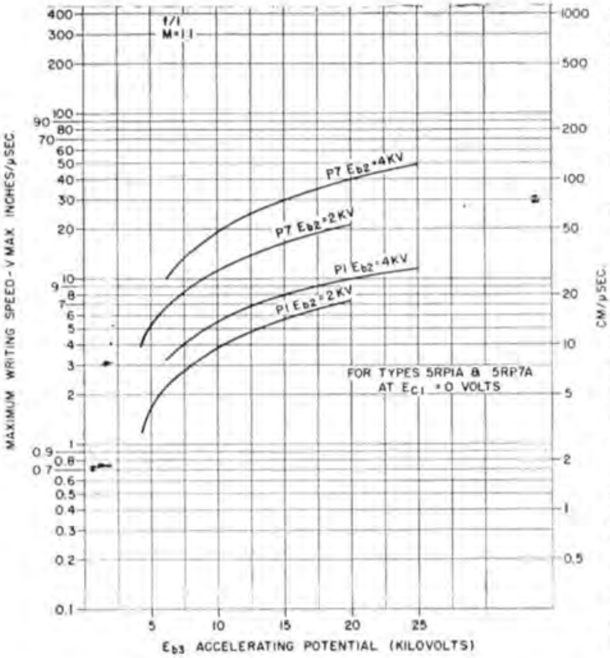


1µsec. = 1 microsecond = 1/1,000,000 second

1 msec. = 1 millisecond = 1/1,000 second

Time scale changes below 1 in./µsec. & below 1 cm./µsec.

Figure 12



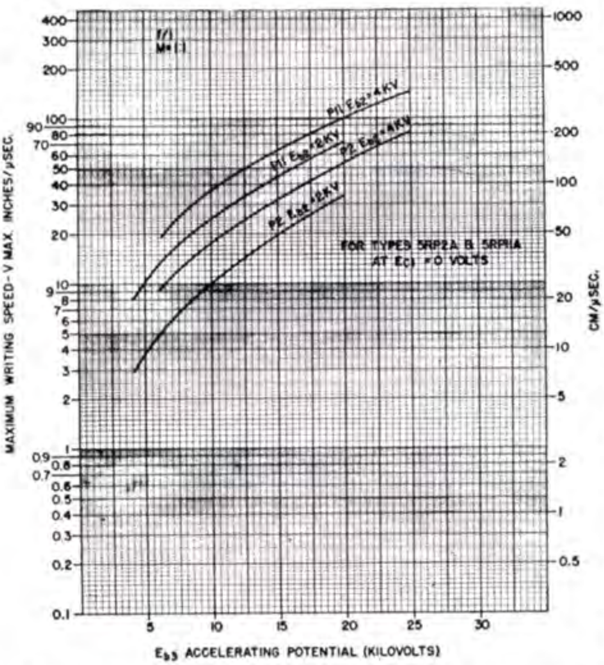


Figure 13. Graphs showing relationship between maximum photographic writing speeds and accelerating potential for the Type 5RP-A Cathode-ray Tube.

The speed of the phenomena which is to be recorded can be found from Figure 11 by considering a frequency of 50 kc and dividing the result by ten to give the required frequency of 5 kc. A value of approximately 0.1 cm/μsec is obtained for V^1.

By means of the momograph, Figure 12, we find that with V_{max} = 3 cm/μsec, a signal of V^1 = 0.1 cm/μsec can be recorded using an aperture of f/5.6 for M = 1. If a different ratio of object on screen to image on film is desired, perhaps M = 10:1, a line drawn from this value to 0.1 cm/μsec on the V^1 scale crosses the V scale at 0.33 cm/μsec. Use of M = 10:1 permits the recording of speeds 3.3 times higher than with M = 1. To confirm this, locate 0.33 cm/μsec. on the V^1 scale and draw a line to the previous determined aperature f/5.6. The cross point on the V_{max} scale established the corresponding increase in V_{max} to 10.2 cm/μsec. Since the recorded speed is only 0.1 cm/μsec .a line can be drawn from 10.2 cm/μsec on the V_{max} scale through V^1 = 0.1 cm/μsec. which shows an aperture between f/9 and f/11. Consequently, the phenomenon can be recorded either with an aperture f/5.6 for M = 1, with f/10 for M = 10:1, or with any intermediate values.

Recording of Transient Rectangular Wave

Assume a rectangular wave with a maximum rise of 5 cm/μsec. is to be recorded. The maximum speed to be recorded is therefore 5 x 10^6 cm/sec or 2 inches per μsec.

The available lens has a maximum aperture of f/1.9. The nomograph of Figure 12 shows that V_{max} = 18 cm/μsec. Figure 10 indicates that a P11 screen with B = 5.6 Ft. L. would be satisfactory. Assuming that in this case only 4 Ft. L are available from the cathode-ray tube under the given operating conditions, it would probably be advisable to increase the exposure by raising the object-image ratio. For M = 8:1 the apparent writing speed is increased three-fold, and a recording of satisfactory density would be secured.

Recording of High-Speed Transients

The curves of Figure 10 should *not* be extrapolated to include the high brightness levels and writing rates obtained with the new Type 5RP-A high-voltage cathode-ray tubes. These brightness data are based upon light measurements made under *steady raster* conditions with relatively low beam currents, and accelerating potentials. For transients of high signal writing-speeds and with high beam-currents, the photographic efficiency of the screen phosphors, particularly the P2 and P11, does not remain relative to the light output obtained under steady-state conditions.

It is necessary, under these conditions, to directly determine the maximum photographic writing speeds possible vs. the desired operating conditions. For example, the least variable factor in the characteristics of a cathode-ray tube is its beam-current vs. grid-drive characteristic (I_{b3} vs. E_{c1}), all other factors remaining the same. Since maximum beam current is always desirable, a set of curves may be plotted, with $E_{c1} = 0$, of maximum photographic writing speed vs. accelerating voltage. The parameter for these curves would be E_{b2} (2nd anode-to-cathode potential), since the beam current I_{b3} varies roughly as the 1.4th power of cathode-to-2nd anode voltage, E_{b2}.

The graphs of Figure 13 show the experimentally determined maximum photographic writing rates for the Type 5RP-A tube at E_{b2} equal to 2,000 and 4,000 volts. The grid voltage, E_{c1}, is at 0 volts in each case. The total accelerating voltage E_{b3} was varied from 4,000 to 25,000 volts. These curves are intended for use only with the Type 5RP-A tube and for high emulsion-speed film and developer (E.K. Linagraph Pan or Ortho and SD-19a). The values obtained from the curve do not represent absolute limits since a variation of as much as ±50% can be obtained depending on the efficiency of the particular screen or age of the tube, the freshness of the film stock, processing conditions and lens quality, etc. From the curve for the Type 5RP11A, the maximum photographic writing speed given at E_{b2} = 4,000 volts and E_{b3} = 25,000 volts is 150 inches/microsecond (for f/1 and M = 1:1). In most 35 mm cameras the object:image ratio is 3:1 or higher. For an object:image ratio of 4.5:1, the maximum writing rate would be increased about 2.7 times. Therefore the previously selected figure of 150 inches/µsec. at f/1 and M = 1:1 would be equivalent to a writing speed of 400 inches/µsec at f/1 and M = 4.5:1.

Recording of Recurrent Phenomena

As another example of the use of data given in this article, assume the exposure time for the recording of recurrent phenomena is to be determined.

Let us assume that a sine wave of amplitude, A = 2 cm, and a frequency of 1000 cps, with a sweep frequency of 100 cps, appears on a P1 screen, yielding a brightness, B, of 7.5 Ft. L. If n is the number of images per second appearing on the screen, t is the exposure time, and V is the maximum writing speed of the phenomenon which has to be recorded, then $V = t.n.\ V_{max}$ or $t = V/(n\ V_{max})$. Referred to a lens with aperture f, $t = Vf^2/(n\ V_{max})$.

In this case n = 100, and $V = 2\pi \times 10^3 \times 2 = 12.6 \times 10^3$ cm/sec. From the graph of Figure 10, $V_{max} = 6 \times 10^5$ cm/sec, and it can then be calculated that $t = 2.1 \times 10^{-4} f^2$ sec. If an aperture of f/7 is employed, t = 1/100th sec.

Exposure for Continuous-Motion Recording

Since the film is in motion at all times, the trace is continuously recorded on a different part of the emulsion and the exposure should be determined in the same manner as single frame recording of single transients. The writing speed of the spot on the film depends somewhat upon which method of continuous-motion recording is used (see "Recording by Means of Continuous-Motion Cameras"). Using Method 1, the film motion provides the time-base and, if the optically-reduced signal writing speed is considerably greater than the film speed, the latter may be neglected. Using Method 2, the exact spot writing speed (referred to the film plane) is the vector sum of the oscillograph sweep-speed (optically-reduced), the film-speed, and the signal writing speed (optically reduced). The film speed is ordinarily much less than either of the other speeds and can be neglected. Thus if a sinusoidal signal is recorded using Method 2, and about 10 cycles appear on the screen for each sweep, the effective writing speed is $2\pi fA$ (referred to the screen) or $2\pi fA/M$ (referred to the film plane).

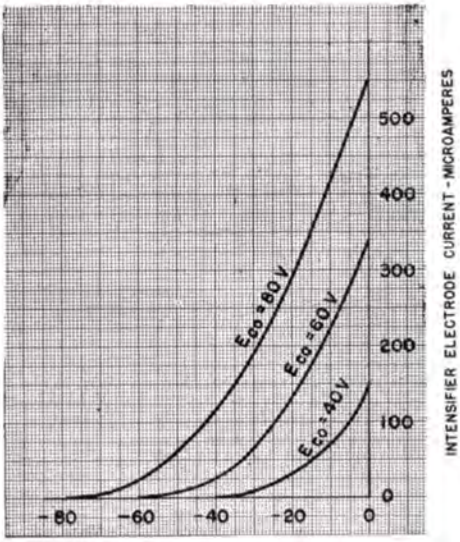


Figure 14. Typical grid-voltage vs. screen-current characteristics for three different tubes of the same tube type.

Large variations occur in the grid voltage versus screen current[1] characteristics or the grid voltage versus light output characteristics of individual cathode-ray tubes of the same type, due to unavoidable manufacturing tolerances. Average characteristics, plotted in the usual way as in Figure 14, are therefore of little help to equipment designers. A somewhat different method of approach has been found more satisfactory for cathode-ray tubes.

The designer of cathode-ray tube equipment is interested primarily in two characteristics insofar as the grid (control electrode) is concerned. First, he must know the cutoff bias limits in order that he may provide a sufficient range of negative d-c grid bias to cut the tube off (extinguish the beam and spot) in all cases. Secondly, he is interested in the variation of screen current or brightness as the grid is made more positive with respect to the cutoff voltage[2]. In general, the modulating signal is a-c and is superimposed on the d-c grid voltage, so that the absolute value of grid voltage for a given brightness is not so important as the voltage above cutoff; the designer must know how much modulation signal (above cutoff) he needs to provide, to produce the required screen current or brightness. This voltage above cutoff has become known as *Grid Drive,* and the characteristic of Grid Drive versus screen current or light output has become known as the *Grid Drive Characteristic.*

If Grid Drive is plotted against screen current for a large number of tubes, it is found that most of the tubes give approximately straight lines, at least over the part of the curve which is of interest. In tubes in which only a small part of the total cathode current is utilized, which includes most electrostatic deflection tubes, this curve has a slope of approximately 2, indicating an exponential of the form $I = KE_d^2$, for the Grid Drive versus Screen Current Characteristic. Furthermore, on such tubes, the Grid Drive Characteristic curves do not vary appreciably with Cutoff Bias. It is therefore possible to represent the average Grid Drive Characteristic of an electrostatic deflection tube by a straight line curve on log paper such as shown in Figure 15. To provide for manufacturing variations, a minimum curve can be drawn below the average curve.

The equipment designers approach then resolves into the following: (1) provide sufficient negative d-c bias at the intensity control to cut off the tube having the maximum cutoff bias permitted by the tube specifications; and (2) if grid modulation is used, provide sufficient grid modulation voltage (Grid Drive) to drive the tube to the desired screen current or brightness.

Of course, each tube type has a specified brightness, or beam current rating, (specified for a given operating condition) and the equipment designer cannot depend upon the tube providing more than the specified value. The tube characteristic sheet also specifies the grid drive which must be provided in the equipment for the specified screen current or light output. Thus, the answer is given immediately for the designer who is operating the tube under the conditions for which the light output or screen current is specified, and who wants to obtain the full rated screen current or light output. He must be careful, however, to take precautions against the grid being driven positive with respect to the cathode.

For most magnetic deflection tubes, the Grid Drive Characteristics differ from those of electrostatic tubes in that they vary appreciably with the cutoff bias of the particular tube as shown in Figure 16. However, this fact in no way precludes the tube manufacturer from specifying a maximum Grid Drive for the rated screen current, and the equipment de-

1 Current in the electron beam reaching the fluorescent screen.

2 Note that this does not mean that the grid is made positive, but only less negative.

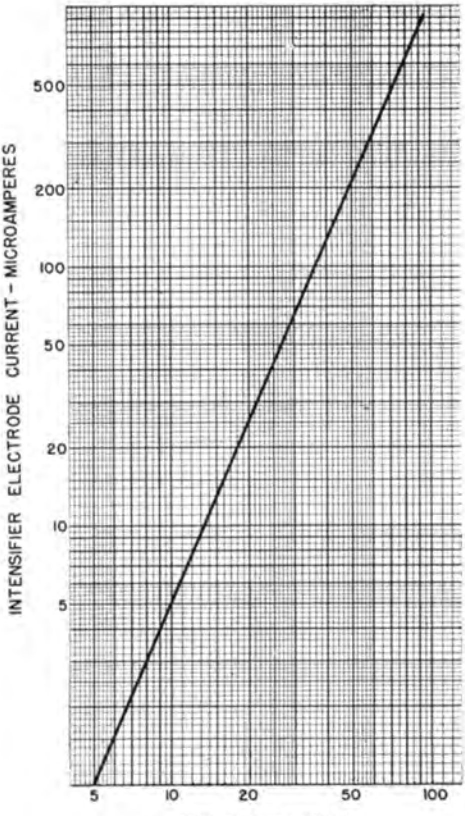


Figure 15. *Average grid-drive characteristic for a typical electrostatic cathode-ray tube.*

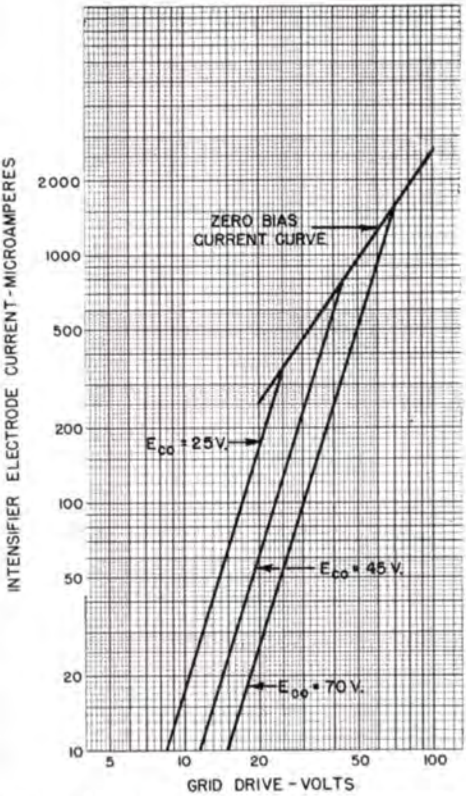


Figure 16. *Average grid-drive characteristics for typical magnetic cathode-ray tubes.*

signer proceeds exactly as for the electrostatic tube.

In cases in which the tube is not operated at the conditions of accelerating voltage, etc., at which the Maximum Grid Drive is specified, the following approximate relationships will guide the equipment designer in determining necessary Grid Drive:

Electrostatic Deflection Tubes[3]

$$I=K_1E_{b2}—1/2E_d^2$$

Magnetic Deflection Tubes[3]

$$I=K_2E_{c2}—3/2E_d^3$$

$$I=K_3E_{co}—3/2E_d^3$$

where K_1, K_2, K_3 are constants for a given gun design

Note that in the electrostatic case the effect of accelerating electrode voltage on the grid drive characteristic is small, and that in the magnetic case the accelerating electrode voltage has no effect[4].

OPERATING NOTES

Cathode-ray tube power supplies must usually provide between 1000 and 5000 volts d-c at from one to three milliamperes. In oscillographic applications, usual practice is to operate the accelerating electrode (second anode) at ground potential, in order that the deflection plates may be substantially at ground potential and thus facilitate their coupling to

3 The basic distinction is between tubes with the potential of the electrode next to the grid proportional to Eb2 and small utilization of the total cathode current; as compared to tubes in which the potential of the electrode next to the grid is independent of Eb2 and in which most of the cathode current reaches the screen.

4 There is a tendency to institute the use of limiting apertures in magnetic guns, which will result in the accelerating voltage having some effect on the grid drive characteristics.

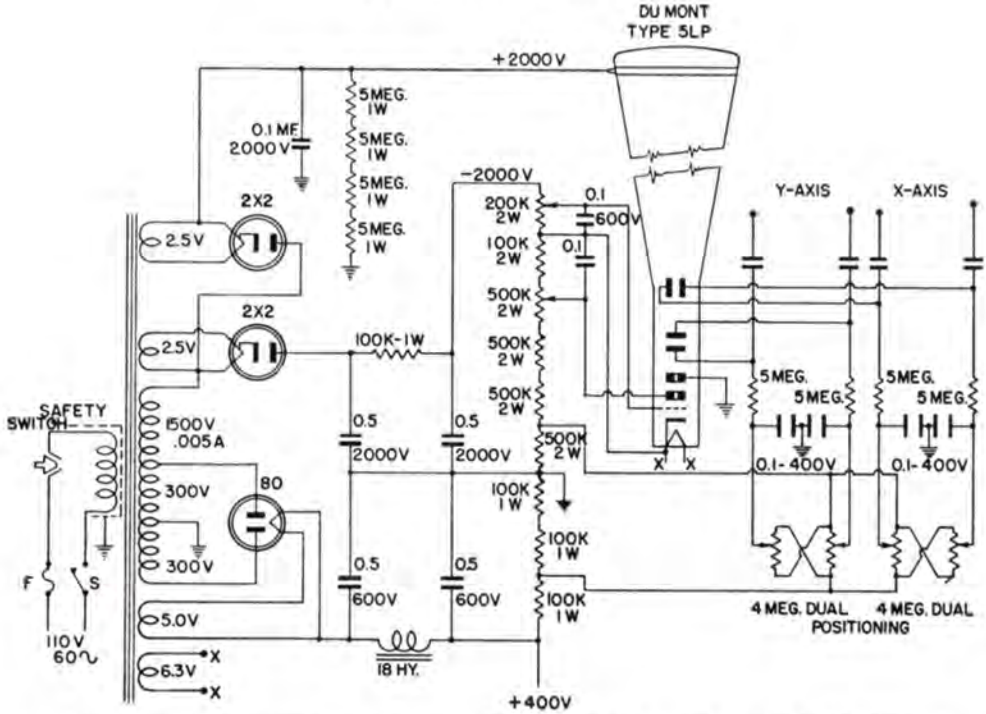


Figure 17. Typical power supply circuit for intensifier type cathode-ray showing the bleeder system which furnishes proper potentials to all the tube electrodes.

deflecting signal circuits and reduce the hazard in making connections directly to the deflection plates. When this method of operation is used, it is necessary to insulate the transformer winding supplying heater power to the cathode-ray tube for the full accelerating voltage, since the heater and cathode are operated at a negative potential with respect to ground equal to this voltage.

A voltage divider is ordinarily used to provide the required voltages for the control electrode (grid) and focusing electrode (first anode. The negative voltage is provided by a rheostat or potentiometer at the negative end of the voltage divider, and sufficient range should be provided to permit variation of grid bias from zero to a value at least equal to the maximum cut-off voltage for the tube at the accelerating voltage at which it is to be operated. The focusing voltage potentiometer should be capable of providing a range of voltage to the focusing electrode corresponding to the range over which the voltage required for focus is permitted to vary by the specification for the particular tube type involved.

In order to reduce defocusing of the spot to a minimum, positioning and signal voltages should be balanced whenever possible; that is, equal positive and negative voltages should be applied to the two plates of a deflection-plate pair.

The intensifier should ordinarily be operated at a potential 30% to 100% above the accelerating electrode potential. When lower values of intensifier voltage are to be used, the intensifier can be connected to a 300 or 400 volt plate supply if such a supply is readily available. If a higher intensifier potential is desired, a separate rectifier, operating from the same high voltage transformer winding as the accelerating voltage supply, with heater winding and a simple resistance-capacitance filter, are easily provided.

A typical power supply, with positioning circuits and deflection-plate input circuits, is shown in Figure 17. Such a supply will provide adequate voltages for operating intensifier-type cathode-ray tubes, such as the Type 5LP-A series.

