THE OSCILLOGRAPHER

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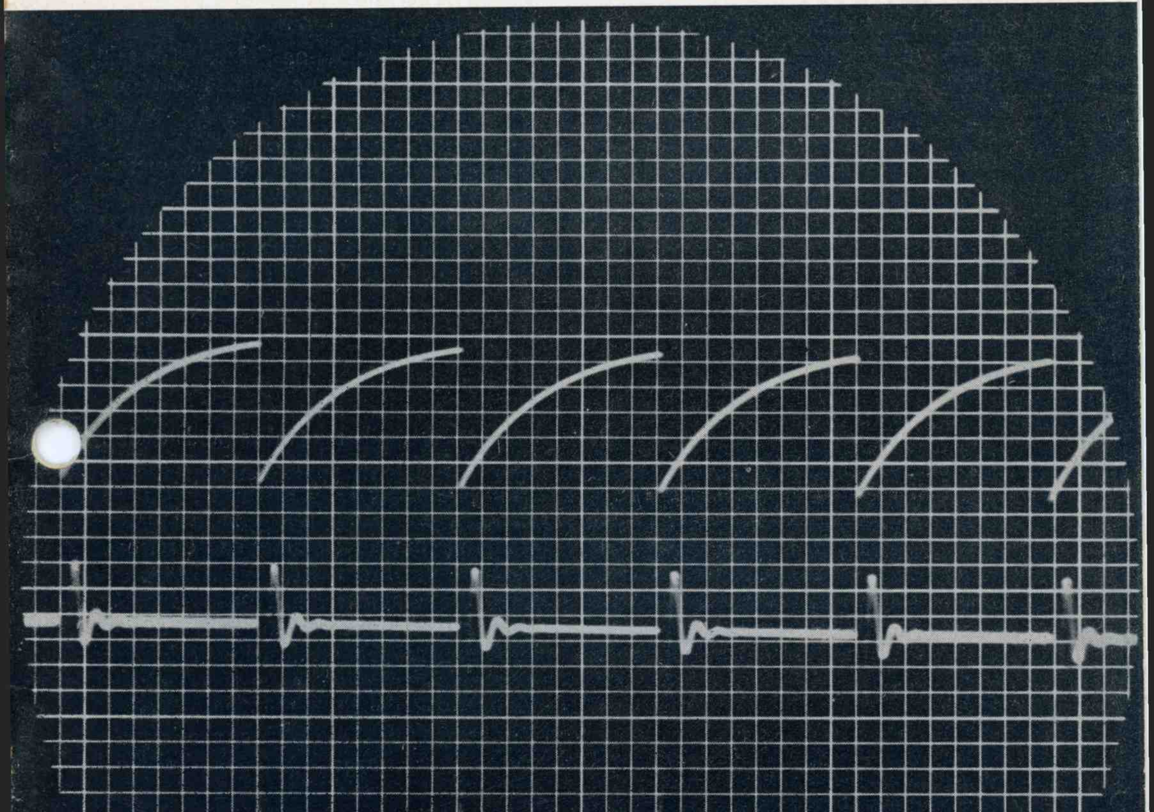

DUAL-BEAM DISPLAY SEE PAGE 2

FIVE PROMOTIONS ANNOUNCED BY INSTRUMENT DIVISION

Promotion of five top members of the Instrument Division, Allen B. Du Mont Laboratories, Inc., to new key posts within the division was announced today by Rudolf Feldt, Manager of the Instrument Division.

The five appointees and their new posts are as follows:

Dr. P. S. Christaldi has been named Assistant Division Manager. He was formerly Engineering Manager.

G. Robert Mezger, formerly Technical Sales Manager, has been named Engineering Manager.

Emil G. Nichols has been appointed Technical Sales Manager. He was formerly Assistant Technical Sales Manager.

Melvin B. Kline and William G. Fockler have been appointed Assistant Engineering Managers. Mr. Kline is the former head of the Special Projects Section of the Instrument Engineering Department; and Mr. Fockler the former head of the Development Engineering Section of the same department.