In a transformer designed for operating cathode-ray tube circuits, both the cathode-ray tube heater winding and the primary winding should be completely surrounded with grounded electrostatic shields. These shields are necessary to prevent electrostatic coupling to the heater winding which might cause intensity modulation of the cathode-ray beam, and to prevent electrostatic coupling from the high voltage winding to the power-line. It is advisable to ground the chassis of cathode-ray equipment to prevent any possibility of the chassis attaining a high potential with respect to ground. The potentials at which cathode-ray tubes operate are dangerous, and precaution should be taken to prevent contact with them.

USE OF TUBE CHARACTERISTIC SHEETS

On the following pages will be found descriptions and characteristics of the various Du Mont cathode-ray tubes. These bulletins are arranged to give the essential data on each type in the manner which has been found most useful and complete.

Designers of cathode-ray equipment will find these characteristic sheets useful in the choice of a cathode-ray tube for a given application, as a guide toward best utilization of the cathode-ray tube for the particular application, and as a means of assuring that the equipment is so designed as to provide for the production tolerances needed in the mass production manufacture of cathode-ray tubes. This latter point is particularly important for any equipment which is to be made in quantity, and in which it is necessary to be able to use any cathode-ray tube of a given type interchangeably. Many pieces of equipment have been "designed around" a particular sample cathode-ray tube only to find that many tubes of production lots will not work in the equipment. The following paragraphs will be of assistance in interpreting the various sections of the characteristic sheets.

Description

Each Du Mont Cathode-ray Tube Characteristic Sheet is preceded by a concise but accurate general description of the tube type. These descriptions will be of assistance in choosing the proper tube for a given application.

Mechanical Characteristics

The Mechanical Characteristics indicate the tolerances which must be provided for in tube mountings, shields, etc. Equipment designers should not design closely form fitting shields based upon nominal dimensions in the outline drawing which do not have tolerances. Care should be exercised to provide for the angular tolerances of base and contact orientation. For example, in order that the traces of electrostatic type tubes may be properly aligned in the equipment, the base and intensifier terminal connections must each be movable through their specified angular tolerances with the trace.

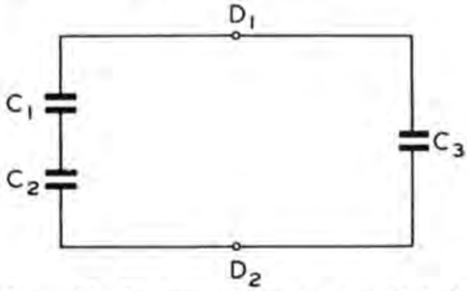


Figure 18. Diagram showing an equivalent circuit for deflection plate capacitances in a cathode-ray tube.

Direct Interelectrode Capacitances

The values given are nominal ones, which are usually average values, but which are subject to minor variation as improvements are made in designs. An equivalent circuit for a deflection plate pair, when used for balanced deflection is given in Figure 18 where C_1 = direct capacity from D_1 to all electrodes except D_2, C_2 = direct capacity from D_2 to all electrodes except D_1, C_3 = direct capacity from D_1 to D_2. For the case of unbalanced deflection, for example where D_2 is tied to A_2, the total capacitance is that of C_1 and C_3 in parallel.

Maximum Ratings and Circuit Values

Heater voltage should always be maintained as close as possible to the rated value. In no case should the applied heater voltage differ from the rated value by more than 10%.

All d-c potentials given in the characteristics sheets are with respect to cathode unless otherwise indicated. References to E_{b3}/E_{b2} ratios are also for potentials with respect to cathode.

Maximum values of voltages given under "Ratings" are "design center" values which should not be exceeded by designers of equipment. These values are 10% below the absolute maximum values formerly specified, and as such take into account the possibility of line voltage variations or variations in the values of components which may raise the supply voltage above the "design center" value.

Exceeding the specified maximum value of grid circuit resistance may cause loss of grid control. Exceeding the specified value of deflecting electrode circuit impedance may result in ripple appearing on the trace at the power supply frequency, or in serious depositioning of the trace.

Exceeding the specified maximum ratio of E_{b3}/E_{b2} (intensifier potential to accelerating electrode potential) will result in excessive spot distortion with deflection, and may result in pattern distortion or "folding back" of the spot onto the screen area after it has been deflected off. It also may result in voltage breakdown across the intensifier gap (gap between accelerating electrode coating and intensifier electrode coating on wall of tube).

Typical Operating Conditions

The typical values given for accelerating voltage indicate the range of voltages over which successful operation may be expected. In general, the highest voltages should be chosen when best spot size and intensity are required, and the lowest voltages consistent with the required performance when high deflection sensitivity and economy in weight or cost of equipment are of paramount importance.

The Anode No. 1 voltage for focus indicates the range of voltage which the focus control must provide for the corresponding Anode No. 2 voltage. The proper range of focus voltage for E_{b2} values other than those given under Typical Operating Conditions may be determined readily from the fact that the E_{b1} value for focus varies directly with E_{b2}. (It is not appreciably affected by E_{b3}).

The value of grid voltage for beam cutoff indicates the amount of negative voltage which must be provided by the intensity control for the given typical operating condition in order to extinguish the spot. The intensity control must be capable of varying the grid voltage from zero to the maximum value of cutoff, with something to spare to provide for leakage current drop across the grid circuit resistance. In applications where pulsing or other grid modulation is used, care should be taken to consider all the composite effects of a-c and d-c grid voltages, so as to provide for intensity control from zero bias to cutoff for the part of the trace which is to be observed. (For example, if the beam is to be pulsed on and off with a square pulse, and to be visible only at the top of the pulse, control should be provided so that the potential of the grid at the time that the pulse is on, can be varied from zero to the maximum cutoff value. In some cases of complicated grid signals, a means of providing the necessary control with a minimum of operating controls, will be to provide a "screw-driver" adjustment which is adjusted only when changing tubes.

The cutoff voltage varies directly with accelerating electrode voltage (E_{b2}) in tubes which do not have a separately connected screen grid (most electrostatic focus tubes), and varies nearly directly with the screen grid voltage (E_{c2}) for tubes which have a screen grid (most magnetic focus tubes).

The gun and screen currents, and the light output values given for the various types are nominal values obtained by averaging the test results of a number of tubes selected at random. Individual tubes of a given type may be expected to depart from these curves to some extent because of slight unavoidable variations in manufacturing. The screen current is taken as the intensifier current of intensifier type tubes, or as the anode current of magnetic focus tubes.

Unless otherwise specified, values given for light output and screen efficiency data are given in accordance with the following measurement method: — A 2" x 2", 50 line raster is set up on the tube, a photronic cell type illumination meter is used, which has been calibrated in foot candles with a standard light source having a color temperature of 2700° K. The cell is placed directly in contact with the tube face over the center of the raster and the reading of the meter in foot candles is taken. For visual brightness measurements, a photocell with a filter, such as to give standard eye spectral response, is used and it is assumed that the value obtained is the brightness of the screen in foot lamberts. For P5 and P11 screens, a standard #3 photronic cell without eye correction is used and the units are arbitrary. It has been found, however, that the measurements so made on P5 and P11 screens correspond fairly well to photographic efficiency.

For television picture tubes the screen brightness is measured as a function of grid drive (peak signal volts from cutoff) with a raster size typical of the tube type.

The above rules, together with the preceding data on Screen Characteristics and the material in the section on Grid Drive Characteristics, can be used to determine the grid drive required for operating conditions other than the one indicated.

Deflection factors are proportional to accelerating electrode potential for electrostatic deflection tubes without intensifiers. In intensifier type tubes, the deflection factor is still proportional to the accelerating voltage so long as the ratio of E_{b3}/E_{b2} remains constant. Deflection factors for intensifier tubes at E_{b3}/E_{b2} ratios other than the ones given under typical operating conditions, can be estimated by interpolating between the data given for different values of E_{b3} at some one accelerating electrode voltage (E_{b2}), to give a deflection factor at the desired ratio, and then making use of the fact that the deflection factor is proportional to E_{b2} for a given E_{b3}/E_{b2} ratio.

Basing

No connections should be made to socket terminals corresponding to pins marked "internal connection" since these pins may be connected to an internal part of the tube. In fact, it is recommended that no connections be made to any unused terminals of cathode-ray tube sockets.

Symbols

- g_1 grid No. 1, control electrode (in tubes having more than one grid).
- g grid, control electrode (in tubes having only one grid).
- g_2 grid No. 2, screen grid.
- a_1 anode No. 1, focusing electrode.
- a anode, accelerating electrode (in tubes having only one anode).
- a_2 anode No. 2, accelerating electrode.
- a_3 anode No. 3, intensifier electrode.
- D_1 deflection plate No. 1.
- D_2 deflection plate No. 2.
- D_3 deflection plate No. 3.
- D_4 deflection plate No. 4.
- D_1D_2 deflection plate pair made up of D_1 and D_2, pair nearer screen.
- D_3D_4 deflection plate pair made up of D_3 and D_4, pair nearer gun.
- E_c grid voltage (for tubes having only one grid).
- E_{c1} grid No. 1 voltage, control electrode voltage.
- E_{c2} grid No. 2 voltage, screen grid voltage.
- E_{c0} control electrode voltage for beam cutoff (for reduction of beam current and screen intensity to zero; more precisely, for visual extinction of undeflected, focused spot).
- E_b anode voltage (for tubes having only one anode).
- E_{b1} anode No. 1 voltage, accelerating electrode voltage.
- E_{b2} anode No. 2 voltage, accelerating electrode voltage.
- E_{b3} anode No. 3 voltage, intensifier electrode voltage.
- E_{b3}/E_{b2} ratio of intensifier electrode voltage to accelerating electrode voltage.
- E_{cd} grid drive voltage.

INSTALLATION NOTES

Du Mont cathode-ray tubes may be operated in any position. They should be shielded from external magnetic fields by a high permeability shield such as mu-metal, and they should be located as far as possible from transformers and chokes, the magnetic fields of which can cause spurious magnetic deflection. All Du Mont cathode-ray tubes are now made with a structure which cannot become magnetized and produce spurious effects.

It is possible however, that with tubes of older design, the nickel assembly composing the deflection plate structure will become magnetized due to a strong magnetic field. The effect of such magnetization may be to defocus the spot, or otherwise change its shape, to reduce its intensity, to distort the deflecting fields thus producing non-linear deflection, or to displace the spot or trace permanently. This disturbance may be remedied by placing the tube axially within a solenoid which produces a strong alternating field and then gradually removing the tube from the influence of that alternating field.

Du Mont cathode-ray tubes are sufficiently strong mechanically to withstand the shocks of ordinary handling and temperature changes. Especially in the case of the larger tubes, however, the glass bulb is under considerable stress from atmospheric pressure. Consequently, hard bumps and extreme temperature changes should be avoided. Care should be taken to avoid scratching the bulb since such scratches will greatly weaken the glass.

TELEVISION PICTURE TUBES

Modern television picture tubes are commercially available for direct view and projection applications. Direct view type tubes are made with screen sizes as large as possible consistent with manufacturing costs, and are capable of producing clear, sharp pictures of maximum brilliance. Tubes are presently available with bulb face diameters ranging from 7" to 20".

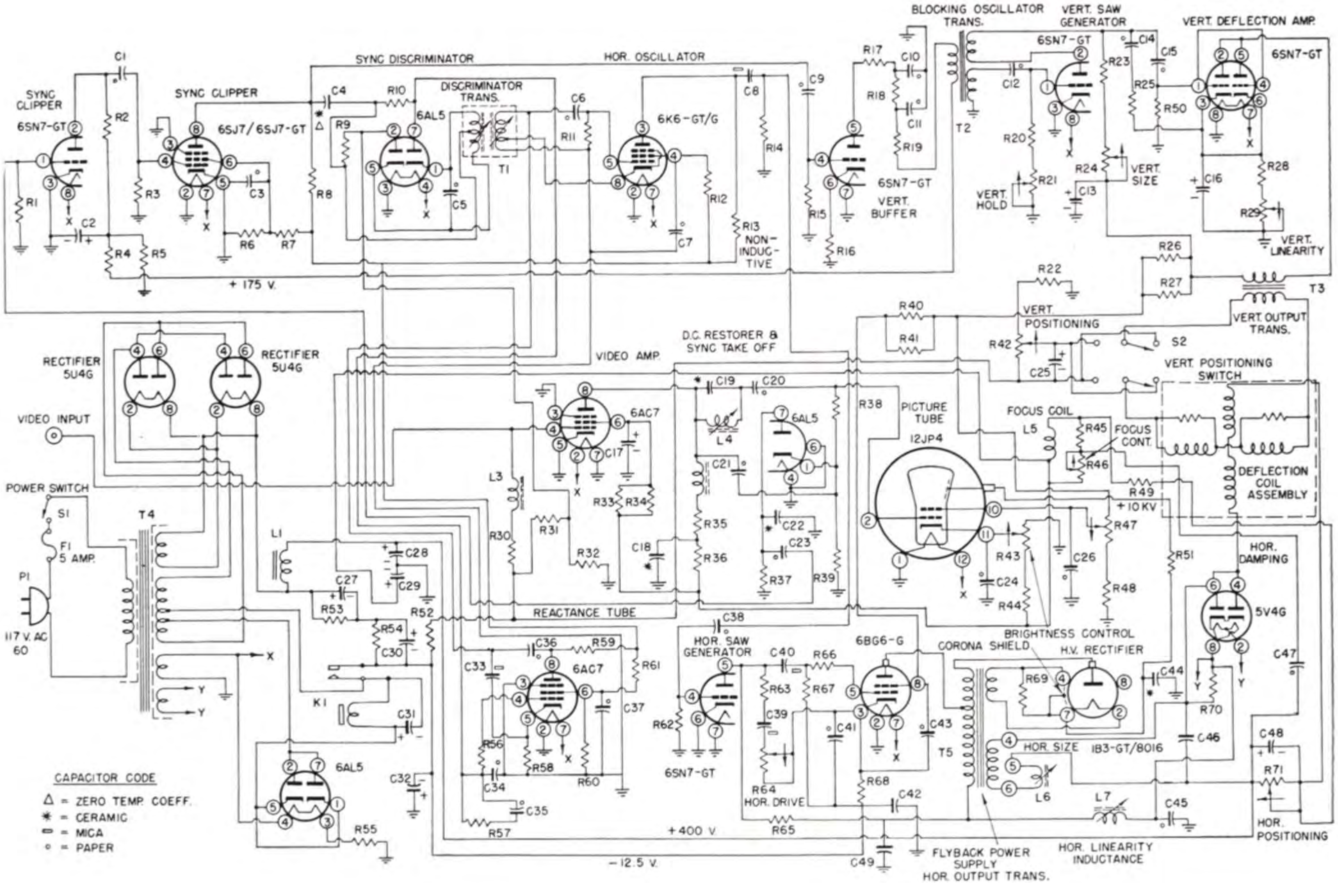

SYNC CLIPPER
6SN7-GT
SYNC CLIPPER
6SJ7/6SJ7-GT
SYNC DISCRIMINATOR
DISCRIMINATOR TRANS.
6AL5
T1
HOR. OSCILLATOR
6K6-GT/G
R13 NON-INDUCTIVE
6SN7-GT
VERT. BUFFER
BLOCKING OSCILLATOR TRANS.
T2
VERT. SAW GENERATOR
6SN7-GT
VERT. HOLD
VERT. SIZE
VERT. DEFLECTION AMP.
6SN7-GT
VERT. LINEARITY
+175 V.
T3
VERT. OUTPUT TRANS.
VERT. POSITIONING
S2
VERT. POSITIONING SWITCH
RECTIFIER 5U4G
RECTIFIER 5U4G
VIDEO INPUT
VIDEO AMP.
6AC7
D.C. RESTORER & SYNC TAKE OFF
6AL5
PICTURE TUBE
12JP4
FOCUS COIL
L5
FOCUS CONT.
DEFLECTION COIL ASSEMBLY
+10 KV
POWER SWITCH
S1
F1 5 AMP.
P1
117 V. AC 60
T4
L1
L3
REACTANCE TUBE
6AC7
HOR. SAW GENERATOR
6SN7-GT
6BG6-G
R64 HOR. DRIVE
BRIGHTNESS CONTROL
CORONA SHIELD
H.V. RECTIFIER
1B3-GT/8016
HOR. SIZE
L6
T5
HOR. DAMPING
5V4G
HOR. POSITIONING
L7
HOR. LINEARITY INDUCTANCE
FLYBACK POWER SUPPLY HOR. OUTPUT TRANS.
+400 V.
-12.5 V.
K1
6AL5
CAPACITOR CODE
Δ = ZERO TEMP. COEFF.
✱ = CERAMIC
▭ = MICA
◦ = PAPER

Figure 19

Projection type picture tubes are usually made with small diameter faces, a typical size being 5", and are provided with a face curvature suitable for use with reflective optic systems operating on the Schmidt principle. Flat face projection tubes for use with refractive optic systems have also been made but the low light efficiency of such systems has practically precluded their usefulness.

Standard Du Mont tubes available for television purposes are the direct view type 7EP4, 12JP4, 15AP4, and 20BP4. The 7EP4 is an electrostatic focus and deflection tube designed for use where set cost is the major factor. The use of electrostatic deflection eliminates the need for a deflection yoke and simplifies the deflection amplifier requirements. Electrostatic deflection tubes, however, have inherently more deflection defocusing than the magnetic deflection type and hence their use is not recommended where the utmost in picture quality is required. The Du Mont 12", 15" and 20" tubes utilize magnetic focus and deflection for maximum picture brilliance and definition.

The following table gives approximate picture sizes for the various tubes, based on a ratio of corner radius to picture width of

$$\frac{r}{w} = 0.20$$

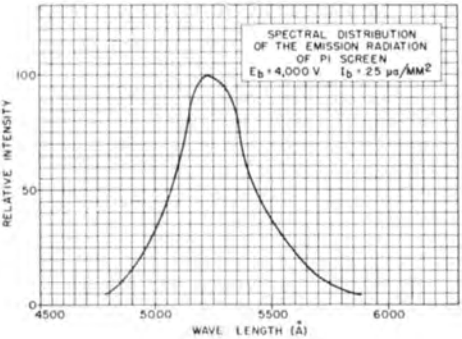
Bulb Face Diameter	Picture Size	Area—Sq. Inches (Neglecting Masked Corners)
7"	4¼" x 5¾"	24
10"	6½" x 8⅝"	56
12"	7¾" x 10¼"	80
15"	9½" x 12¾"	121
20"	12⅞" x 17¼"	222

For most magnetic deflection picture tubes, the angle through which the beam must be deflected is approximately the same regardless of screen size, hence the deflection requirements are fixed by the type of deflection coil and the anode voltage of the picture tube. The amount of deflection current required for a given tube and deflection coil is proportional to the square of the anode voltage used. However, picture definition and brightness increase with increasing anode voltage, and the use of as high a voltage as economically practical is recommended for best performance. Typical operating voltages are 10,000 volts for 12" tubes, 12,000 volts for the 15" tube, and 15,000 volts for the 20" tube.

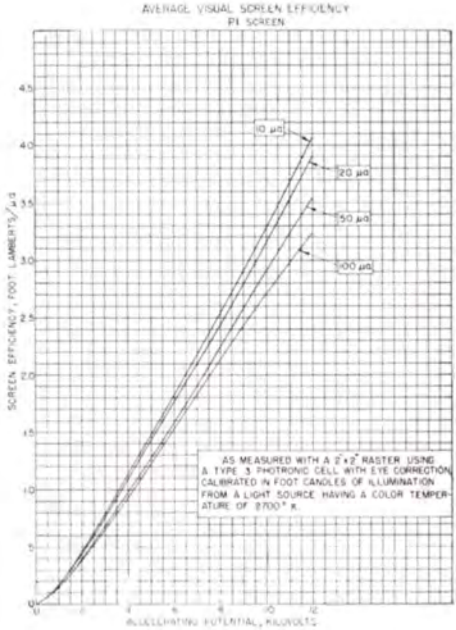
DU MONT
CATHODE-RAY TUBE
SCREEN CHARACTERISTICS

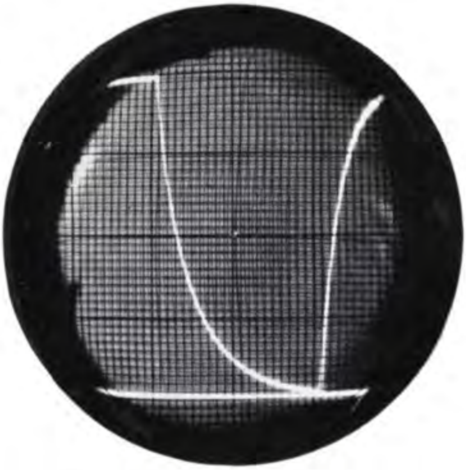
General Description

Medium persistence green screen of high visual efficiency, suited for general-purpose visual oscillographic and indicating applications.



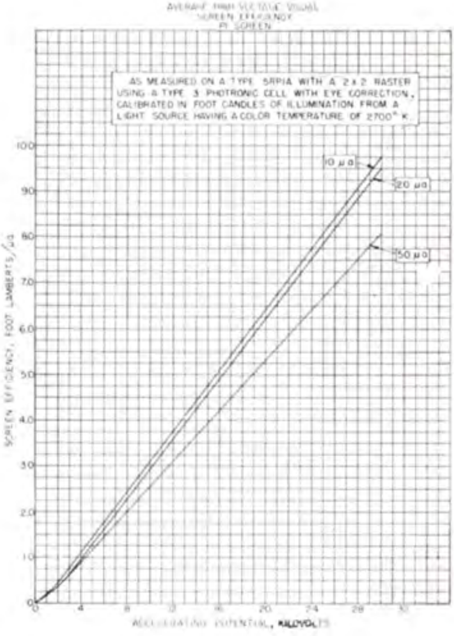
Representative Spectral Characteristic
Stationary spot excitation.





Persistence

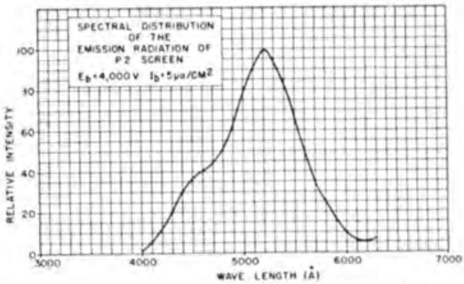
For 10% of the initial intensity, the persistence time for a current density of 25 μa/cm² at 4000 volts is approximately 30 milliseconds. The persistence time decreases slightly with increasing current density to about 25 milliseconds for 600 μa/cm². There is little change in persistence time with voltage. Decay curve is for about 25 μa/cm² at 4000 volts: 1 division = 2.5 milliseconds. This data and curve are for repetitive stationary spot excitation.



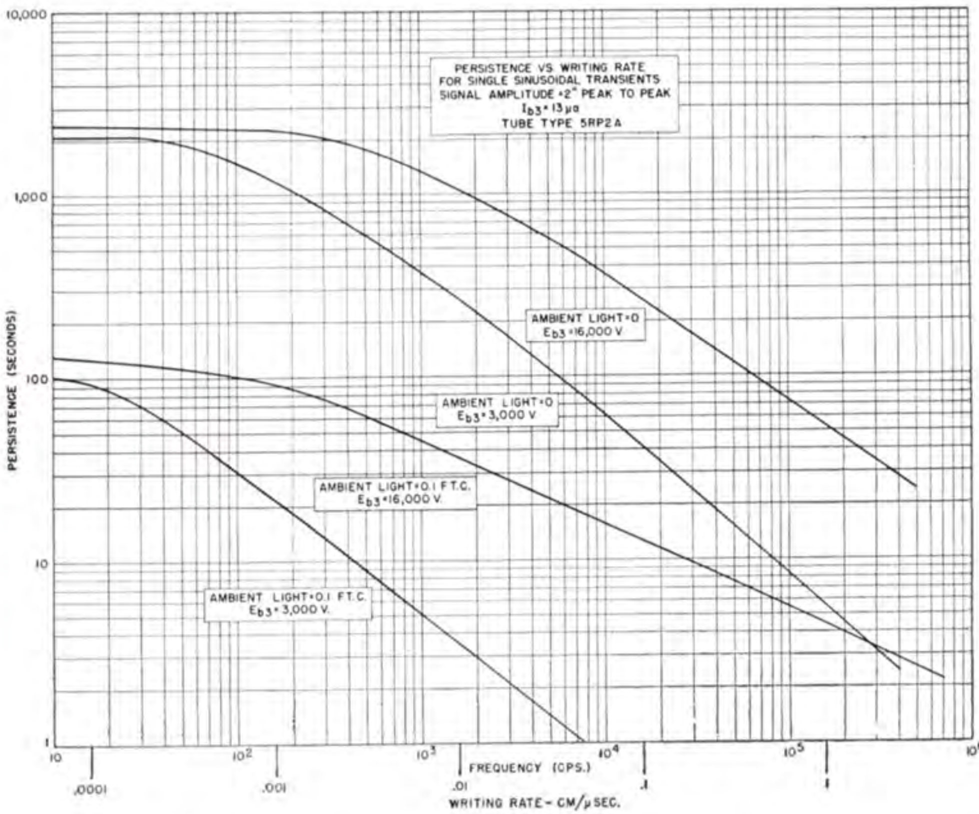
General Description

Long persistence screen with a short persistence blue-green fluorescent characteristic, and a very long yellow-green phosphorescence, suited for applications requiring long persistence at high writing rates (short interval excitation).

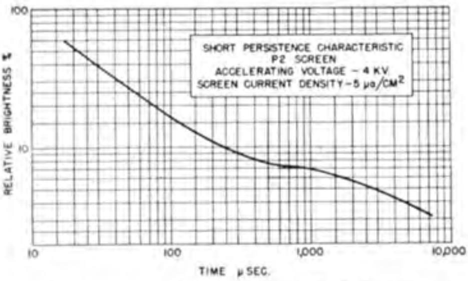
Because the ratio of fluorescent to phospherescent light is very high, the P2 screen may also be used for visual observation and photography in applications where it is desirable to have the characteristics of a short persistence screen. By the use of a suitable filter the fluorescent light only may be selected.



Representative Spectral Characteristic
Stationary spot excitation.

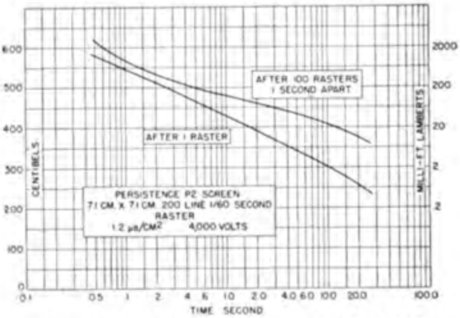


Persistence versus writing rate for single sinusoidal transients. (Eye adapted to ambient light condition.)



Persistence for early part of decay

Excitation by a single stationary spot impulse at a current density of 5 $\mu a/cm^2$ and 4000 volts.

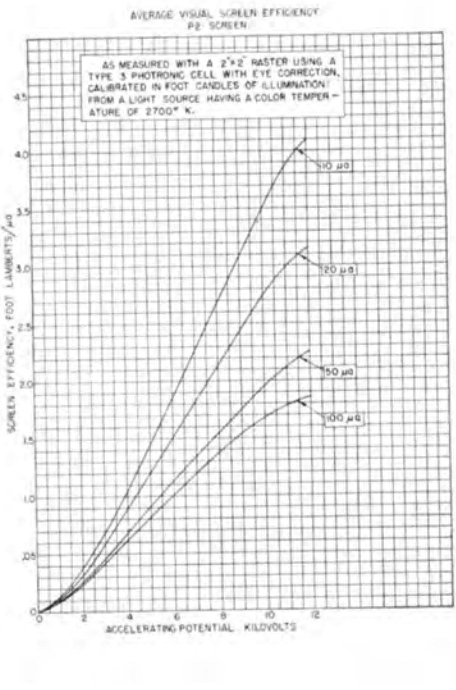


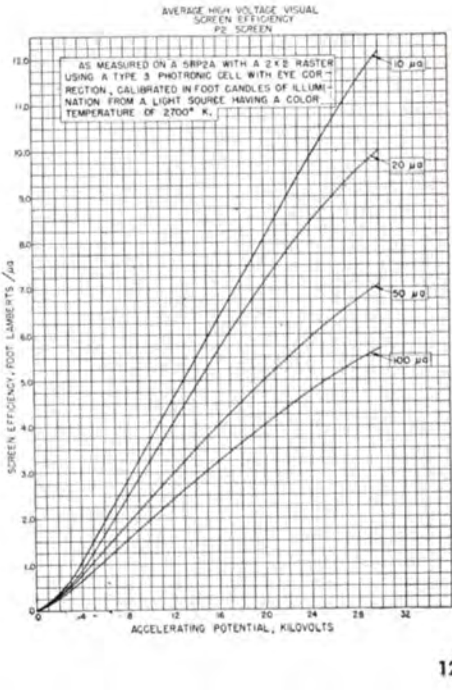
Persistence for latter part of decay

Excitation by a single 200 line raster in 1/60 second, and by a large number of 200 line rasters 1 second apart.

Persistence of early part of decay

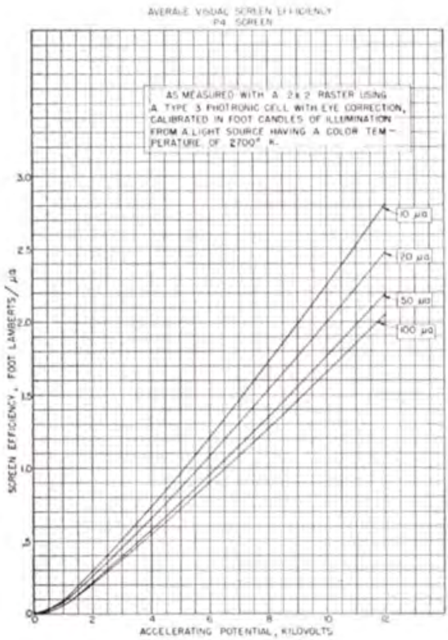
For 10% of the initial intensity, the persistence time for current density of 25 $\mu a/cm^2$ at 4000 volts is approximately 95 microseconds. The persistence time decreases with increasing current density to about 35 microseconds for 600 $\mu a/cm^2$. There is little change in persistence time with voltage at a current density of 25 $\mu a/cm^2$. Decay curve is for about 25 $\mu a/cm^2$ at 4000 volts, 1 division = 2.5 milliseconds. The above data and curve are for repetitive stationary spot excitation.





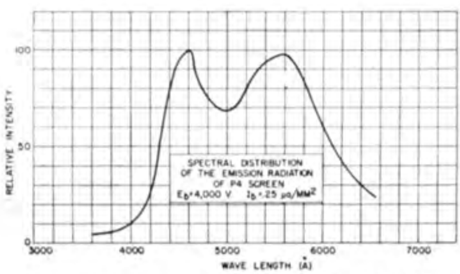
General Description

A medium persistence white screen suited for television picture tube application.



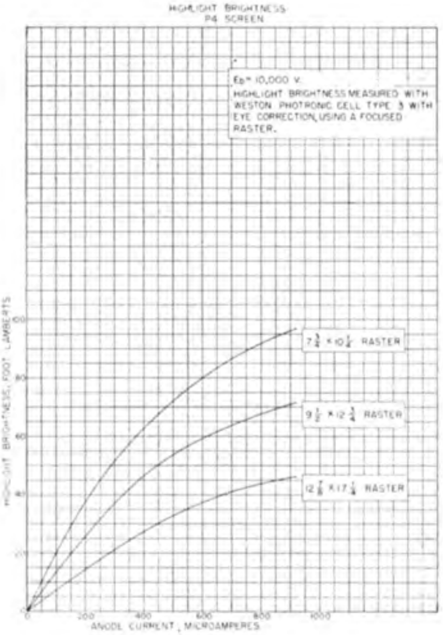
Persistence

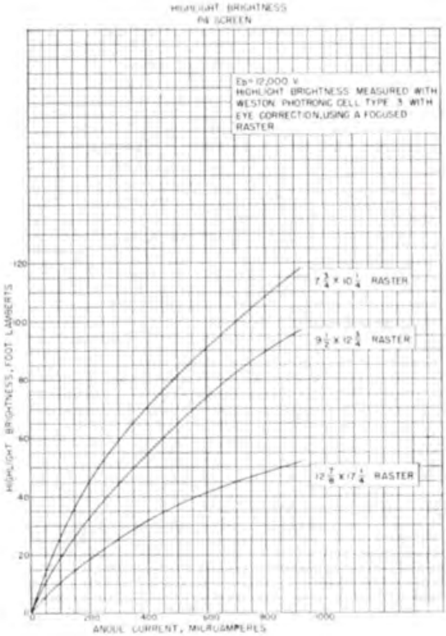
For 10% of the initial intensity, the persistence time for a current density of about 25 $\mu a/cm^2$ at 4000 volts is approximately 150 μsec. The persistence time decreases with increasing current density to about 35 μsec. for 600 $\mu a/cm^2$. The persistence time increases somewhat with increasing voltage at constant current density. Decay curve is for about 25 $\mu a/cm^2$ at 4000 volts; 1 division = 25 microseconds. The above data and curve are for repetitive stationary spot excitation.

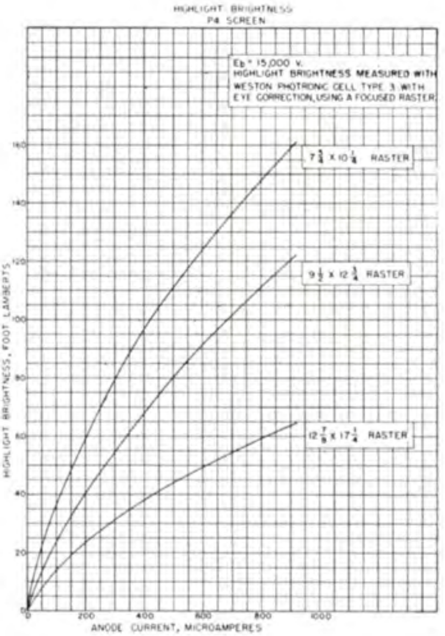


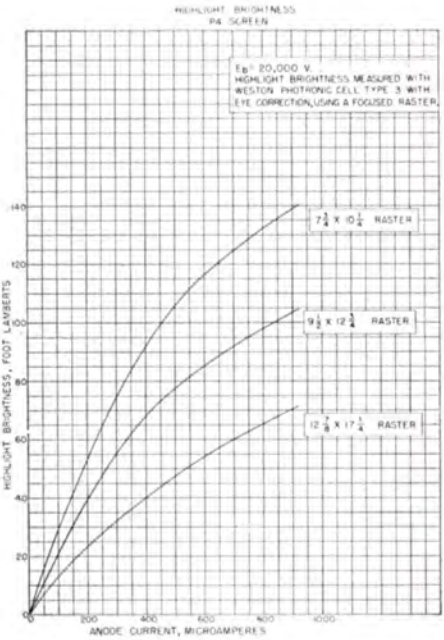
Representative Spectral Characteristic
Stationary spot excitation.

P4 SCREEN CHARACTERISTICS



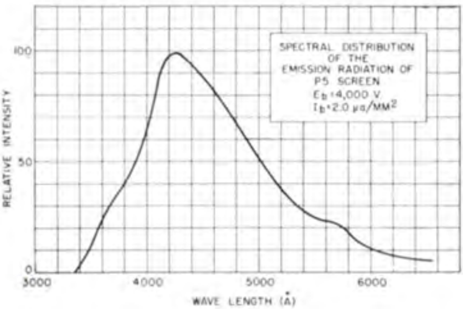




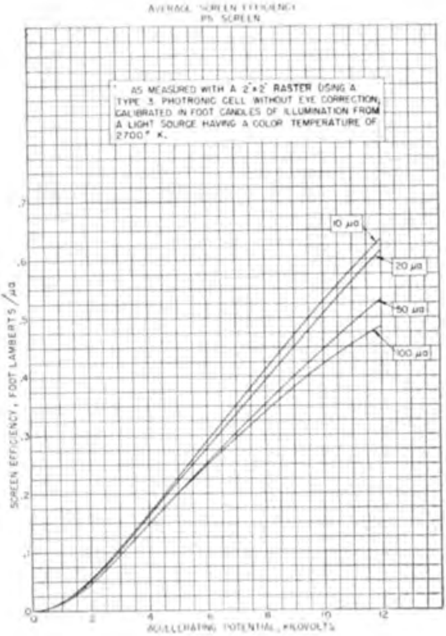


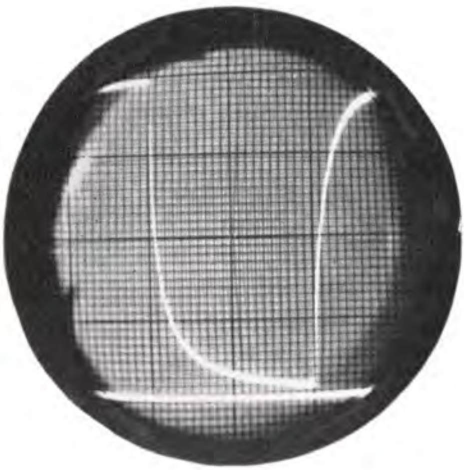
General Description

Extremely short persistence blue screen material, suited for photographic recording applications where extremely short persistence is required.



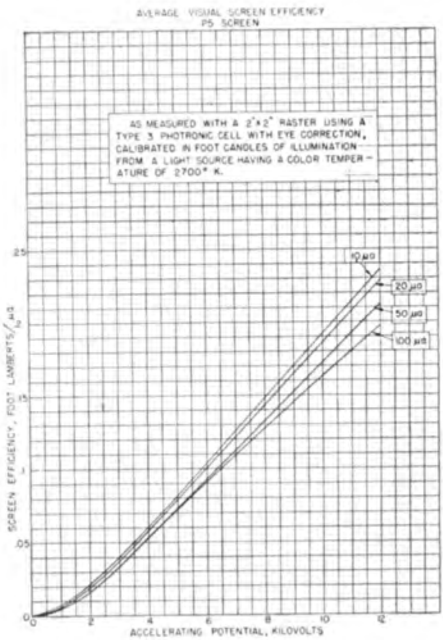
Representative Spectral Characteristic





Persistence

For 10% of the initial intensity, the persistence time for a current density of 25 μa/m² at 4000 volts is approximately 17 μsec. The persistence time decreases with increasing current density to about 7 μsec. for 600 μa/cm². (See decay curve.)

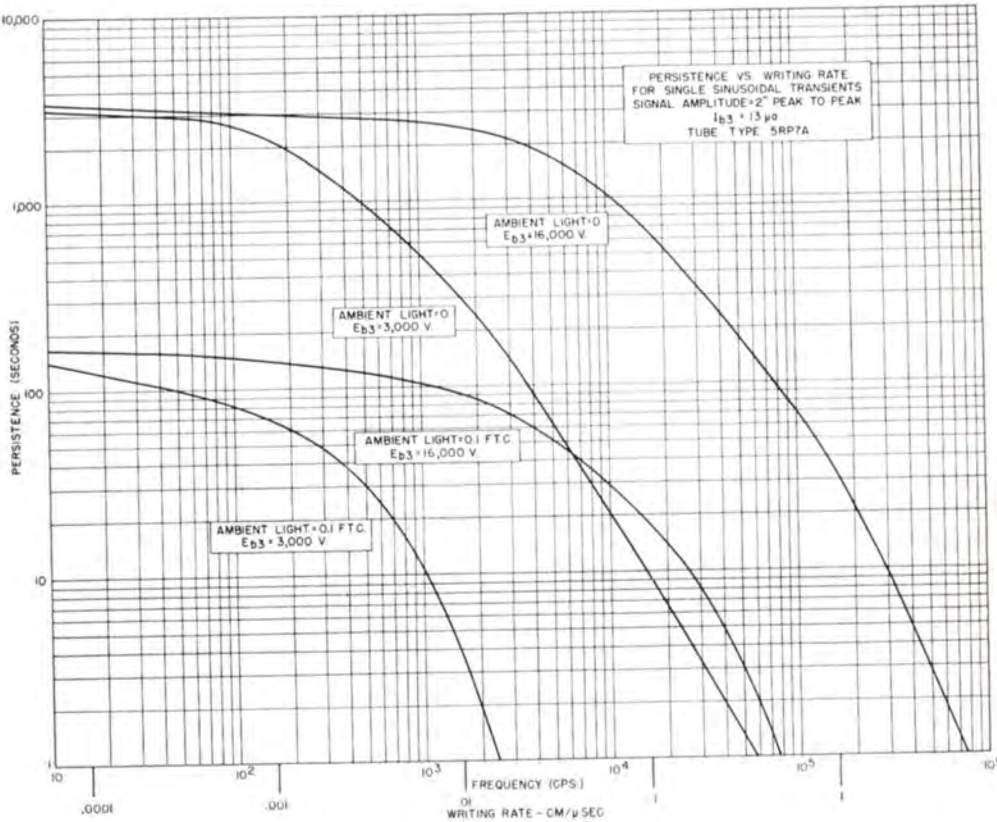


DU MONT P7 SCREEN CHARACTERISTICS

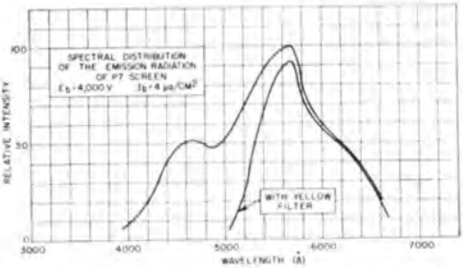
General Description

Long persistence screen with blue fluorescence and yellow phosphorescence, suited for applications requiring long persistence at slow and intermediate writing rates, for applications where it is desirable to filter out the initial "flash", and for applications where high buildup of phosphorescent intensity as a result of repeated excitation is desired.