"The new promotions," Mr. Feldt said, "will allow greater integration of divisional activities to meet Du Mont's rapidly expanding production of precision electronic instruments both for commercial use and for the military services. The assignments will permit the division to make greater use of the capabilities of these top experts in the electronic instruments field."

The appointments, Feldt pointed out, are in line with Du Mont's policy of promotion from within its organization.

Dr. Christaldi, a nationally known expert on cathode-ray tubes and oscillographs, has been with the Du Mont organization since 1938 when he joined the company as an engineer engaged in developing commercial tubes and electronic instruments. From 1941 until 1947 he was Chief Engineer, and during the war years played a leading part in the design, development and production of military electronic equipment as well as cathode-ray tubes at Du Mont. In 1947, when in the course of the rapid expansion the company was organized on a divisional basis, Dr. Christaldi became Engineering

(*Continued on Page* 17)

THE
OSCILLOGRAPHER

A publication devoted exclusively to the cathode-ray oscillograph, providing the latest information on developments in equipment, applications, and techniques. Permission for reprinting any material contained herein may be obtained by writing to the Editor at address below.

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Neil Uptegrove - Editor

ON THE COVER

A typical example of the great utility of a dual-beam display in general development work is this oscillogram in which waveforms from two points in an experimental circuit are displayed simultaneously on the screen. In this instance, the two signals are presented on a common time base enabling a precision and convenience of correlation unobtainable with two individual oscillographs. The use of the illuminated calibrated scale greatly facilitates such studies.

This oscillogram was photographed from the screen of a Du Mont Type 322 Dual-beam oscillograph, which was announced recently by the Instrument Division. Full technical details on the Type 322 may be obtained by writing the Instrument Division at the above address.

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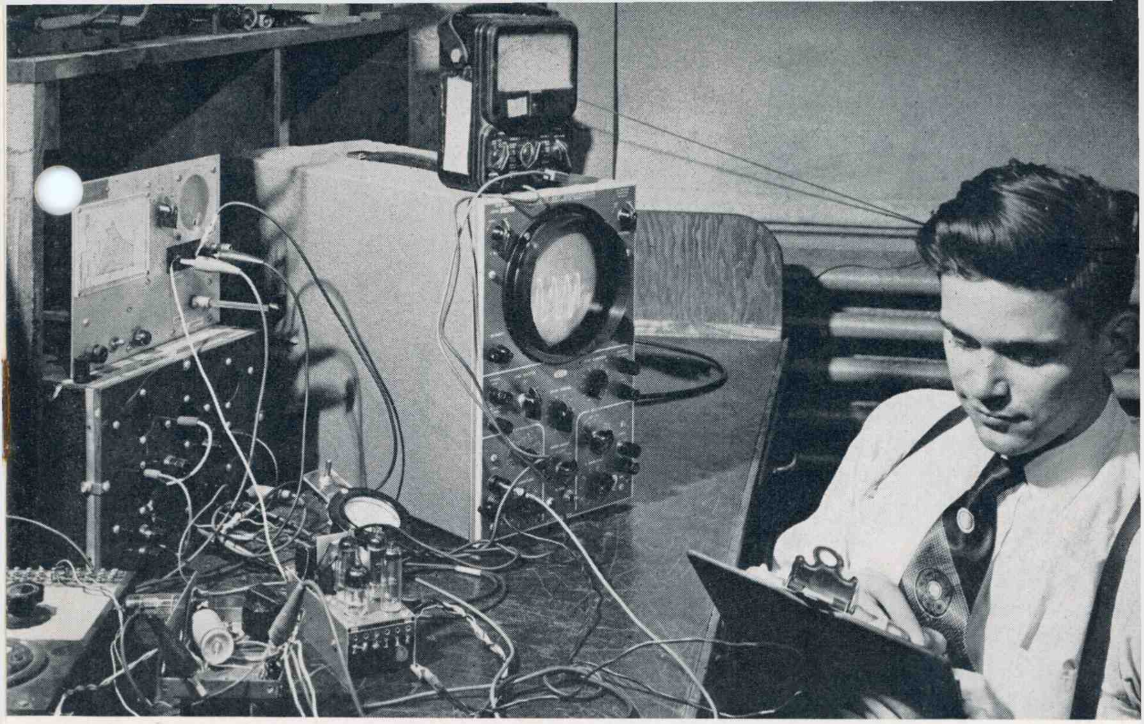


Techniques of Measurement in Oscillography

Part 1

By Dr. P. S. Christaldi

A MAJOR question in oscillography is: What is the best means of measurement for a particular application? Or, more simply, how do I get the answers I need? To help solve such questions, here is a summary of the more important factors involved in devising and selecting techniques of oscillographic measurement.