The P7 screen is also well suited for dual purpose equipment where it is desirable to have available the characteristics of a long persistence screen and a short persistence screen in the same tube. By the use of suitable filters either the short persistent blue light, or the long persistent yellow light may be selected.

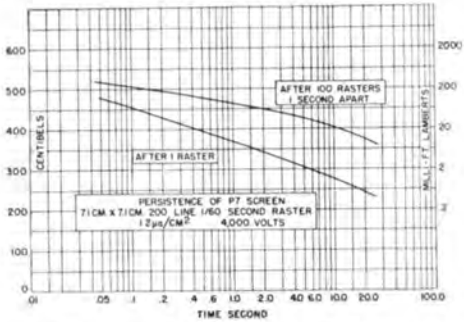


Persistence versus frequency for single sinusoidal transients. (No filter used; eye adapted to ambient light condition.)



Representative Spectral Characteristic

Stationary spot excitation. The short wave length peak is representative of the blue fluorescence. The long wave length peak is representative of the yellow phosphorescence. The curve with filter is for the Wratten #15 filter which is recommended for filtering out the blue "flash" of the screen.



Persistence Characteristic of P7 Screen

Excitation by a singe 200 line raster in 1/60 of a second, and persistence characteristic after excitation by a large number of 200 line rasters applied 1 second apart.

METHOD OF SPECIFYING DATA

Light Output

P7 light output is measured one second after the application of one or more 200 line rasters applied at one second intervals and at $Q = 20$ millimicrocoulombs/cm² where

$$Q = \frac{I_b * t}{A}$$ (I_b = microamps to screen, t = total excitation time in seconds = 1/60 second, A = area of raster in cm²). The light output generally used for indicating tube quality is the light output from a standard screen area of 7.1 x 7.1 cm, one second after the fifth raster application. This value is known as Cb and is expressed in units of the logarithmic centibel* scale, with reference to the light output from a standard P7 light source prepared by the M.I.T. Radiation Laboratory.

$* \; Cb = 100 \log_{10} \frac{(L1)}{(L2)}$ where $\frac{L1}{L2}$ = ratio of light output.

Buildup Ratio

The buildup ratio is the ratio of the light output measured one second after a pulse following the initial pulse, to the light output measured one second after the initial pulse. (Note: The word "pulse" as used here refers to application of the 200 line test raster for 1/60 second.)

Usually the ratio $G_{5:1}$ is used, where $G_{5:1}$ is the ratio of light output one second after the fifth pulse to the light output one second after the initial pulse.

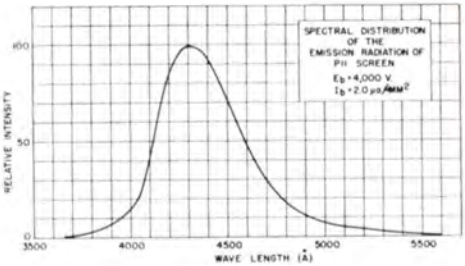
Flash Ratio

Flash ratio is the ratio of the initial "flash" light output to the Cb_5 light output. It is usually expressed as the difference $Cb_1 - Cb_5$ in centibels.

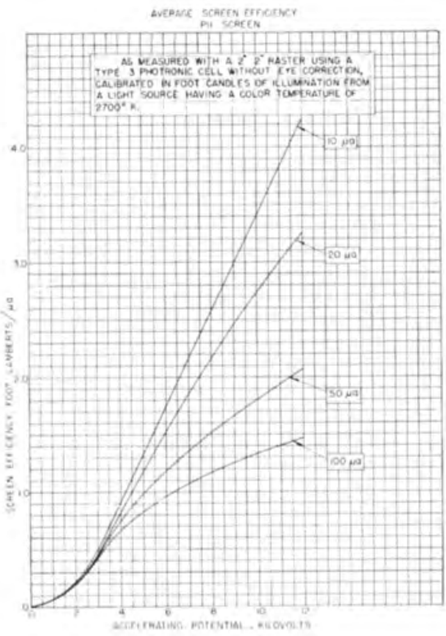
The flash light output (Cb_1) is the calculated Cb level which, if maintained constant for one tenth second, would integrate to give the same value as the integration of the light output one second following and including the initial excitation pulse.

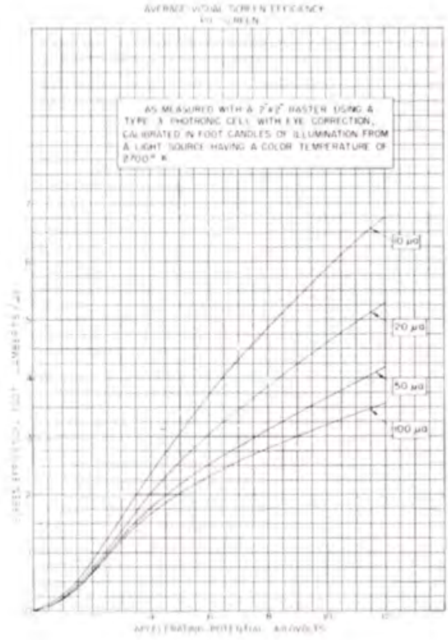
General Description

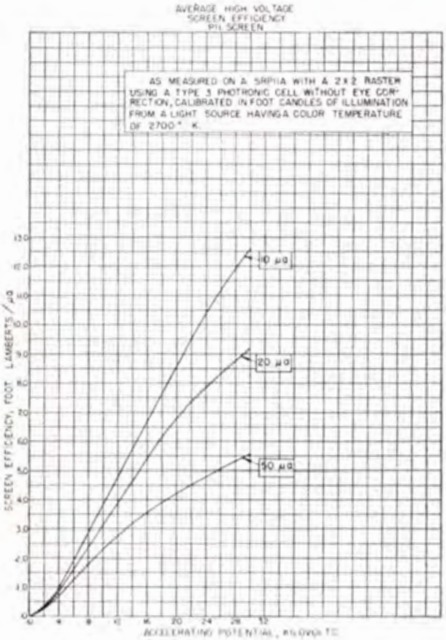
A short persistence blue screen material of very high photographic efficiency suited for photography where the extremely short persistence of the P5 screen is not required.

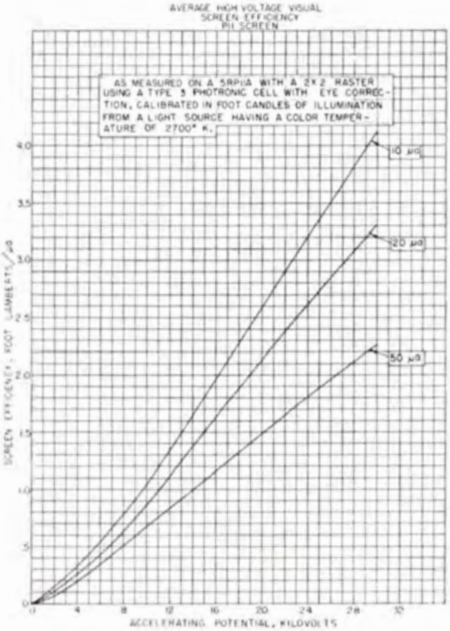


Representative Spectral Characteristic









Persistence

For 10% of the initial intensity, the persistence time for a current density of 25 μa/cm² at 4000 volts is approximately 100 μsec. The persistence time decreases with increasing current density to about 20 μsec for 600 μa/cm². (See decay curve.)

DU MONT
CATHODE-RAY TUBES

TUBE CHARACTERISTICS

3AP-A CATHODE-RAY TUBE

The Type 3AP-A Cathode-ray Tubes are designed for oscillographic and other applications where simplicity of the equipment is of paramount importance. A small bright spot is obtained at low accelerating voltage and without balanced deflection. The gun is designed to draw negligible focusing electrode current.

The two types differ only in the characteristics of the fluorescent screens.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	2.5 ± 10% Volts	
Heater Current	2.1 ± 10% Amperes	
Focusing Method	Electrostatic	
Deflecting Method	Electrostatic	
Phosphor	P1	P11
Fluorescence	Green	Blue
Persistence	Medium	Short

Direct Interelectrode Capacitances, Nominal

Grid #1 to all other electrodes	9.0 μμf.
D1 to all other electrodes	8.5 μμf.
D3 to all other electrodes	6.5 μμf.

Mechanical

Overall Length	11-1/2″ ± 3/8″
Greatest Diameter of Bulb	3″ ± 1/16″
Minimum Useful Screen Diameter	2-3/4″
Base	Medium 7 pin
Basing	7CE
Base Alignment 3D4 trace aligns with Pin #6 and tube axis	± 10 Degrees

Positive voltage on D2 deflects beam approximately toward Pin #1
Positive voltage on D4 deflects beam approximately toward Pin #6

MAXIMUM RATINGS—(Design Center Values)

Anode No. 2 Voltage	1500 Max. Volts D-C
Anode No. 1 Voltage	1000 Max. Volts D-C
Grid No. 1 Voltage	
Negative—Bias Value	125 Max. Volts D-C
Positive—Bias Value	0 Max. Volts D-C
Positive—Peak Value	2 Max. Volts
Peak Voltage between Anode No. 2 and any Deflection Electrode	550 Max. Volts

TYPICAL OPERATING CONDITIONS

For Anode No. 2 Voltage of	1000	1500	Volts
Anode No. 1 Voltage for focus	200 to 344	300 to 516	Volts
Grid No. 1 Voltage[1]	–16.5 to –49.5	-25 to –75	Volts
Deflection Factors:			
D1 and D2	61 to 91	91 to 137	Volts D-C per Inch
D3 and D4	58 to 88	87 to 131	Volts D-C per Inch
Anode No. 1 Voltage for focus	20% to 34.4% of Eb2 Volts		
Grid No. 1 Voltage[1]	1.65% to 4.95% of Eb2 Volts		
Anode No. 1 Current for any operating condition	–50 to ± 10 Microamperes		
Spot Position (undeflected)[2]	Within 15 Millimeters square		

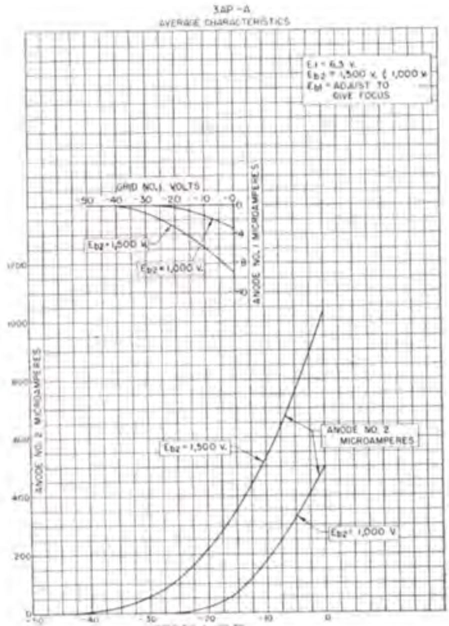
MAXIMUM CIRCUIT VALUES

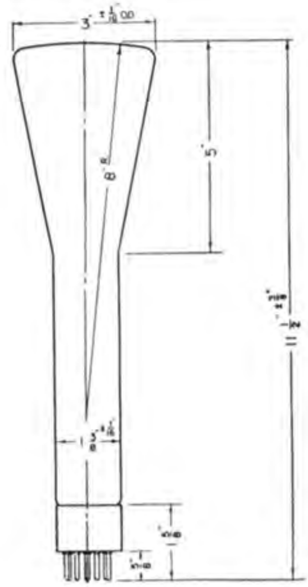
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[3] .... 5 Max. Megohms

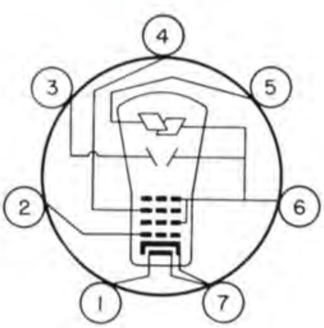
NOTES

1. Visual extinction of undeflected focused spot.
2. When tube is operated at (1) normal heater voltage (2) Eb2=1500 volts; (3) Eb1 adjusted for focus; (4) Ec1 set at such a value as will avoid damage to the screen; (5) with each of the deflecting electrodes connected to Anode No. 2 and (6) with the tube shielded against external influences:

   The spot will fall within a 15 mm. square, the center of which coincides with the geometric center of the tube face, and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
3. It is recommended that the deflecting electrode circuit resistances be approximately equal.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	Control Electrode
3	Deflection Plate D3
4	Focusing Electrode
5	Deflection Plate D1
6	Accelerating Electrode Deflection Plates D2, D4
7	Heater and Cathode

3GP-A CATHODE-RAY TUBES

The 3GP-A Cathode-ray Tubes are designed for oscillographic and other applications where small spot size, a brilliant trace, and a minimum of defocusing with deflection are required. The gun is designed to draw negligible focusing electrode current.

The two types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts	
Heater Current	0.6 ± 10% Ampere	
Focusing Method	Electrostatic	
Deflecting Method	Electrostatic	
Phosphor	P1	P11
Fluorescence	Green	Blue
Phosphorescence		
Persistence	Medium	Short
Direct Interelectrode Capacitances, Nominal		
Grid #1 to all other electrodes	7.0 μμf.	
D1 to D2	1.7 μμf.	
D3 to D4	1.5 μμf.	
D1 to all other electrodes except D2	6.5 μμf.	
D2 to all other electrodes except D1	6.4 μμf.	
D3 to all other electrodes except D4	4.9 μμf.	
D4 to all other electrodes except D3	4.7 μμf.	

Mechanical

Overall Length	11-1/2" ± 3/8"
Greatest Diameter of Bulb	3" ± 1/16"
Minimum Useful Screen Diameter	2-3/4"
Base	Medium Magnal
Basing	11N
Base Alignment 3D4 trace aligns with Pin #6 and tube axis	± 10 Degrees

Positive voltage on D1 deflects beam approximately toward Pin #3.
Positive voltage on D3 deflects beam approximately toward locating key.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 2 Voltage	1500 Max. Volts D-C
Anode No. 1 Voltage	1000 Max. Volts D-C
Grid No. 1 Voltage:	
Negative Bias Value	125 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts
Peak Voltage between Anode No. 2 and any Deflection Electrode	550 Max. Volts

TYPICAL OPERATING CONDITIONS

For Anode No. 2 Voltage of	1000	1500 Volts
Anode No. 1 Voltage for focus	163 to 291	245 to 437 Volts
Grid No. 1 Voltage[1]	−16.5 to −49.5	−25 to −75 Volts
Deflection Factors:		
D1 and D2	64 to 96	96 to 144 d-cV/in.
D3 and D4	56 to 84	84 to 126 d-cV/in.

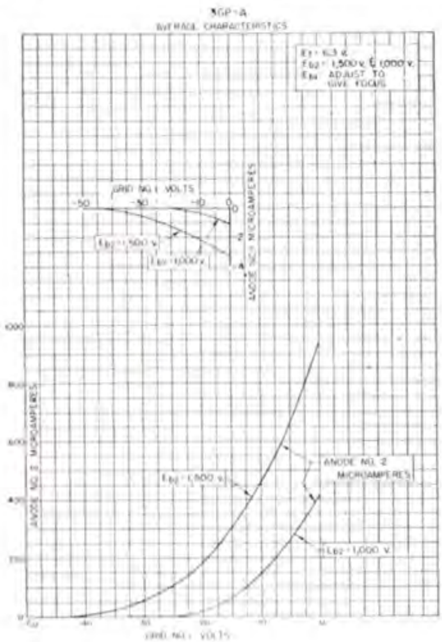
Anode No. 1 Voltage for focus	16.3% to 29.1% of Eb2 Volts
Grid No. 1 Voltage[1]	1.7% to 5% of Eb2 Volts
Anode No. 1 Current for any operating condition	−50 to + 10 Microamperes
Spot Position (Undeflected)[2]	Within 15 Millimeters square

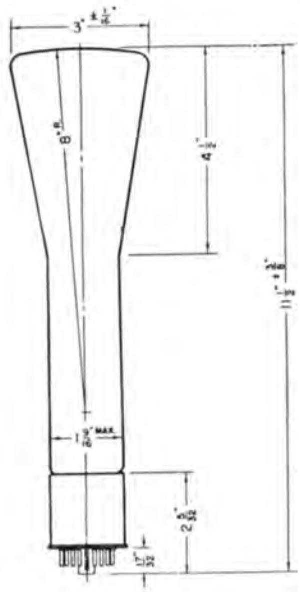
MAXIMUM CIRCUIT VALUES

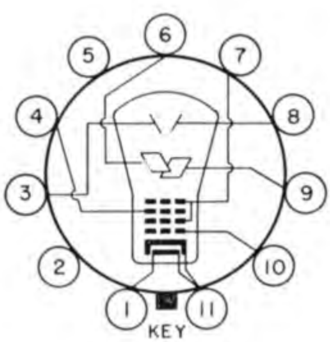
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[3] .... 5 Max. Megohms

NOTES

1. Visual extinction of undeflected focused spot.
2. When the tube is operated at (1) normal heater voltage; (2) Eb2=1500 volts; (3) Eb1 adjusted for focus; (4) Ec1 set at such a value as will avoid damage to the screen and with (5) each of the deflecting electrodes connected to Anode No. 2; and (6) with the tube shielded against external influences:
   The spot will fall within a 15 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
3. It is recommended that the deflecting electrode circuit resistances be approximately equal.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	No Connection
3	Deflection Plate D1
4	Focusing Electrode
5	Internal Connection
6	Deflection Plate D4
7	Accelerating Electrode
8	Deflection Plate D2
9	Deflection Plate D3
10	Control Electrode
11	Heater and Cathode

3JP- CATHODE-RAY TUBES

The Type 3JP- Cathode-ray Tubes are designed for oscillographic applications requiring a small short tube with very high light output and good deflection sensitivity. The intensifier electrode and extremely high current gun provide high excitation of the screen. The gun is designed so that the focusing electrode current under operating conditions is negligible. The 2" diameter neck and diheptal base provide adequate insulation between electrode leads for high altitude installation.

The four types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage .... 6.3 ± 10% Volts
Heater Current .... 0.6 ±10% Ampere
Focusing Method .... Electrostatic
Deflecting Method .... Electrostatic

Phosphor	P1	P2	P7	P11
Fluorescence	Green	Green	Blue	Blue
Phosphorescence		Green	Yellow	
Persistence	Medium	Long	Long	Short

Direct Interelectrode Capacitances, Nominal

- Cathode to all other electrodes .... 4.6 μμf.
- Grid #1 to all other electrodes .... 5.5 μμf.
- D1 to D2 .... 2.6 μμf.
- D3 to D4 .... 2.2 μμf.
- D1 to all other electrodes except D2 5.3 μμf.
- D2 to all other electrodes except D1 5.3 μμf.
- D3 to all other electrodes except D4 4.5 μμf.
- D4 to all other electrodes except D3 4.5 μμf.

Mechanical

Overall Length .... 10" ± 1/4"
Greatest Diameter of Bulb .... 3" ± 1/16"
Minimum Useful Screen Diameter .... 2-3/4"
Base .... Medium 12-pin Diheptal
Basing 14J
Base Alignment 1D2 trace aligns with Pin #5 and tube axis .... ± 10 Degrees
  Positive voltage on D1 deflects beam approximately toward Pin #5.
  Positive voltage on D3 deflects beam approximately toward Pin #2.
Bulb Contact Alignment
  Anode No. 3 contact aligns with 1D2 trace .... ± 10 Degrees
  Anode No. 3 contact on same side as pin #5.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 3 Voltage (Accelerator High-Voltage Electrode) .... 4000 Max. Volts D-C
Anode No. 2 Voltage .... 2000 Max. Volts D-C.
Ratio Anode No. 3 Voltage to Anode No. 2 Voltage .... 2.3 Max.
Anode No. 1 Voltage .... 1000 Max. Volts D-C
Grid No. 1 Voltage
  Negative Bias Value .... 200 Max. Volts D-C
  Positive Bias Value .... 0 Max. Volts D-C
  Positive Peak Value .... 2 Max. Volts

Peak Heater Cathode Voltage[1]
Heater negative with respect to cathode .... 125 Max. Volts D-C
Heater positive with respect to cathode .... 125 Max. Volts D-C
Peak Voltage between Anode No. 2 and any Deflection Electrode .... 550 Max. Volts

TYPICAL OPERATING CONDITIONS

For anode No. 3 Voltage of	1500	3000	4000 Volts
For Anode No. 2 Voltage of	1500	1500	2000 Volts
Anode No. 1 Voltage for focus	302 to 517	302 to 517	403 to 690 Volts
Grid No. 1 Voltage[2]	–22.5 to –67.5	–22.5 to –67.5	–30 to –90 Volts
Deflection Factors:			
D1 and D2	102 to 138	127 to 173	170 to 230 d-cV/in.
D3 and D4	76 to 102	94 to 128	125 to 170 d-cV/in.

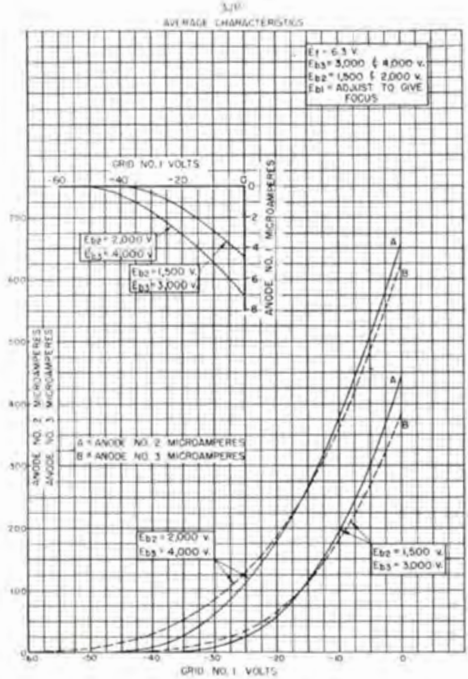
Anode No. 1 Voltage for focus .... 20.1% to 34.5% of Eb2 Volts
Grid No. 1 Voltage[2] .... 1.5% to 4.5% of Eb2 Volts
Anode No. 1 Current for any operating condition –50 to + 10 Microamperes
Deflection Factors:
No. 3rd Anode or Eb3 = Eb2
D1 and D2 .... 68 to 92 Volts D-C per Inch per Kilovolt of Eb2
D3 and D4 .... 51 to 68 Volts D-C per Inch per Kilovolt of Eb2
Eb3 = Twice Eb2
D1 and D2 .... 85 to 115 Volts D-C per Inch per Kilovolt of Eb2
D3 and D4 .... 63 to 85 Volts D-C per Inch per Kilovolt of Eb2
Spot Position (Undeflected)[3] .... Within 15 Millimeters square

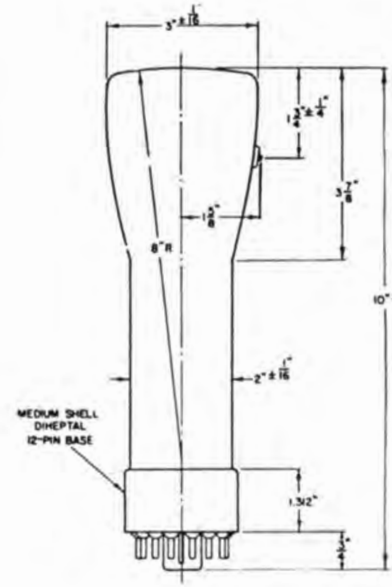
MAXIMUM CIRCUIT VALUES

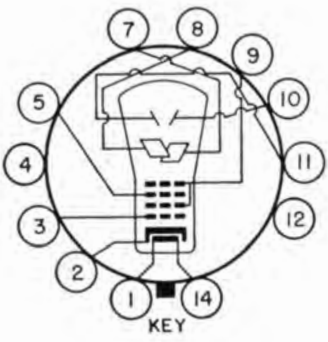
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[4] .... 5 Max. Megohms

NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Visual extinction of undeflected focused spot.
3. When the tube is operated at (1) normal heater voltage; (2) Eb3 = 3000 volts; (3) Eb2 = 1500 volts; (4) Eb1 adjusted for focus; (5) Ec1 set at such a value as will avoid damage to the screen and with (6) each of the deflecting electrodes connected to Anode No. 2; and (7) with the tube shielded against external influences:
   The spot will fall within a 15 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
4. It is recommended that the deflecting electrode circuit resistance be approximately equal.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	Cathode
3	Control Electrode
4	Internal Connection
5	Focusing Electrode
7	Deflection Plate D3
8	Deflection Plate D4
9	Accelerating
10	Deflection Plate D2
11	Deflection Plate D1
12	No Connection
14	Heater

5BP-A CATHODE-RAY TUBES

The Type 5BP-A Cathode-ray Tubes are designed for oscillographic applications where the use of an intensifier type tube is not essential. The gun is designed to draw negligible focusing electrode current.

The two types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts	
Heater Current	0.6 ± 10% Ampere	
Focusing Method	Electrostatic	
Deflecting Method	Electrostatic	
Phosphor	P1	P11
Fluorescence	Green	Blue
Phosphorescence		
Persistence	Medium	Short
Direct Interelectrode Capacitances, Nominal		
Grid #1 to all other electrodes	8.0 $\mu\mu f$.	
D1 to D2	1.3 $\mu\mu f$.	
D3 to D4	1.2 $\mu\mu f$.	
D1 to all other electrodes except D2	8.0 $\mu\mu f$.	
D2 to all other electrodes except D1	7.5 $\mu\mu f$.	
D3 to all other electrodes except D4	10.0 $\mu\mu f$.	
D4 to all other electrodes except D3	7.5 $\mu\mu f$.	

Mechanical

Overall Length	16-3/4" ± 3/8"
Greatest Diameter of Bulb	5-1/4" + 1/16", –3/32"
Minimum Useful Screen Diameter	4-1/2"
Base	Medium Magnal
Basing	11N
Base Alignment 3D4 trace aligns with Pin #1 and tube axis	± 10 Degrees

Positive voltage on D1 deflects beam approximately toward Pin #4.
Positive voltage on D3 deflects beam approximately toward Pin #1.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 2 Voltage	2000 Max. Volts D-C
Anode No. 1 Voltage	1000 Max. Volts D-C
Grid No. 1 Voltage	
Negative Bias Value	125 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts
Peak Voltage between Anode No. 2 and any Deflection Electrode	500 Max. Volts

TYPICAL OPERATING CONDITIONS

For Anode No. 2 Voltage of	1500	2000 Volts
Anode No. 1 Voltage for focus	253 to 422	338 to 562 Volts
Grid No. 1 Voltage[1]	–15 to –45	–20 to –60 Volts
Deflection Factors:		
D1 and D2	52 to 74	70 to 98 d-cV/in.
D3 and D4	47 to 67	63 to 89 d-cV/in.

Anode No. 1 Voltage for focus	16.9 to 28.1% of Eb2 Volts
Grid No. 1 Voltage[1]	1% to 3% of Eb2 Volts
Anode No. 1 Current for any operating condition	–50 to + 10 Microamperes

Deflection Factors:
- D1 and D2 .... 35 to 49 Volts D-C per Inch per Kilovolt of Eb2
- D3 and D4 .... 31.5 to 44.5 Volts D-C per Inch per Kilovolt of Eb2

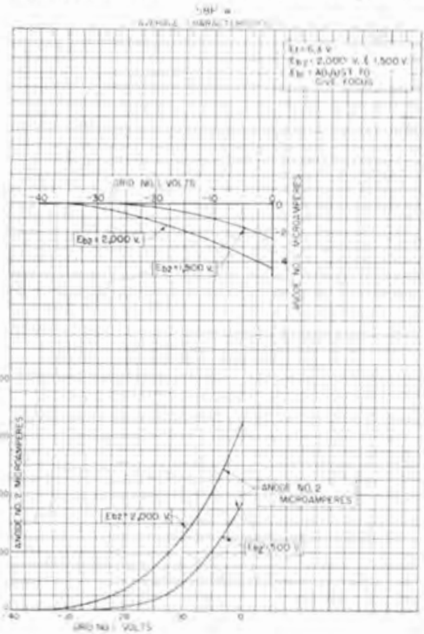
Spot Position (Undeflected)[2] .... Within 15 Millimeters square

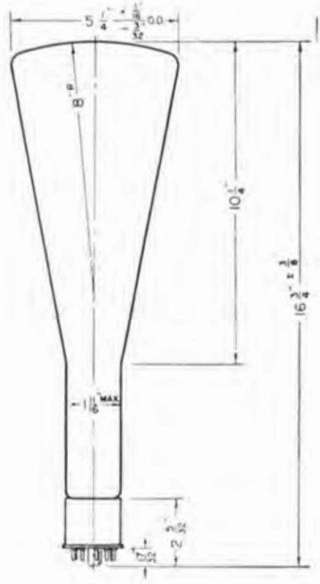
MAXIMUM CIRCUIT VALUES

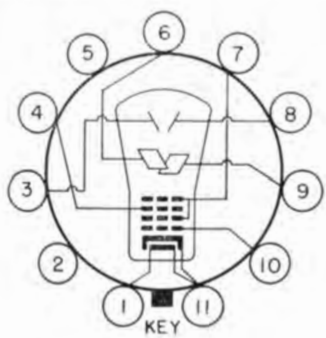
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[3] .... 5 Max. Megohms

NOTES

1. Visual extinction of undeflected focused spot.
2. When the tube is operated at (1) normal heater voltage; (2) Eb2 = 1500 volts; (3) Eb1 adjusted for focus; (4) Ec1 set at such a value as will avoid damage to the screen and with (5) each of the deflecting electrodes connected to Anode No. 2; and (6) with the tube shielded against external influences:
   The spot will fall within a 15 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
3. It is recommended that the deflecting electrode circuit resistance be approximately equal.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	No Connection
3	Deflection Plate D1
4	Focusing Electrode
5	Internal Connection
6	Deflection Plate D4
7	Accelerating Electrode
8	Deflection Plate D2
9	Deflection Plate D3
10	Control Electrode
11	Heater and Cathode

5CP-A CATHODE-RAY TUBES

The Type 5CP-A Cathode-ray Tubes are designed for oscillographic applications. The intensifier principle is used to provide a maximum deflection sensitivity for a given final accelerating voltage. A glass envelope has been designed to provide great mechanical strength and the tube base design provides adequate insulation between electrode leads for high altitude installation. The gun is designed to draw negligible focusing electrode current.

The four types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage .... 6.3 ± 10% Volts
Heater Current .... 0.6 ± 10% Ampere
Focusing Method .... Electrostatic
Deflecting Method .... Electrostatic

Phosphor	P1	P2	P7	P11
Fluorescence	Green	Green	Blue	Blue
Phosphorescence		Green	Yellow	
Persistence	Medium	Long	Long	Short

Direct Interelectrode Capacitances, Nominal

Cathode to all other electrodes	9 μμf.
Grid #1 to all other electrodes	8 μμf.
D1 to D2	2 μμf.
D3 to D4	2 μμf.
D1 to all other electrodes except D2	7 μμf.
D2 to all other electrodes except D1	7 μμf.
D3 to all other electrodes except D4	5 μμf.
D4 to all other electrodes except D3	6 μμf.

Mechanical

Overall Length	16-3/4" ± 3/8"
Greatest Diameter of Bulb	5-1/4" ± 3/32"
Minimum Useful Screen Diameter	4-1/2"
Bulb Contact	Snap terminal ball contact
Base	Medium 12-pin diheptal
Basing	14J
Base Alignment 1D2 trace aligns with Pin #5 and tube axis	± 10 Degrees

Positive voltage on D1 deflects beam approximately toward Pin #5.
Positive voltage on D3 deflects beam approximately toward Pin #2.

Bulb contact alignment:
Anode #3 contact aligns with 1D2 trace ± 10 Degrees.
Anode #3 contact on same side as Pin #5.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 3 Voltage (accelerator High Voltage Electrode)	4000 Max. Volts D-C
Anode No. 2 Voltage	2000 Max. Volts D-C
Ratio Anode No. 3 Voltage to Anode No. 2 Voltage	2.3 Max.
Anode No. 1 Voltage	1000 Max. Volts D-C
Grid No. 1 Voltage	
Negative Bias Value	200 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts

Peak Heater-Cathode Voltage[1]
- Heater Negative with respect to Cathode .... 125 Max. Volts D-C
- Heater Positive with respect to Cathode .... 125 Max. Volts D-C

Peak Voltage between Anode No. 2 and any Deflection Electrode .... 550 Max. Volts

TYPICAL OPERATING CONDITIONS (Values are for each unit)

For Anode No. 3 Voltage of	2000	3000	4000 Volts
For Anode No. 2 Voltage of	2000	1500	2000 Volts
Anode No. 1 Voltage for focus	374 to 690	302 to 518	374 to 690 Volts
Grid No. 1 Voltage[2]	−30 to −90	−22.5 to −67.5	−30 to −90 Volts
Deflection Factors:			
D1 and D2	62 to 84	59 to 80	78 to 106 d-cV/in.
D3 and D4	54 to 74	50 to 68	66 to 90 d-cV/in.

Anode No. 1 Voltage for focus .... 18.7% to 34.5% of Eb2 Volts
Grid No. 1 Voltage[2] .... 1.5% to 4.5% of Eb2 Volts
Anode No. 1 Current for any operating condition ... −50 to ± 10 Microamperes
Deflection Factors:
- No 3rd Anode or Eb3 = Eb2
  - D1 and D2 .... 31 to 42 Volts D-C per inch per Kilovolt of Eb2
  - D3 and D4 .... 27 to 37 Volts D-C per inch per Kilovolt of Eb2
- Eb3 = Twice Eb2
  - D1 and D2 .... 39 to 53 Volts D-C per inch per Kilovolt of Eb2
  - D3 and D4 .... 33 to 45 Volts D-C per inch per Kilovolt of Eb2

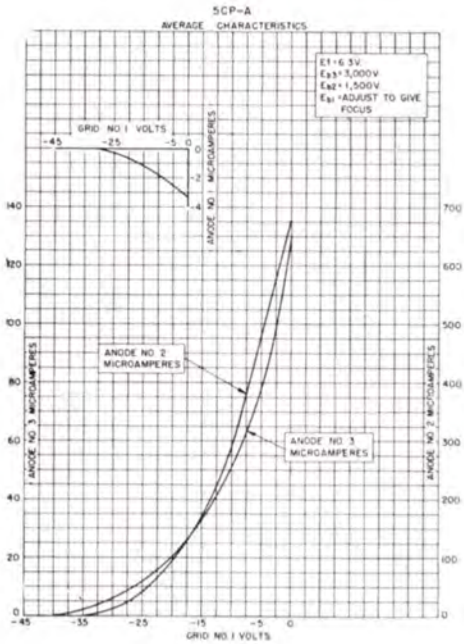
Spot Position (Undeflected)[3] .... Within 25 Millimeters square

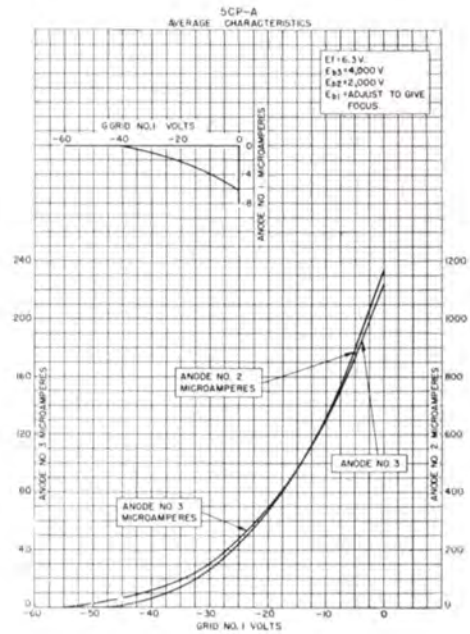
MAXIMUM CIRCUIT VALUES

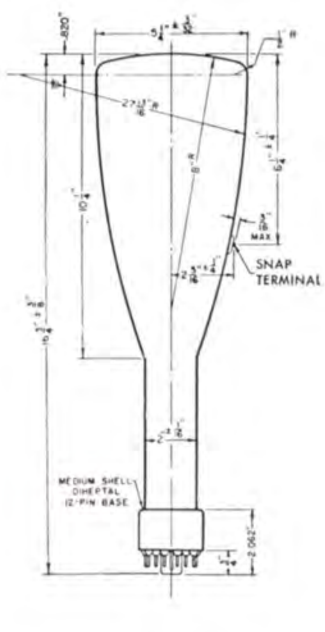
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting-Electrode Circuit[4] .... 5 Max. Megohms

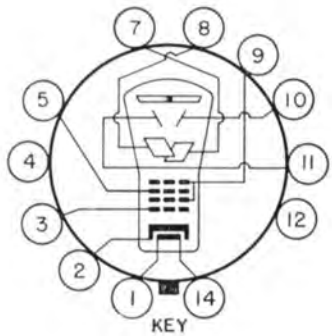
NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Visual extinction of undeflected focused spot.
3. When the tube is operated at (1) normal heater voltage; (2) Eb3 = 3000 volts; (3) Eb2 = 1500 volts; (4) Eb1 adjusted for focus; (5) Ec1 set at such a value as will avoid damage to the screen; (6) with each of the deflecting electrodes connected to Anode No. 2; and (7) with the tube shielded against external influences:
   The spot will fall within a 25 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
4. It is recommended that the deflecting electrode circuit resistances be approximately equal.









Bottom View of Base

Pin No.	*Element*
1	Heater
2	Cathode
3	Control Electrode
4	Internal Connection
5	Focusing Electrode
7	Deflection Plate D3
8	Deflection Plate D4
9	Accelerating Electrode
10	Deflection Plate D2
11	Deflection Plate D1
12	No Connection
14	Heater

5JP-A CATHODE-RAY TUBES

The 5JP-A types are designed for oscillographic applications where low deflection plate capacitances are essential. The deflection plate leads are short and direct terminating in caps on the wall of the tube rather than in the tube base. The intensifier principle is used to provide a maximum deflection sensitivity for a given final accelerating voltage. The gun is designed to draw negligible focusing electrode current.

The four types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage .... 6.3 ± 10% Volts
Heater Current .... 0.6 ± 10% Ampere
Focusing Method .... Electrostatic
Deflecting Method .... Electrostatic

Phosphor	P1	P2	P7	P11
Fluorescence	Green	Green	Blue	Blue
Phosphorescence		Green	Yellow	
Persistence	Medium	Long	Long	Short

Direct Interelectrode Capacitances, Nominal
- Grid #1 to all other electrodes .... 8.2 μμf.
- D1 to D2 .... 1.5 μμf.
- D3 to D4 .... 1.4 μμf.
- D1 to all other electrodes except D2 .... 2.5 μμf.
- D2 to all other electrodes except D1 .... 2.9 μμf.
- D3 to all other electrodes except D4 .... 2.6 μμf.
- D4 to all other electrodes except D3 .... 2.7 μμf.

Mechanical

Overall Length .... 16-3/4" ± 3/8"
Greatest Diameter of Bulb .... 5-5/16" ± 1/16"
Minimum Useful Screen Diameter .... 4-1/2"
Bulb Contact (Anode No. 3) .... Small Cap
Bulb Contacts (Deflection Plate) .... Miniature Cap
Base .... Medium Magnal
Basing 11E
Base Alignment 3b4 trace aligns with Pin #6 and tube axis .... ± 10 Degrees
Positive voltage on D1 deflects beam approx. toward Pon #3.
Positive voltage on D3 deflects beam approx. toward locating key.

Bulb contact alignment
Anode No. 3 Contact aligns with 3D4 trace ± 10 Degrees.
Anode No. 3 Contact on same side as locating key.
Deflection Plate Contacts are within 10 degrees of the plane through the tube axis and their respective traces.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 3 Voltage (accelerator High-Voltage Electrode) .... 4000 Max. Volts D-C
Anode No. 2 Voltage .... 2000 Max. Volts D-C
Ratio Anode No. 3 Voltage to Anode No. 2 Voltage .... 2.0 Max.
Anode No. 1 Voltage .... 1000 Max. Volts D-C

Grid No. 1 Voltage
- Negative Bias Value .... 125 Max. Volts D-C
- Positive Bias Value .... 0 Max. Volts D-C
- Positive Peak Value .... 2 Max. Volts

Peak Voltage between Anode No. 2 and any Deflecting Electrode .... 500 Max. Volts

TYPICAL OPERATING CONDITIONS

For Anode No. 3 Voltage of	3000	4000 Volts
For Anode No. 2 Voltage of	1500	2000 Volts
Anode No. 1 Voltage for focus	250 to 472	333 to 630 Volts
Grid No. 1 Voltage[1]	–34 to –79	–45 to –105 Volts
Deflection Factors:		
D1 and D2	58 to 86	77 to 115 d-cV/in.
D3 and D4	58 to 86	77 to 115 d-cV/in.