A corollary intention of the article is to discourage the frequently encountered tendency of deciding that present equipment is incapable of providing the desired information if the first setup does not prove satisfactory. Often, with improved techniques or minor modifications, the equipment will give excellent results.

First, some definitions are in order. The term *applications* will refer to the use of cathode-ray equipment to permit measurement or observation of a specialized kind. On the other hand, *techniques,* which are more general in nature, may be applied in a variety of applications.

Selection of Oscillographic Equipment

While not always considered in the sense of a technique, the selection of the equipment with which a measurement or scientific observation is to be carried out is truly an important phase in an investigation. Unfortunately, there are so many variables involved that a simple figure of merit is not feasible. However, some of the factors leading to the selection of equipment should be reviewed.

Types of Display

In the analysis of a new measuring problem or application, one of the first points to be determined is the type of

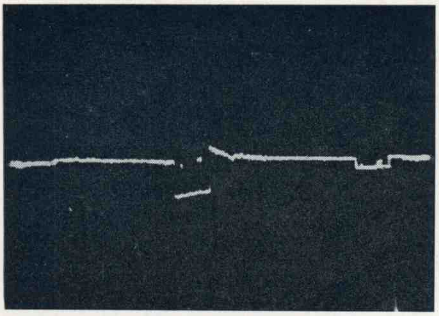


Figure 1. Typical off-on indication which shows arrival and departure of shuttle at the shuttle box of textile loom

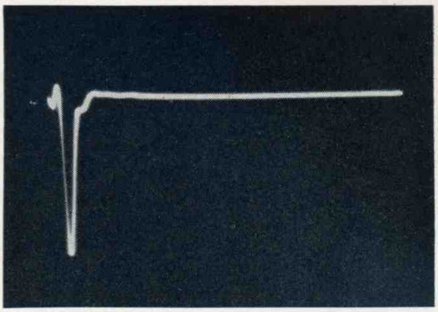


Figure 2. An example of the most frequently used oscillographic display in which amplitude is plotted as a function of time

display that will present the desired information in the most convenient form. The simplest type of display that still provides the required information should always be sought, particularly in those cases where the equipment is to be operated by relatively unskilled personnel. Since we are generally accustomed to equipment in which amplitude is plotted as a function of time, we might not always consider the possibility of using other forms of display. Following are typical presentations:

On-off indications, which show the presence or absence of some phenomenon, may be made by deflecting the electron beam, or by modulating its intensity. In many cases it is unnecessary to measure the duration or the amplitude of the events producing such an indication. The detection of corona in high-voltage transformers is a typical example of such an application, although usually level is of some interest here. Another example of the off-on display is shown in Figure 1, where the arrival and departure of the shuttle at the shuttle box is indicated by the vertical deflections. Indications of this type sometimes can be obtained without recourse to the cathode-ray tube, but one must not neglect the advantage offered by the visual persistence of certain screen materials, or of using photocell pick-ups to operate other indicating or recording devices.

The most frequently encountered type of display in oscillography, well suited to the study of waveforms, is the linear orthogonal display in which voltage is plotted as a function of time. Its widespread use results not only from the fact that it presents the information required in the form in which it is usually desired, but also because the oscillogram presented in this manner is quite readily interpretable. (See Figure 2). A similar display, often described as the "A-scan," is used in radar range indicators to plot voltage as a function of range.

An expanded display may be desirable.