Anode No. 1 Voltage for focus .... 16.6% to 31.5% of Eb2 Volts
Grid No. 1 Voltage[1] .... 2.3% to 5.3% of Eb2 Volts
Anode No. 1 Current for any operating condition ... –50 to + 10 Microamperes
Deflection Factors:
- No 3rd Anode or Eb3 = Eb2
  - D1 and D2 .... 34 to 50 Volts D-C per inch per Kilovolt of Eb2
  - D3 and D4 .... 34 to 50 Volts D-C per inch per Kilovolt of Eb2
- Eb3 = Twice Eb2
  - D1 and D2 .... 38 to 58 Volts D-C per inch per Kilovolt of Eb2
  - D3 and D4 .... 38 to 58 Volts D-C per inch per Kilovolt of Eb2

Spot Position (Undeflected)[2] .... Within 15 Millimeters square

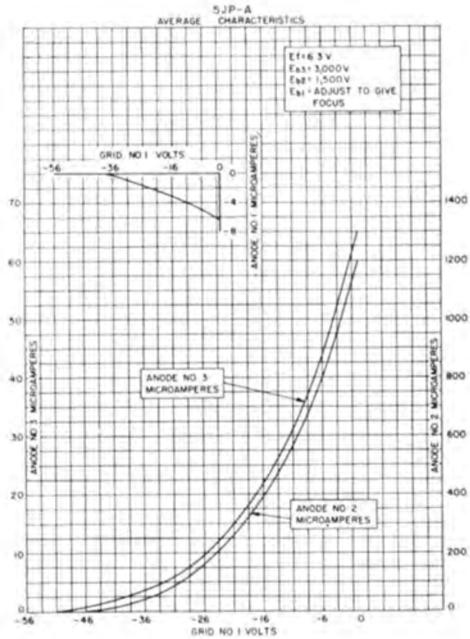
MAXIMUM CIRCUIT VALUES

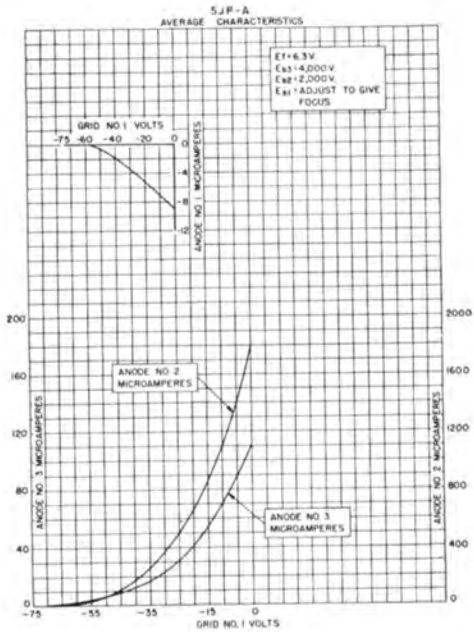
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[3] .... 5 Max. Megohms

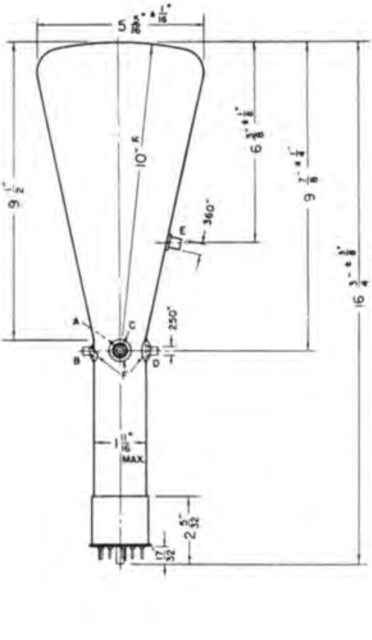
NOTES

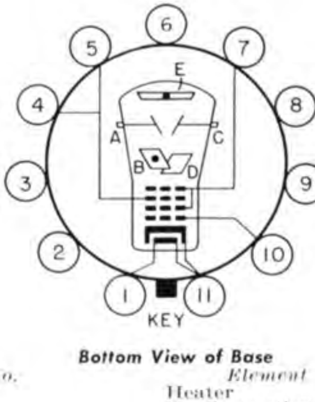
1. Visual extinction of undeflected focused spot.
2. When the tube is operated at (1) normal heater voltage; (2) Eb3 = 3000 volts; (3) Eb2 = 1500 volts; (4) Eb1 adjusted for focus; (5) Ec1 set at such a value as will avoid damage to the screen; (6) with each of the deflecting electrodes connected to Anode No. 2; and (7) with the tube shielded against external influences:

   The spot will fall within a 15 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
3. It is recommended that the deflecting electrode circuit resistances by approximately equal.









Bottom View of Base

Pin No.	*Element*
1	Heater
2	No Connection
3	No Connection
4	Focusing Electrode
5	Internal Connection
6	No Connection
7	Accelerating Electrode
7	No Connection
9	No Connection
10	Control Electrode
11	Heater and Cathode
Terminal A	Deflection Plate D1
B	Deflection Plate D4
C	Deflection Plate D2
D	Deflection Plate D3
E	Intensifier Electrode

5LP-A CATHODE-RAY TUBES

The Type 5LP-A cathode-ray tubes are designed for oscillographic applications. The intensifier principle is used to provide a maximum deflection sensitivity for a given final accelerating voltage. The gun is designed to draw negligible focusing electrode current.

The four types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage .... 6.3 ± 10% Volts
Heater Current .... 0.6 ± 10% Ampere
Focusing Method .... Electrostatic
Deflecting Method .... Electrostatic

Phosphor	P1	P2	P7	P11
Fluorescence	Green	Green	Blue	Blue
Phosphorescence		Green	Yellow	
Persistence	Medium	Long	Long	Short

Direct Interelectrode Capacitances, Nominal

- Grid #1 to all other electrodes .... 9.1 μμf.
- D1 to D2 .... 2.0 μμf.
- D3 to D4 .... 1.6 μμf.
- D1 to all other electrodes except D2 7.5 μμf.
- D2 to all other electrodes except D1 7.7 μμf.
- D3 to all other electrodes except D4 5.9 μμf.
- D4 to all other electrodes except D3 6.9 μμf.

Mechanical

Overall Length .... 16-3/4" ± 3/8"
Greatest Diameter of Bulb .... 5-5/16" ± 1/16"
Minimum Useful Screen Diameter .... 4-1/2"
Bulb Contact .... Small Cap
Base .... Medium Magnal
Basing 11F
Base Alignment 3D4 trace aligns with Pin #6 and tube axis .... ± 10 Degrees
Positive voltage on D1 deflects beam approximately toward Pin #3.
Positive voltage on D3 deflects beam approximately toward locating key.
Bulb contact alignment:
Anode No. 3 Contact aligns with 3D4 trace ± 10 Degrees.
Anode No. 3 Contact on same side as locating key.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 3 Voltage (accelerator High Voltage Electrode) .... 4000 Max. Volts D-C
Anode No. 2 Voltage .... 2000 Max. Volts D-C
Ratio Anode No. 3 Voltage to Anode No. 2 Voltage .... 2 Max.
Anode No. 1 Voltage .... 1000 Max. Volts D-C
Grid No. 1 Voltage
Negative Bias Value .... 125 Max. Volts D-C
Positive Bias Value .... 0 Max. Volts D-C
Positive Peak Value .... 2 Max. Volts
Peak Voltage between Anode No. 2 and any Deflection Electrode .... 550 Max. Volts

5LP1A, 5LP2A, 5LP4A, 5LP5A, 5LP7A, 5LP11A

TYPICAL OPERATING CONDITIONS

For Anode No. 3 Voltage of	3000	4000 Volts
For Anode No. 2 Voltage of	1500	2000 Volts
Anode No. 1 Voltage for focus	282 to 475	376 to 633 Volts
Grid No. 1 Voltage[1]	–22.5 to –67.5	–30 to –90 Volts
Deflection Factors:		
D1 and D2	62 to 93	83 to 124 d-cV/in.
D3 and D4	54 to 81	72 to 108 d-cV/in.

Anode No. 1 Voltage for focus .... 18.8% to 31.6% of Eb2 Volts
Grid No. 1 Voltage[1] .... 1.5% to 4.5% of Eb2 Volts
Anode No. 1 Current for any operating condition ... –50 to + 10 Microamperes
Deflection Factors:
No 3rd Anode or Eb3 = Eb2
D1 and D2 .... 33 to 51 Volts D-C per Inch per Kilovolt of Eb2
D3 and D4 .... 31 to 45 Volts D-C per Inch per Kilovolt of Eb2
Eb3 = Twice Eb2
D1 and D2 .... 41.5 to 62 Volts D-C per Inch per Kilovolt of Eb2
D3 and D4 .... 36 to 54 Volts D-C per Inch per Kilovolt of Eb2
Spot Position (Undeflected)[2] .... Within 20 Millimeters square

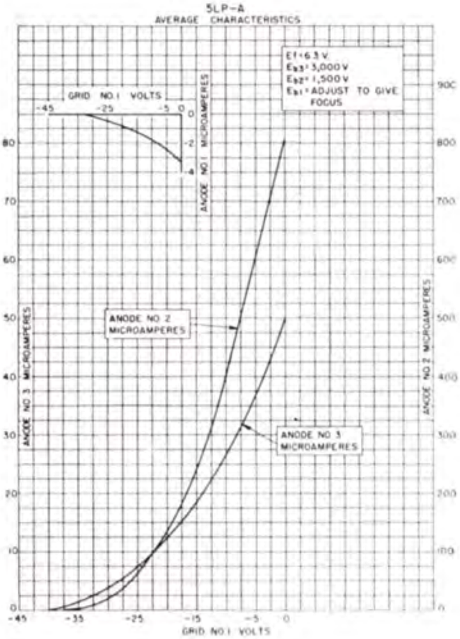
MAXIMUM CIRCUIT VALUES

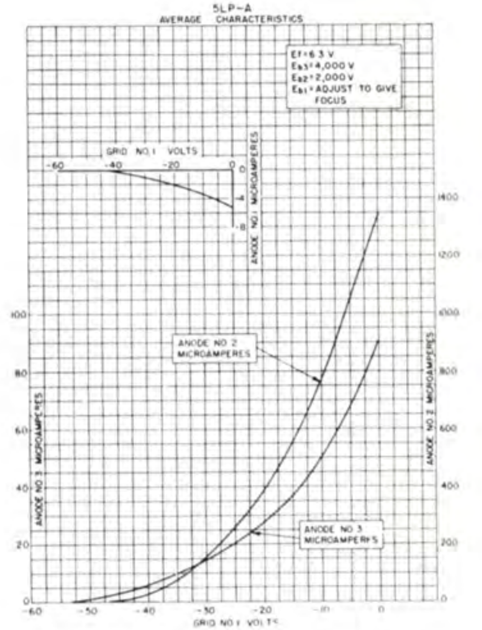
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[3] .... 5 Max. Megohms

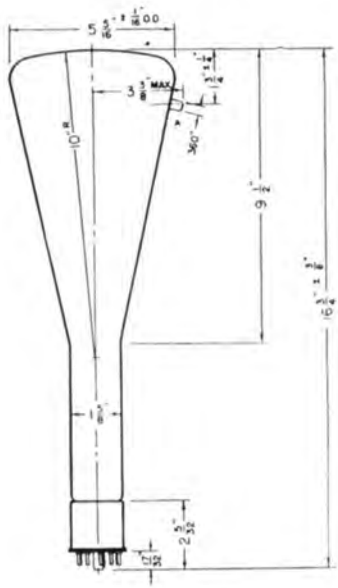
NOTES

1. Visual extinction of undeflected focused spot.
2. When the tube is operated at (1) normal heater voltage; (2) Eb3 = 3000 volts; (3) Eb2 = 1500 volts; (4) Eb1 adjusted for focus; (5) Ec1 set at such a value as will avoid damage to the screen; (6) with each of the deflecting electrodes connected to Anode No. 2; and (7) with the tube shielded against external influences:

   The spot will fall within a 20 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
3. It is recommended that the deflecting electrode circuit resistances be approximately equal.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	No Connection
3	Deflection Plate D1
4	Focusing Electrode
5	Internal Connection
6	Deflection Plate D4
7	Accelerating Electrode
8	Deflection Plate D2
9	Deflection Plate D3
10	Control Electrode
11	Heater and Cathode
Terminal A	Intensifier Electrode

5RP-A CATHODE-RAY TUBES

The Type 5RP-A Cathode-ray Tubes are high voltage tubes which incorporate an intensifier subdivided into several steps. This feature permits the use of much higher overall accelerating voltages with deflection sensitivities only slightly less than heretofore obtainable in low voltage cathode-ray tubes. Operation with intensifier to second anode voltage ratios as high as 10-1 are made possible by the multiband feature. The tube has a flat face, a cylindrical body and the deflection plate and anode connections are made through the neck instead of through the base. Low capacity deflection plate leads facilitate high frequency operation. The gun is designed to draw negligible focusing electrode current.

The two types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts	
Heater Current	0.6 ± 10% Ampere	
Focusing Method	Electrostatic	
Deflecting Method	Electrostatic	
Phosphor	P2	P11
Fluorescence	Green	Blue
Phosphorescence	Green	
Persistence	Long	Short

Direct Interelectrode Capacitances, Nominal

Cathode to all other electrodes	5.0 μμf.
Grid #1 to all other electrodes	5.4 μμf.
D1 to D2	1.8 μμf.
D3 to D4	1.8 μμf.
D1 to all other electrodes except D2	2.3 μμf.
D2 to all other electrodes except D1	2.1 μμf.
D3 to all other electrodes except D4	2.4 μμf.
D4 to all other electrodes except D3	2.2 μμf.

Mechanical

Overall Length	16-3/4" ± 3/8"
Greatest Diameter of Bulb	5-1/4" ± 3/32"
Minimum Useful Screen Diameter	4-1/4"
Bulb Contacts	Snap terminal ball contact
Neck Contacts	Special lateral contacts
Base	Medium 12-pin diheptal
Basing	14F
Base Alignment 1D2 trace aligns with Pin #5 and tube axis	± 10 Degrees

Positive voltage on D1 deflects beam approximately toward Pin #5.
Positive voltage on D3 deflects beam approximately toward Pin #2.

Bulb contact alignment:

Snap terminal contacts align with 1D2 trace ± 10 Degrees.
Contacts on same side as Pin #5

MAXIMUM RATINGS—(Design Center Values)

Anode No. 3 Voltage (accelerator High Voltage Electrode)	25,500 Max. Volts D-C
Anode No. 2 Voltage	3,500 Max. Volts D-C

Ratio Anode No. 3 Voltage to Anode No. 2 Voltage .... 10 Max.
Anode No. 1 Voltage .... 1,550 Max. Volts D-C
Grid No. 1 Voltage
Negative—Bias Value .... 125 Max. Volts D-C
Positive—Bias Value .... 0 Max. Volts D-C
Positive—Peak Value .... 2 Max. Volts
Peak Heater Cathode Voltage[1]
Heater Negative with respect to Cathode .... 125 Max. Volts D-C
Heater Positive with respect to Cathode .... 125 Max. Volts D-C
Peak Voltage between Anode No. 2 and any Deflection Electrode .... 1,200 Max. Volts

TYPICAL OPERATING CONDITIONS

For Anode No. 3 Voltage[2] of	10,000	20,000 Volts
For Anode No. 2 Voltage of	2,000	2,000 Volts
Anode No. 1 Voltage for focus	362 to 695	362 to 695 Volts
Grid No. 1 Voltage[3]	–30 to –90	–30 to –90 Volts
Deflection Factors:		
D1 and D2	102 to 154	140 to 210 d-cV/in.
D3 and D4	97 to 145	131 to 197 d-cV/in.

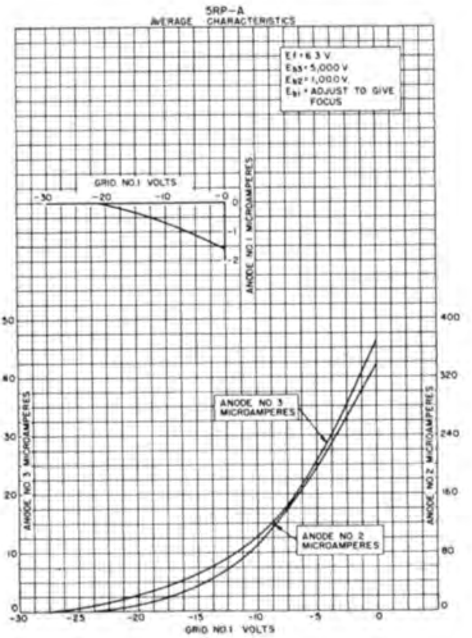
Anode No. 1 Voltage for focus .... 18.1% to 34.8% of Eb2 Volts
Grid No. 1 Voltage[3] .... 1.5% to 4.5% of Eb2 Volts
Anode No. 1 Current for any operating condition ... –50 to ± 10 Microamperes
Deflection Factors:
No 3rd Anode or Eb3 = Eb2
D1 and D2 .... 30 to 45 Volts D-C per inch per Kilovolt of Eb2
D3 and D4 .... 30 to 45 Volts D-C per inch per Kilovolt of Eb2
Eb3 = Twice Eb2
D1 and D2 .... 36 to 54 Volts D-C per inch per Kilovolt of Eb2
D3 and D4 .... 36 to 54 Volts D-C per inch per Kilovolt of Eb2
Spot Position (Undeflected)[4] .... Within 20 Millimeters square

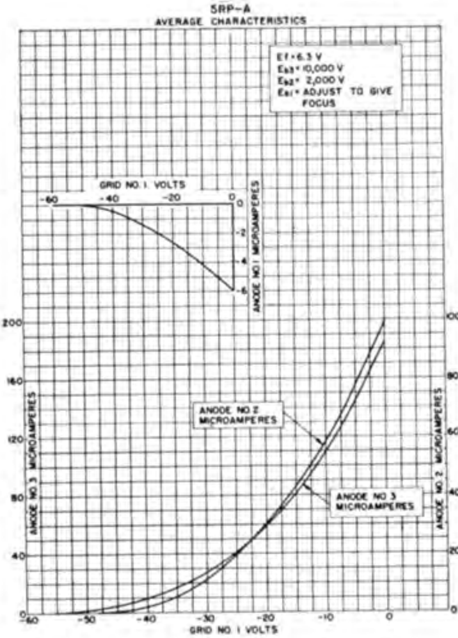
MAXIMUM CIRCUIT VALUES

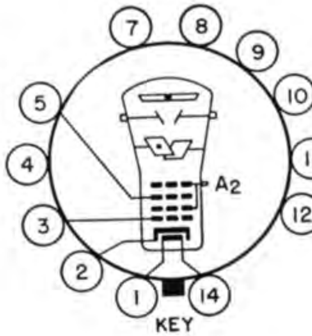
Grid No. 1 Circuit Resistance .... 1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[5] .... 5 Max. Megohms

NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Equally divided over the three intensifier electrodes. See page 158 for suggested method of connection.
3. Visual extinction of undeflected focused spot.
4. When the tube is operated at (1) normal heater voltage; (2) Eb2 = 2000 volts; (3) Eb3 = 10,000 volts; (4) Eb1 adjusted for focus; (5) Ec1 set at such a value as will avoid damage to the screen; (6) with each of the deflecting electrodes connected to Anode No. 2; and (7) with the tube shielded against external influences:
   The spot will fall within a 20 mm. square, the center of which coincides with the geometric center of the tube face; and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
5. It is recommended that the deflecting electrode circuit resistances be approximately equal.

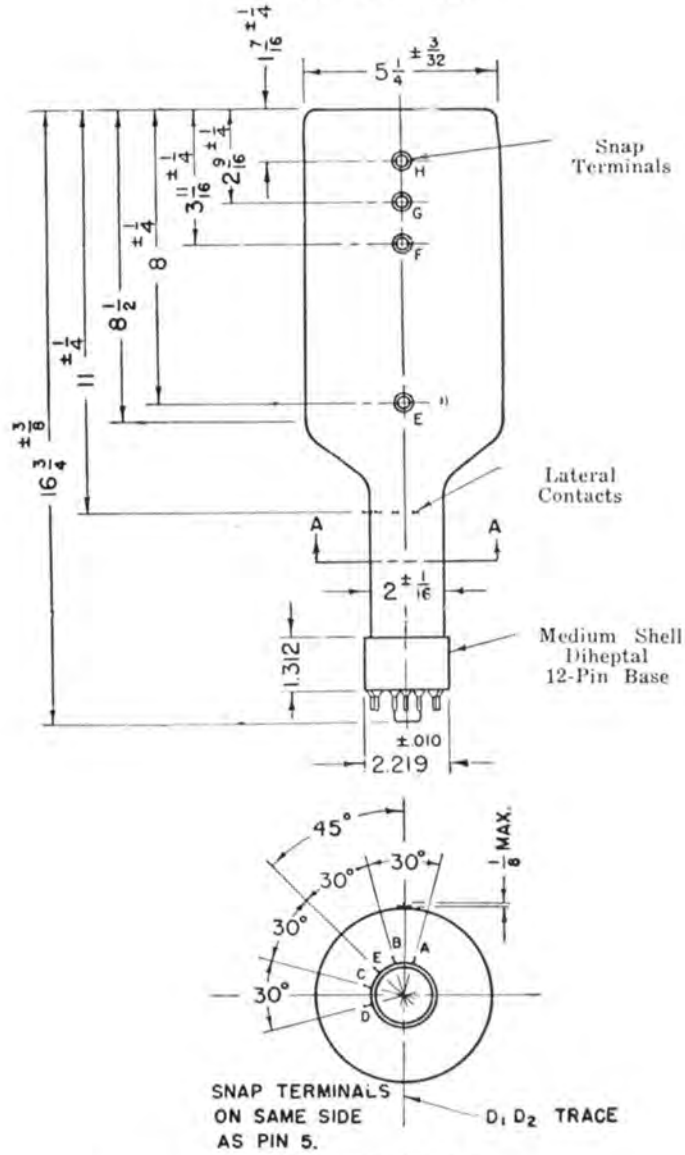






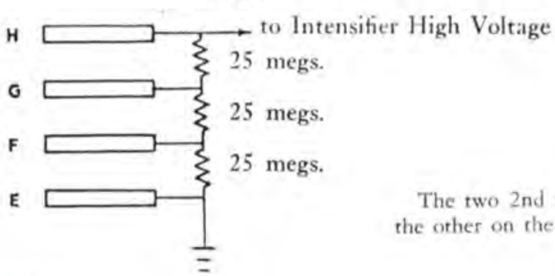
Bottom View of Base

Pin No.	*Element*
1	Heater
2	Cathode
3	Control Electrode
4	Internal Connection
5	Focusing Electrode
7	No Connection
8	" "
9	" "
10	" "
11	" "
12	" "
14	Heater
Terminal A	Deflection Plate D4
B	Deflection Plate D3
C	Deflection Plate D1
D	Deflection Plate D2
E	2nd Anode
F	Intensifier Electrode #1
G	Intensifier Electrode #2
H	Intensifier Electrode #3



SECTION A-A

Suggested Method of Intensifier Connection



The two 2nd anode terminals (one on the tube head, the other on the tube neck) must be connected together.

5SP- CATHODE-RAY TUBES

The Du Mont 5SP- is a flat face, two beam cathode-ray tube having two gun and deflection plate structures. All electrodes are independent except second anode and intensifier. The 5SP- is intended for application where it is desired to present two related or entirely independent phenomena on a single cathode-ray tube screen for simultaneous observation and comparison. The guns of the 5SP- are so designed as to draw no appreciable focusing electrode current. The intensifier principle is used to obtain maximum deflection sensitivity at high brightness. All deflection plate connections are brought directly through the neck of the tube to minimize lead capacitance and inductance. The second anode connections are also brought through the neck to give maximum insulation. The two deflection plate structures are shielded from each other to prevent interaction.

The four types differ only in the characteristics of the fluorescent screens. Other screen types may be obtained on special order.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage ... 6.3 ± 10% Volts
Heater Current (drawn by each unit) ... 0.6 ± 10% Ampere
Focusing Method ... Electrostatic
Deflecting Method ... Electrostatic

Phosphor	P1	P2	P7	P11
Fluorescence	Green	Green	Blue	Blue
Phosphorescence		Green	Yellow	
Persistence	Medium	Long	Long	Short

Direct Interelectrode Capacitances, Nominal (for each unit)
- Cathode to all other electrodes ... 3.7 μμf.
- Grid #1 to all other electrodes ... 3.8 μμf.
- D1 to D2 ... 1.9 μμf.
- D3 to D4 ... 1.8 μμf.
- D1 to all other electrodes except D2 ... 2.1 μμf.
- D2 to all other electrodes except D1 ... 2.0 μμf.
- D3 to all other electrodes except D4 ... 2.2 μμf.
- D4 to all other electrodes except D3 ... 2.2 μμf.

Mechanical

Overall Length ... 18-1/4" ± 3/8"
Greatest Diameter of Bulb ... 5-1/4" ± 3/32"
Minimum Useful Screen Diameter ... 4-1/2"
Bulb Contact ... Snap terminal ball contact
Neck Contacts ... Miniature caps
Base ... Medium 12-pin diheptal
Basing ... 14K
Base Alignment (for each unit) 3D4 trace aligns with Pin #4 and tube axis ... ± 10 Degrees
Positive voltage on D1 deflects beam approx. toward Pin #1.
Positive voltage on D3 deflects beam approx. toward Pin #11.
Bulb contact alignment
Snap terminal contacts align with 3D4 trace ... ± 10 Degrees
Contacts on same side as Pin #4.

MAXIMUM RATINGS—Design Center Values (Values are for each unit)

Anode No. 3 Voltage (accelerator High Voltage Electrode)	6000 Max. Volts D-C
Anode No. 2 Voltage	2000 Max. Volts D-C
Ratio Anode No. 3 Voltage to Anode No. 2 Voltage	3 Max.
Anode No. 1 Voltage	1000 Max. Volts D-C
Grid No. 1 Voltage	
Negative Bias Value	125 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts
Peak Heater-Cathode Voltage[1]	
Heater Negative with respect to Cathode	125 Max. Volts D-C
Heater Positive with respect to Cathode	125 Max. Volts D-C
Peak Voltage between Anode No. 2 and any Deflection Electrode	550 Max. Volts

TYPICAL OPERATING CONDITIONS—(Values are for each unit)

For Anode No. 3 Voltage of	3000	4000 Volts
For Anode No. 2 Voltage of	1500	2000 Volts
Anode No. 1 Voltage for focus	272 to 521	363 to 695 Volts
Grid No. 1 Voltage[2]	−22.5 to −67.5	−30 to −90 Volts
Deflection Factors:		
D1 and D2	55 to 83	74 to 110 d-cV/in.
D3 and D4	47 to 71	63 to 95 d-cV/in.

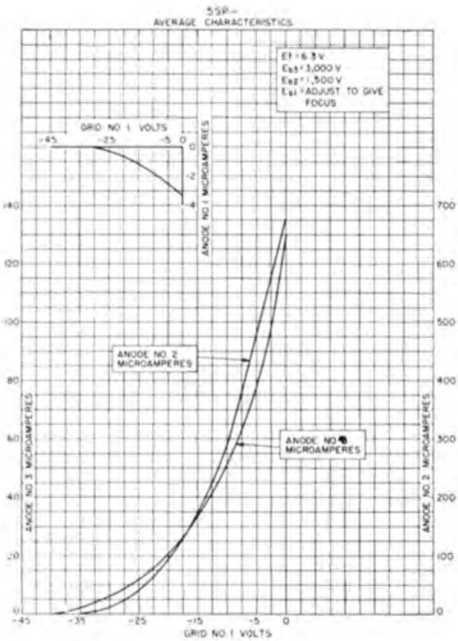
Anode No. 1 Voltage for focus	18.1% to 34.8% of Eb2 Volts
Grid No. 1 Voltage[2]	1.5% to 4.5% of Eb2 Volts
Anode No. 1 Current for any operating condition	−50 to ± 10 Microamperes
Deflection Factors:	
No 3rd Anode or Eb3 = Eb2	
D1 and D2	29 to 44 Volts D-C per inch per Kilovolt of Eb2
D3 and D4	25 to 39 Volts D-C per inch per Kilovolt of Eb2
Eb3 = Twice Eb2	
D1 and D2	37 to 55 Volts D-C per inch per Kilovolt of Eb2
D3 and D4	31 to 47 Volts D-C per inch per Kilovolt of Eb2
Spot Position (Undeflected)[3]	Within 25 Millimeters square

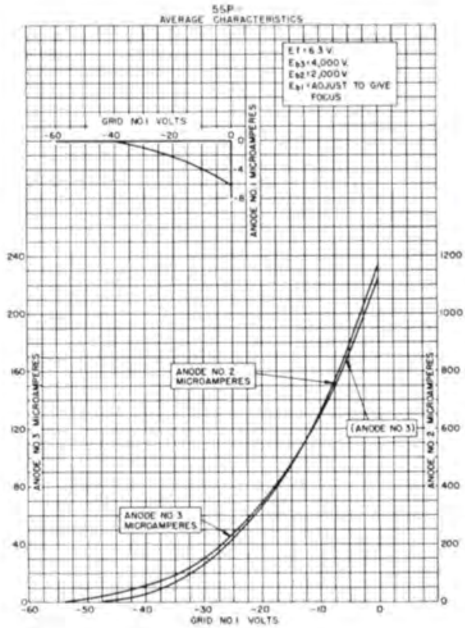
MAXIMUM CIRCUIT VALUES

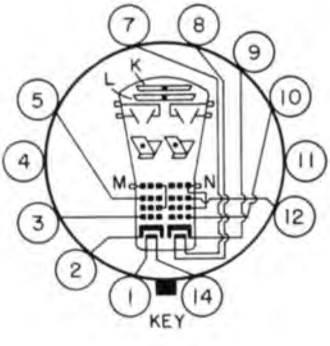
Grid No. 1 Circuit Resistance	1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[4]	5 Max. Megohms

NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Visual extinction of undeflected focused spot.
3. When both guns are operated at (1) normal heater voltage; (2) Eb3 = 4000 volts; (3) Eb2 = 2000 volts; (4) Eb1 adjusted for focus; (5) Ec1 set at such a value as will avoid damage to the screen; (6) with each of the deflecting electrons connected to Anode No. 2; and (7) with the tube shielded against external influences:
   The spots will fall within a 25 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
4. It is recommended that the deflecting electrode circuit resistances be approximately equal.

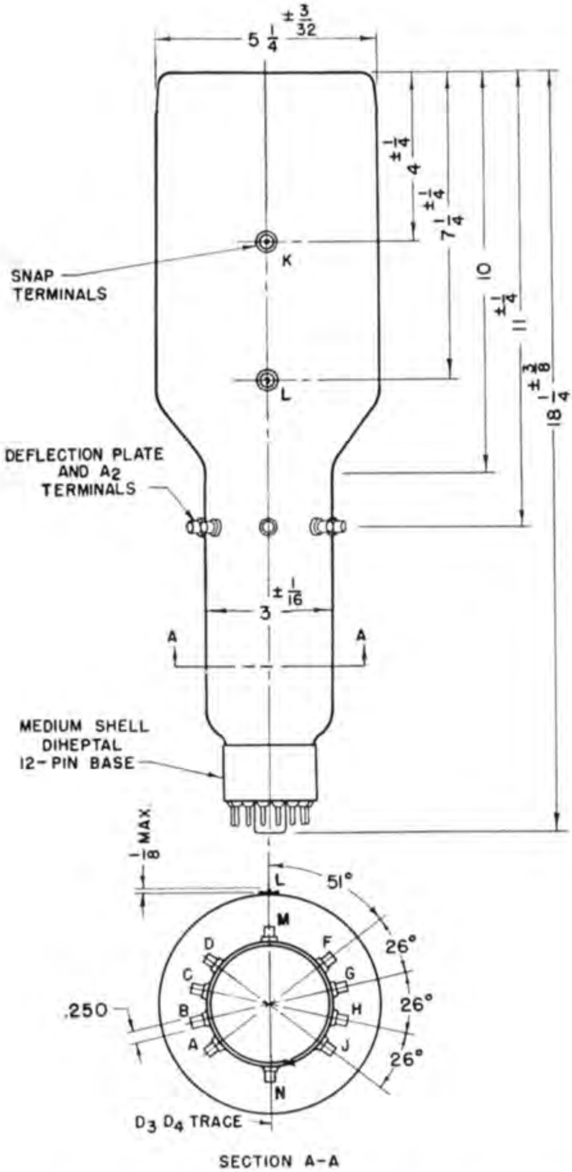






Bottom View of Base

Pin No.	*Element*
	Unit A
1	Heater
2	Cathode
3	Control Electrode
4	Internal Connection
5	Focusing Electrode
14	Heater
Terminal A	Deflection Plate D2
B	Deflection Plate D1
C	Deflection Plate D3
D	Deflection Plate D4
M	Accelerating Electrode
	Unit B
7	Heater
8	Heater
9	Cathode
10	Control Electrode
11	No Connection
12	Focusing Electrode
Terminal F	Deflection Plate D1
G	Deflection Plate D2
H	Deflection Plate D4
J	Deflection Plate D3
N	Accelerating Electrode



Note: Terminals M and N are connected internally; L and M-N must be connected together externally and to a common ground.

7EP4 CATHODE-RAY TUBES

The Type 7EP4 is a 7" electrostatic focus and deflection television picture tube designed to give good brilliance and spot size at low accelerating voltages. The screen will provide a useful picture area of approximately 4-1/4" x 5-3/4". The gun is designed to draw negligible focusing electrode current. The Type 7EP4 is intended primarily for use in low cost television receivers.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts
Heater Current	0.6 ± 10% Ampere
Focusing Method	Electrostatic
Deflecting Method	Electrostatic
Phosphor	P4
Fluorescence	White
Persistence	Medium
Direct Interelectrode Capacitances, Nominal	
Grid #1 to all other electrodes	7.0 μμf.
D1 to D2	1.8 μμf.
D3 to D4	1.6 μμf.
D1 to all other electrodes except D2	6.5 μμf.
D2 to all other electrodes except D1	6.4 μμf.
D3 to all other electrodes except D4	4.9 μμf.
D4 to all other electrodes except D3	4.8 μμf.

Mechanical

Overall Length	15-1/2" ± 3/8"
Greatest Diameter of Bulb	7" ± 1/8"
Minimum Useful Screen Diameter	6"
Base	Medium Magnal
Basing	11N
Base Alignment 3D4 trace aligns with Pin #1 and tube axis	± 10 Degrees

Positive voltage on D1 deflects beam approximately toward Pin #4.
Positive voltage on D3 deflects beam approximately toward Pin #1.

MAXIMUM RATINGS—(Design Center Values)

Anode No. 2 Voltage	3000 Max. Volts D-C
Anode No. 1 Voltage	1375 Max. Volts D-C
Grid No. 1 Voltage	
Negative Bias Value	200 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts
Peak Voltage between Anode No. 2 and any Deflection Electrode	700 Max. Volts

TYPICAL OPERATING CONDITIONS

For Anode No. 2 Voltage of	2500	3000 Volts
Anode No. 1 Voltage for focus	455 to 715	546 to 858 Volts
Grid No. 1 Voltage[1]	−36 to −84	−43 to −100 Volts
Deflection Factors:		
D1 and D2	88 to 132	106 to 158 d-cV/in.
D3 and D4	76 to 114	91 to 137 d-cV/in.

Anode No. 1 Voltage for focus	18.2% to 28.6% of Eb2 Volts
Grid No. 1 Voltage[1]	1.44% to 3.36% of Eb2 Volts
Anode No. 1 Current for any operating condition	−50 to ± 10 Microamperes

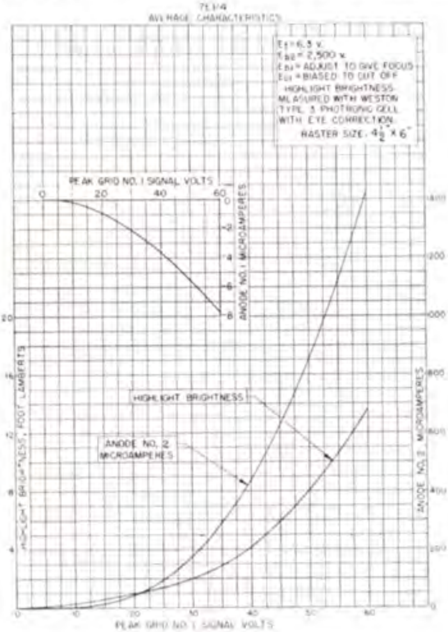
Deflection Factors:
D1 and D2 ....35 to 53 Volts D-C per inch per Kilovolt of Eb2
D3 and D4 ....30.5 to 45.5 Volts D-C per inch per Kilovolt of Eb2
Spot Position (Undeflected)[2] ....Within 25 Millimeters square

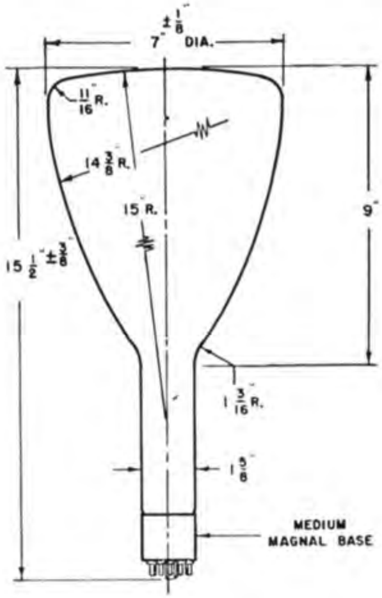
MAXIMUM CIRCUIT VALUES

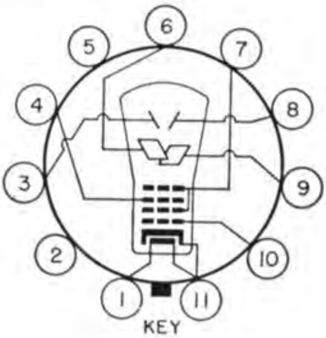
Grid No. 1 Circuit Resistance ....1.5 Max. Megohms
Resistance in any Deflecting Electrode Circuit[3] ....5 Max. Megohms

NOTES

1. Visual extinction of undeflected focused spot.
2. When tube is operated at (1) normal heater voltage; (2) Eb2 = 3000 volts; (3) Eb1 adjusted for focus; (4) Ec1 set at such a value as will avoid damage to the screen; (5) with each of the deflecting electrodes connected Anode No. 2; and (6) with the tube shielded against external influences:
   The spot will fall within a 25 mm. square, the center of which coincides with the geometric center of the tube face, and the sides of which are parallel to the traces produced by deflecting electrodes D1 and D2 and by deflecting electrodes D3 and D4 respectively.
3. It is recommended that the deflecting electrode circuit resistances be approximately equal.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	No Connection
3	Deflection Plate D1
4	Focusing Electrode
5	Internal Connection
6	Deflection Plate D4
7	Accelerating Electrode
8	Deflection Plate D2
9	Deflection Plate D3
10	Control Electrode
11	Heater and Cathode

12JP4 CATHODE-RAY TUBE

The Type 12JP4 is a 12" magnetic focus and deflection television picture tube designed to provide a useful picture size of 7-3/4" x 10-1/4" with high brilliance and definition.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts
Heater Current	0.6 ± 10% Ampere
Focusing Method	Magnetic
Deflecting Method	Magnetic
Max. Deflecting Angle	50 Degrees Approx.
Phosphor	P4
Fluorescence	White
Persistence	Medium
Direct Interelectrode Capacitances, Nominal	
Cathode to all other electrodes	6 μμf.
Grid #1 to all other electrodes	7.9 μμf.

Mechanical

Overall Length	17-1/2" ± 1/2"
Greatest Diameter of Bulb	12" ± 3/16"
Minimum Useful Screen Diameter	10"
Bulb Contact	Recessed small ball cap
Base	7-pin small shell duodecal
Basing	12D
Anode Contact aligns with vacant pin position #3	± 10 Degrees

MAXIMUM RATINGS—(Design Center Values)

Anode Voltage	12,000 Max. Volts D-C
Grid No. 2 Voltage	410 Max. Volts D-C
Grid No. 1 Voltage	
Negative Bias Value	125 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts
Peak Heater-Cathode Voltage[1]	
Heater Negative with respect to cathode	125 Max. Volts D-C
Heater Positive with respect to cathode	125 Max. Volts D-C

TYPICAL OPERATING CONDITIONS

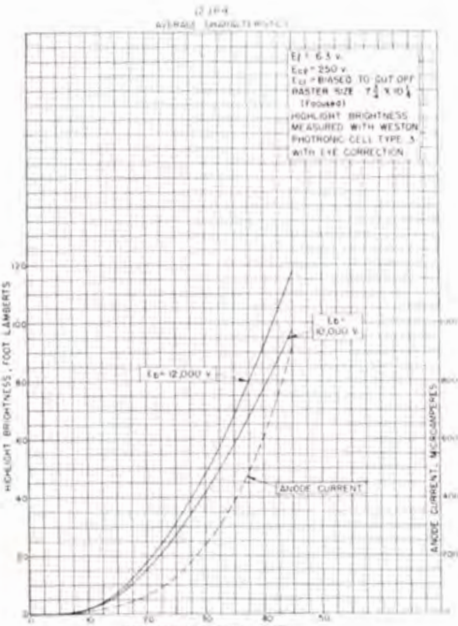
Anode Voltage	10,000 Volts D-C
Grid No. 2 Voltage	250 Volts D-C
Grid No. 1 Voltage[2]	–27 to –63 Volts D-C
Focusing Coil Current[3] (D-C)	146 Approx. Milliamperes
Spot Position (Undeflected)[4]	Within 25 Millimeter radius circle

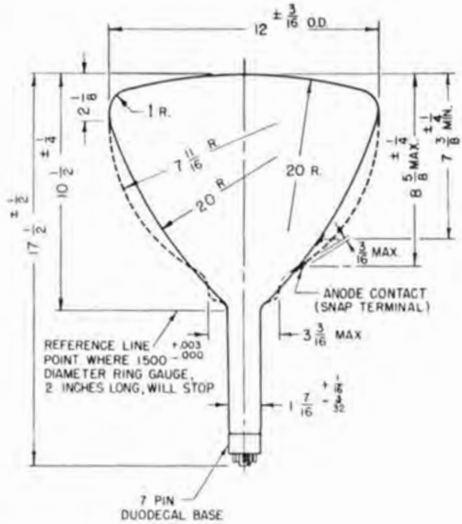
MAXIMUM CIRCUIT VALUES

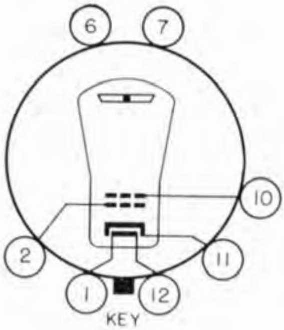
Grid No. 1 Circuit Resistance	1.5 Max. Megohms

NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Visual extinction of undeflected focused spot.
3. For standard focus coil #20, or equivalent, with the combined grid No. 1 bias voltage and video signal voltage adjusted to produce a highlight brightness of 25 foot lamberts on a 7-3/4″ x 10-1/4″ picture area. Distance (D) shall be 3.25 inches.
4. When the tube is operated at (1) normal heater voltage; (2) Eb = 10,000 volts; (3) Ec2 = 250 volts; (4) Ec1 set at such a value as will avoid damage to the screen; and (5) the tube shielded against external influences:
   The undeflected and unfocused spot will fall within a circle of 25 mm. radius, the center of which coincides with the geometric center of the tube face.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	Grid No. 1
6	No Connection
7	No Connection
10	Grid No. 2
11	Cathode
12	Heater

15AP4 CATHODE-RAY TUBE

The Type 15AP4 is a 15" magnetic focus and deflection television picture tube designed to operate at high voltages. The screen will provide a useful picture size of 9-1/2" x 12-3/4" with high brilliance and definition.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts
Heater Current	0.6 ± 10% Ampere
Focusing Method	Magnetic
Deflecting Method	Magnetic
Max. Deflecting Angle	52 Degrees Approx.
Phosphor	P4
Fluorescence	White
Persistence	Medium
Direct Interelectrode Capacitances, Nominal	
Cathode to all other electrodes	5.8 μμf.
Grid #1 to all other electrodes	7.4 μμf.