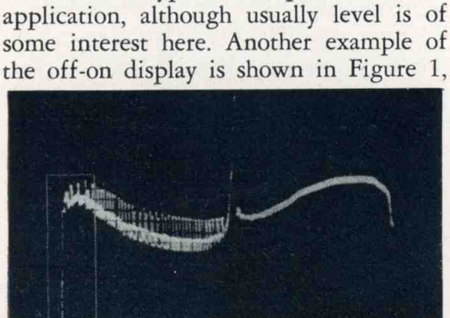


Figure 3. An indication of the voltage field surrounding a fluorescent lamp, displayed without expansion

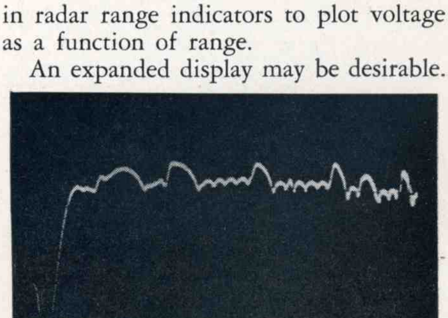


Figure 4. Portion of Figure 3 enclosed by box is expanded here for the study of details on the trace

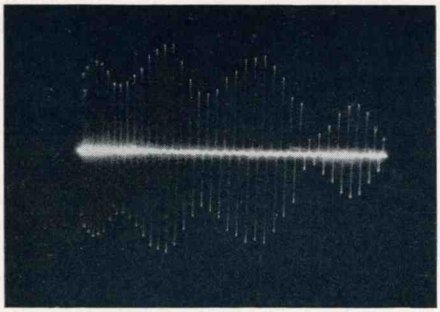


Figure 5. Amplitude range of input signal is expanded, with only peaks of input signal displayed, revealing cyclic variation

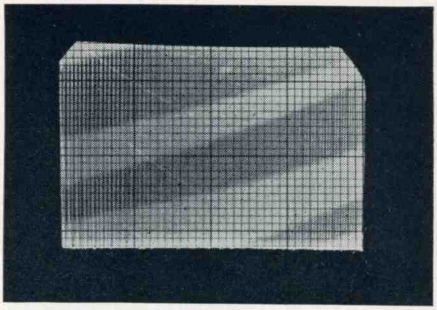


Figure 6. Raster display of focal-plane shutter action. Variation in width of diagonal bars indicates non-uniform shutter speed

Perhaps the simplest method for obtaining an expanded display is to increase the gain of a high-gain horizontal amplifier, and then position on-screen the desired portion of the wave form (See Figures 3 and 4).

Another sort of expanded display occurs in the "R" presentation of the Du Mont Type 256-D Cathode-ray Oscillograph. In this case a portion of the time scale is expanded by delaying a relatively high-speed sweep to delineate a portion of a wave-form pattern which occurs in a time short in relation to the total period. Another expanded display is produced when the amplitude range of a signal is expanded to allow detailed study of small amplitude variations in signals of relatively large amplitude. An example is the study of variations in power-line voltage that were found to occur at a rate of approximately four cycles per second with an amplitude of a fraction of a volt. A biased diode clipper suppressed all but the peaks of the power-line voltage, permitting expansion of the variation of these peaks, as shown in Figure 5.

Occasionally, it is found desirable to study phenomena which are relatively long but which must be measured to fairly high accuracies in time. One successful method is to provide a series of short time bases in the form of a raster, just as is done in the synthesis of a television picture on a cathode-ray tube, but using vertical deflection from each of these segments of the time base or intensity modulation to present the signal information. (See Figure 6). This might be considered as the combination of a series of delayed expanded sweeps on a single cathode-ray tube. In another application of this technique each of the sweeps of the raster accounts for one of a set of cyclic events which occur within a longer cycle. For example, in the study

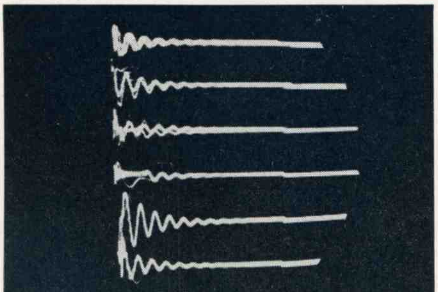


Figure 7. Raster display of spark-plug discharges. Fourth trace from top indicates shorted plug; fifth trace, open