Mechanical

Overall Length	20-1/2" ± 3/8"
Greatest Diameter of Bulb	15-1/2" ± 1/4"
Minimum Useful Screen Diameter	13-1/2"
Bulb Contact	Recessed small ball cap
Base	7-pin small shell duodecal
Basing	12D
Anode Contact aligns with vacant pin position #3	± 10 Degrees

MAXIMUM RATINGS—(Design Center Values)

Anode Voltage	15,000 Max. Volts D-C
Grid No. 2 Voltage	410 Max. Volts D-C
Grid No. 1 Voltage	
Negative Bias Value	125 Max. Volts D-C
Positive Bias Value	0 Max. Volts D-C
Positive Peak Value	2 Max. Volts
Peak Heater Cathode Voltage[1]	
Heater Negative with respect to cathode	125 Max. Volts D-C
Heater Positive with respect to cathode	125 Max. Volts D-C

TYPICAL OPERATING CONDITIONS

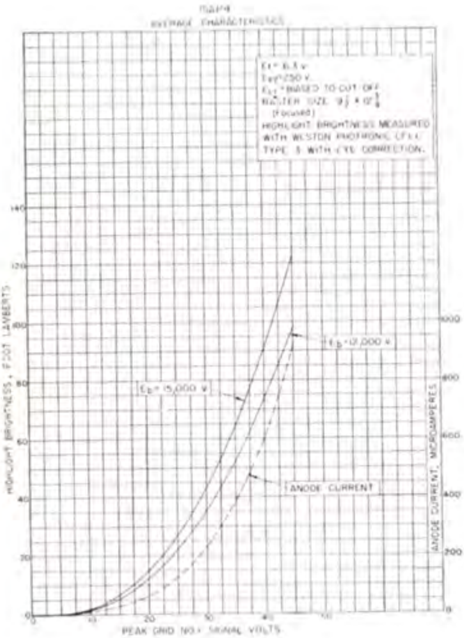
Anode Voltage	12,000 Volts D-C
Grid No. 2 Voltage	250 Volts D-C
Grid No. 1 Voltage[2]	–27 to –63 Volts D-C
Focusing Coil Current[3] (D-C)	159 Approx. Milliamperes
Spot Position (Undeflected)[4]	Within 35 Millimeter radius circle

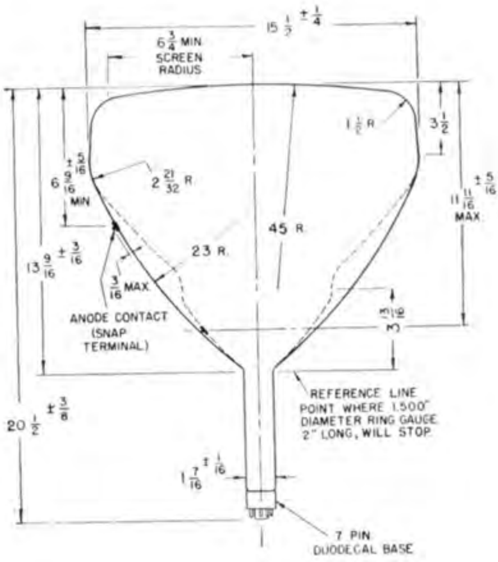
MAXIMUM CIRCUIT VALUES

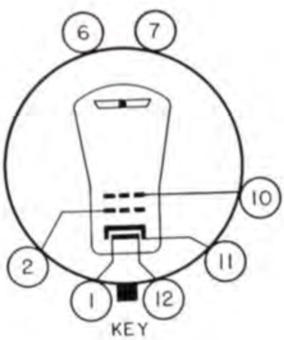
Grid No. 1 Circuit Resistance	1.5 Max. Megohms

NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Visual extinction of undeflected focused spot.
3. For standard focus coil #20, or equivalent, with the combined grid No. 1 bias voltage and video signal voltage adjusted to produce a highlight brightness of 20 foot lamberts on a 9-1/2" x 12-3/4" picture area. Distance (D) shall be 3.25 inches.
4. When the tube is operated at (1) normal heater voltage: (2) Eb = 12,000 volts; (3) Ec2 = 250 volts; (4) Ec1 set at such a value as will avoid damage to the screen; and (5) the tube shielded against external influences:
   The undeflected and unfocused spot will fall within a circle of 35 mm. radius, the center of which coincides with the geometric center of the tube face.







Bottom View of Base

Pin No.	*Element*
1	Heater
2	Grid No. 1
6	No Connection
7	No Connection
10	Grid No. 2
11	Cathode
12	Heater

20BP4 CATHODE-RAY TUBE

The Type 20BP4 is a 20" magnetic focus and deflection television picture tube designed for applications requiring a maximum screen size. The bulb is designed to provide a useful picture size of 12-7/8" x 17-1/4" with high brilliance and definition.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 ± 10% Volts
Heater Current	0.6 ± 10% Ampere
Focusing Method	Magnetic
Deflecting Method	Magnetic
Max. Deflecting Angle	50 Degrees Approx.
Phosphor	P4
Fluorescence	White
Persistence	Medium
Direct Interelectrode Capacitances, Nominal	
Cathode to all other electrodes	6.5 μμf.
Grid #1 to all other electrodes	8.0 μμf.

Mechanical

Overall Length	28-3/4" ± 3/4"
Greatest Diameter of Bulb	20" ± 3/8"
Minimum Useful Screen Diameter	18"
Bulb Contact	Medium Cap
Base	7-pin small shell duodecal
Basing	12D
Anode Contact aligns with vacant pin position #3	± 10 Degrees

MAXIMUM RATINGS—(Design Center Values)

Anode Voltage	20,000 Max. Volts D-C
Grid No. 2 Voltage	410 Max. Volts D-C
Grid No. 1 Voltage	
Negative—Bias Value	125 Max. Volts D-C
Positive—Bias Value	0 Max. Volts D-C
Positive—Peak Value	2 Max. Volts
Peak Heater Cathode Voltage[1]	
Heater Negative with respect to cathode	125 Max. Volts D-C
Heater Positive with respect to cathode	125 Max. Volts D-C

TYPICAL OPERATING CONDITIONS

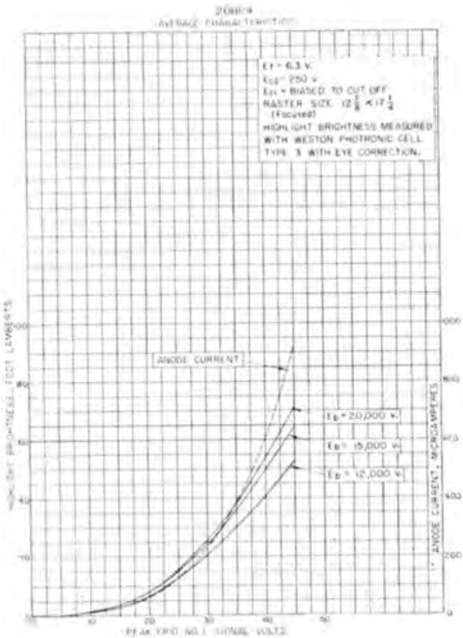
Anode Voltage	15,000 Volts D-C
Grid No. 2 Voltage	250 Volts D-C
Grid No. 1 Voltage[2]	–27 to –63 Volts D-C
Focusing Coil Current[3] (D-C)	135 Approx. Milliamperes
Spot Position (Undeflected)[4]	Within 50 Millimeter radius circle

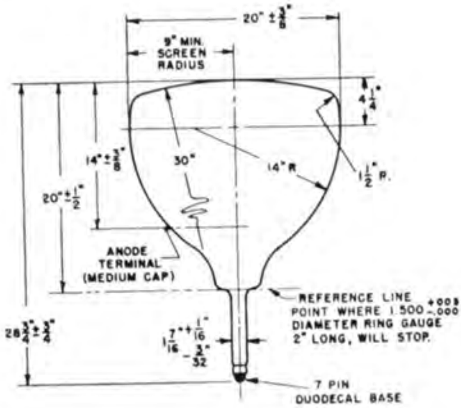
MAXIMUM CIRCUIT VALUES

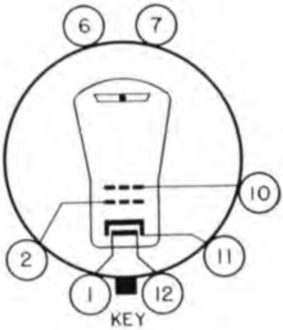
Grid No. 1 Circuit Resistance	1.5 Max. Megohms

NOTES

1. Cathode should be returned to one side or to the mid-tap of the heater transformer winding.
2. Visual extinction of undeflected focused spot.
3. For standard focus coil #20, or equivalent, with the combined grid No. 1 bias voltage and video signal voltage adjusted to produce a highlight brightness of 15 foot lamberts on a 12-7/8" x 17-1/4" picture area. Distance (D) shall be 3.25 inches.
4. When the tube is operated at (1) normal heater voltage: (2) Eb = 15,000 volts; (3) Ec2 = 250 volts; (4) Ec1 set at such a value as will avoid damage to the screen; and (5) the tube shielded against external influences:
   The undeflected and unfocused spot will fall within a circle of 50 mm. radius, the center of which coincides with the geometric center of the tube face.







Bottom View of Base

Pin No.	*Element*
1	Heater
1	Grid No. 1
6	No Connection
7	No Connection
10	Grid No. 2
11	Cathode
Eb	Heater

DU MONT GAS TRIODES

Types 2B4 and 6Q5G

Mechanical Dimensions, Basing, and Average Operating Characteristics

The Type 2B4 and Type 6Q5G Gas Triodes are intended for use in Du Mont Cathode-ray Oscillographs for sweep oscillator service. They are also designed for applications where a gas triode is required for control and counter circuits and where a wide frequency range is desired for sweep oscillators.

CHARACTERISTICS

	6Q5G	2B4
Heater		
Voltage (a.c. or d.c.)	6.3	2.5 volts
Current	0.6	1.4 ampere

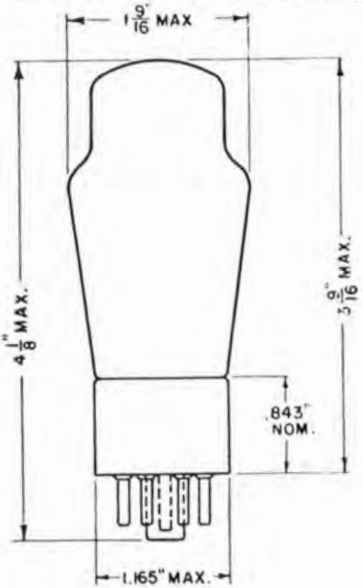
Direct Interelectrode Capitances (Nominal)

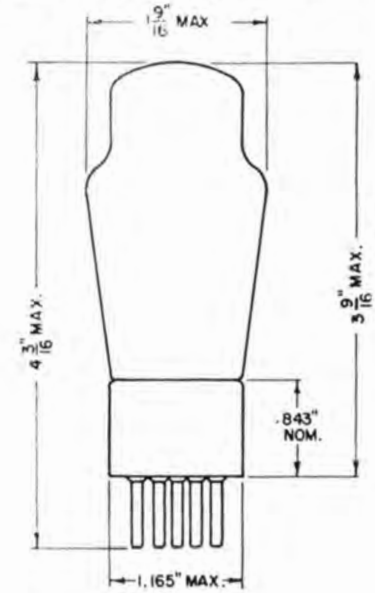
Grid to anode	2.8 μμf.	
Grid to cathode	1.7 μμf.	
Anode to cathode	2.0 μμf.	
Tube Voltage Drop	19 volts approx.	
Maximum Overall Length	4⅛"	4-3/16"
Maximum Diameter	1-9/16"	1-9/16"
Bulb	ST12	ST12
Base	Small shell	Small
	Octal 8 pin	5 pin
Basing—RMA Basing Designation	6Q	5A

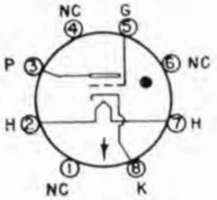
SWEEP-CIRCUIT OSCILLATOR SERVICE

Anode Voltage (Instantaneous)	300 volts (max.)
Peak Anode Current	300 milliamperes (max.)
Average Anode Current	1 milliampere (max.)
Grid Resistance	10,000 ohms (min.) / 100,000 ohms (max.)
Frequency Range:	
2B4	1-30,000 cps.
6Q5G	1-50,000 cps.

Mechanical Dimensions, Basing, and Average Operating Characteristics

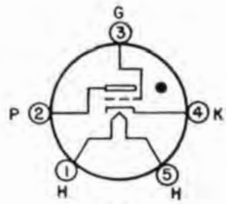






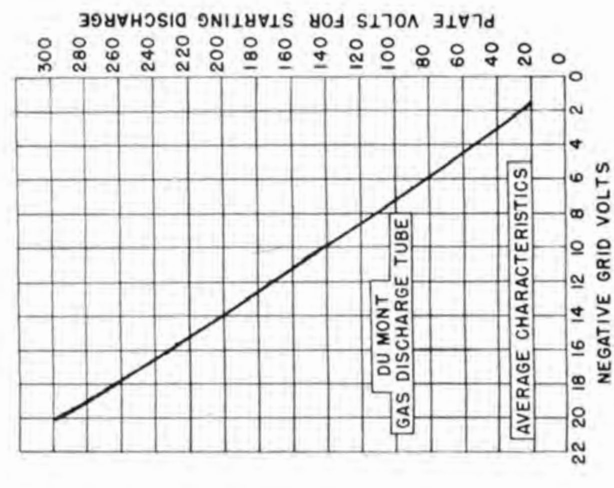
6-Q

Type 6Q5G



5-A

Type 2B4



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PEIRCE, GEORGE H., 715 Camp Street, New Orleans 12, Louisiana.	LOUISIANA—Entire State. ALABAMA—Counties of Baldwin and Mobile. FLORIDA—County of Escambia. TENNESSEE—West of but not including Counties of Macon, Smith, De Kalb, Cannon, Coffee, Moore and Franklin. ARKANSAS—South of but not including Counties of Crawford, Franklin, Johnson, Pope, Conway, Faulkner, Pulaski, Lonoke, Prairie, Monroe and Phillips. MISSISSIPPI—Entire State.
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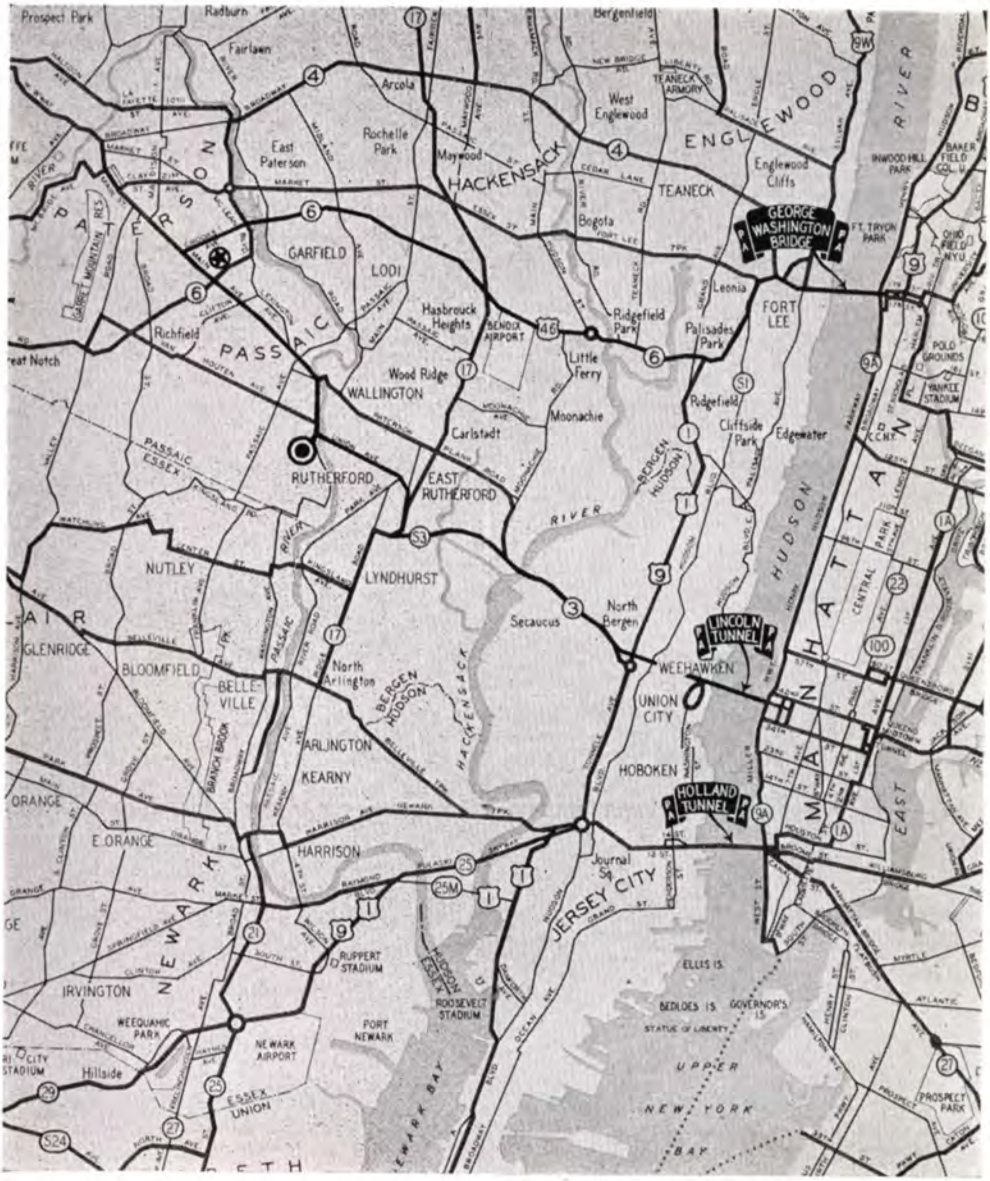
WATERS, R. A., 4 Gordon Street, Waltham, Massachusetts.	ENTIRE NEW ENGLAND STATES.
WRIGHT, JAMES L., JR., Box 276, R. R. 17, Indianapolis 44, Indiana.	KENTUCKY—Entire State.
ALLEN B. DU MONT LABS., INC., 1000 Main Avenue, Clifton, New Jersey.	NEW JERSEY—North of and including Counties of Mercer, Monmouth and Ocean. NEW YORK—Staten Island only.
EXPORT DIVISION, ALLEN B. DU MONT LABS., INC., 630 Fifth Avenue, Room 3469, New York 20, New York.	WORLD—Except Canada, United States and Alaska.

MAP OF NORTHERN NEW JERSEY AND METROPOLITAN NEW YORK AREAS

Map showing direct routes from New York City to either of the two main Du Mont Plants



COURTESY OF PORT OF NEW YORK AUTHORITY

◉ PLANT 1, 2, & 3: 2 MAIN AVE. PASSAIC, N.J.

✪ PLANT 16: 1000 MAIN AVE. CLIFTON, N.J.

The Intercity Bus Corporation runs a bus from the Midtown Bus Terminal on 43rd Street in New York City (between the Avenue of Americas and 7th Avenue) direct to Plant 16.

Take same bus to corner of Van Houten and Main avenues in Passaic to get to Plants 1, 2 and 3. Change at this corner to a No. 74 bus proceeding south ½ mile to the plant.

DU MONT

ALLEN B. DU MONT LABORATORIES, INC.

Cathode-ray Instrument Division

1000 Main Avenue Clifton, N. J.