Figure 8. A typical polar-coordinate display. This type of presentation provides a long, uninterrupted time base

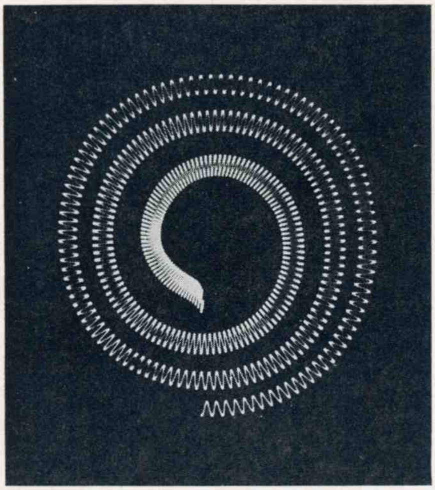


Figure 9. Typical spiral display. Spiral presentations provide a time base longer even than the polar-coordinate

of ignition timing, each of the spark plug discharges could be presented on a sweep which makes up a raster when combined with those corresponding to the other discharges occurring during one revolution of the engine, as shown in Figure 7.

Circular or polar displays have found frequent use in problems involving timing, where the circular time base can be accurately controlled (as from a quartz crystal source), with the event under study being presented as deflection or intensity modulation. (See Figure 8). Considerably longer time bases can be obtained for a given screen size than is generally possible with linear orthogonal sweeps, and the discontinuity of time corresponding to the retrace interval is avoided. Although interpretation of waveforms on a circular time base is not always as simple as in the case of orthogonal displays, it is not particularly difficult. The circular display is also found useful where the pattern is to be related to mechanical rotation; for example, in the study of mechanisms, or in determining the polar characteristics of antennas and light sources.

Where longer time bases are desired than can be achieved with the circular display, spiral displays may be used. With such displays it is possible to extend the baseline by a factor of 10 to 20 times and even more, depending upon the ability to resolve individual lines of the spiral, as shown in Figure 9. Their use imposes a difficulty common with that of the circular or polar displays in that maintenance of truly circular form in the simpler case is not always easy, whereas in the case of the spiral display we have the additional problem of a linear radial modulation of a circular baseline. The spiral display has been used in timing phenomena to fairly high accuracies, and it is applicable to single as well as repetitive transient presentation.

Frequency Ranges and Writing Rates

Once a suitable type of display has been decided upon, the next considerations are those which will determine the general class of equipment required. Important here are the frequency ranges which will be encountered in the phe-

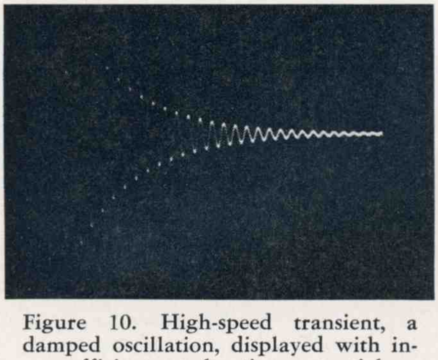


Figure 10. High-speed transient, a damped oscillation, displayed with insufficient accelerating potential

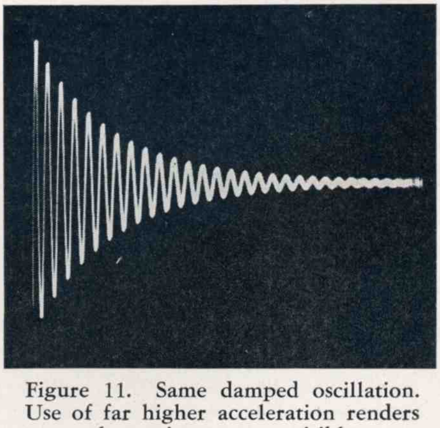


Figure 11. Same damped oscillation. Use of far higher acceleration renders the entire pattern visible

nomena under study, and the writing rates of which the equipment must be capable.

Possibly the first point to be considered is whether the phenomena which are to be studied are recurrent or transient. If transients which are non-repetitive or which recur with a low duty cycle are to be studied, it is probable that the cathode-ray tube must be operated at relatively high accelerating potentials, depending, of course, upon the frequency components involved (See Figures 10 and 11). When the phenomena are recurrent, even though their durations may be short, relatively low accelerating potentials may be entirely adequate. For example, a one-microsecond pulse repeated at a rate of 500,000 times per second can hardly be differentiated from a one-millisecond pulse repeated at a rate of 500 cycles per second. The difference here would be not so much in the accelerating potentials but in the amplifier and sweep circuits.

Along with the rate at which the signals recur, the frequency range of signal components, or the rate of change of voltage, is of considerable importance in determining the characteristics of the equipment required. (See Figures 12 and 13.) We frequently learn, much to our chagrin, that events normally considered to be low-frequency or long-time in nature have important components of very short duration. An example is the make and break of contacts, such as in automobile ignition systems or in relays. If we are truly interested in the characteristics of the contact make or break, we may be concerned with events occurring in fractions of a microsecond, although the duration of the phenomenon may be a matter of many milliseconds. In some cases we are concerned with both low-and high-frequency components of signals, in which case good low-frequency response, or even d-c response, is indicated.

The range of sweep speeds required follows readily from the analysis of signal frequency components which the amplifier must handle. Along with this go the considerations of the nature and levels of the signals required to trigger or synchronize the sweeps and the sweep starting times, and this introduces the consideration of signal delay in the signal channel.

The brightness, persistence, and resolution of the cathode-ray tube also must be considered. Bearing these in mind, requirements for cathode-ray tube performance can be resolved with the aid of published information on the performance of cathode-ray tubes under varying conditions of operation and utilization.

The levels of signals available will indicate whether or not an amplifier is necessary and the requirements for attenuators. The levels at which the signals exist with respect to ground must also be considered, since coupling networks, transformers, balanced input circuits, etc., may be required.

Visual and Photographic Recording

Visual and photographic recording must

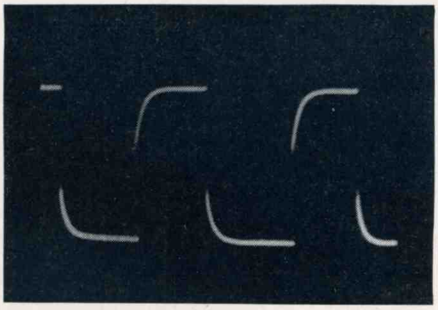


Figure 12. Rounding of this 100-kc squarewave was caused by poor high-frequency response of amplifier

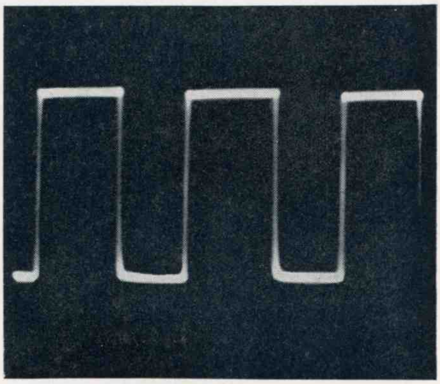


Figure 13. Same waveform as Figure 12, passed through amplifier having far better high-frequency response

be considered in the selection of oscillographic equipment. The response of the screen to excitation, including both build-up and decay of visual effect, must be viewed in relation to the other factors described above. The repetitive nature of the phenomena might influence the selection of screen materials, since certain types of screens, notably the P7, exhibit build-up characteristics. This factor also affects the selection of accelerating potentials and of photographic equipment. Spurious screen excitation from ambient light or other sources is important here; and its effects can be minimized in both the design and the use of the equipment.

Ratings of the Oscillograph

Having analyzed the requirements established by the nature of the work to be done, the next step is to survey the specifications of available equipment. The first factor to be considered is the matter of specifications and ratings on the cathode-ray tube, amplifiers, attenuators, sweep generators, markers, calibrating means, etc. The desired characteristics having been determined, they should be compared to the specifications describing equipment under consideration for a particular application.

The consistency of the design is an important factor to be analyzed — to determine, for example, whether the range of sweep speeds is adequate for the job and will permit full exploitation of the capabilities of the signal channel. The same kind of thinking should be applied to time- and amplitude-calibrating facilities, cathode-ray-tube accelerating potentials, etc.

Any equipment design has certain limitations. These should be determined from a study of the specifications before equipment is selected. Every effort should be made to insure that failure to obtain the desired results is not due to limitations of the equipment, which should have been recognized in advance.

Frequently, the specification material covering such factors as stability and freedom from spurious response is sketchy or non-existent. This is partly the result of inadequate definitions and methods of measurement. Where this information is unavailable in the specifications, one frequently must draw upon experience in this regard.

Use of Auxiliary Equipment

Auxiliary equipment is frequently necessary. This may take the form of transducers to convert phenomena from one form to another, as in the case of mechanical applications, or of accessories which enhance the usefulness or simplify the interpretation of results which the oscillograph will provide. These accessories may range from the more commonly considered test probes and cameras to signal generators, single sweep triggering circuits or other devices.

Setting up for Measurement

Having established the general nature of the measurements to be made and selected suitable equipment, it is timely to review those considerations often described as the techniques of measurement. This broad term includes not only the basic considerations but also some of the things that might be termed "tricks of the trade." Although most of the factors involved seem obvious after they have been mentioned, unfortunately they are all too frequently overlooked even by those with long experience in laboratory methods.

Relationship of the Oscillograph to the Object to be Measured

The relationship of the oscillograph to the object of the study in space, time, and potential determines the method in which the equipment will be employed. Frequently, nothing can be done about the space factor, but in many cases, the location of the equipment for ease and convenience of operation is neglected. If careful measurement is to be made, the observer must be comfortable and relaxed; and he must have no distracting or disturbing influences, including high ambient light levels. Safety is frequently a consideration in determining the locations of the oscillograph and the other parts of the setup, and this factor should not be underestimated. The time, as well as space, relationship involves not only lengths and kinds of leads, including coaxial cables or delay lines, but also the manner of obtaining synchronizing or triggering information, the question as to whether external or internal triggers are to be used, and the selection of appropriate sources of signal. The potential factor includes such things as the signal level which must be connected to the oscillograph, raising the question of insulation of leads and sometimes of the oscillograph cabinet, the use of isolating coupling transformers, etc. Frequently, it may be found necessary to make difference measurements between the potentials of two points not at ground potential. These and the foregoing factors should be considered before preparing the measuring setup.

General Considerations

Among the first considerations to which attention should be given in setting up oscillographic equipment is that the power source voltage and frequency be those for which the equipment is rated. Following are several other troublesome points.

Grounding the instrument cabinet is usually considered desirable for safety reasons. However, from time to time measurements are made on circuits which operate off ground, and in such cases we may be tempted to insulate the case and proceed with our measurements. This is obviously not good general practice. Whenever it is resorted to, extreme caution should be exercised, and the connections broken as soon as the measurements have been completed. Grounding is important for other reasons, but these will be dealt with later.

Frequently, it is important to shield both equipment and leads. This is particularly true when measuring signals having high source impedances using equipment having high input impedance; the signals picked up on the input leads (See Figure 14) may be substantial, whether they be stray power-line voltages or pick-up from local AM or television broadcast stations. Since the oscillograph is frequently used with other equipment close by, we may be concerned with radiation, and shielding and grounding assume even greater importance. Often, it is found helpful to operate all the equipment on a bench which has a ground plane, a large conductive sheet insulated from the bench top itself to which a single ground connection may be made. If this ground plane is not insulated, it is possible to set up circulating ground currents through the equipment cases which cause still further difficulties. In one recent case enough radio-frequency energy was being picked up in a signal lead that detection occurred in the input stage, setting up a d-c component that caused apparent drift in the d-c level of the trace. This type of interference can be eliminated in many ways, shielding being the simplest where applicable. A suitable low-pass filter, such as a radio-frequency choke or parallel-resonant circuit in series with the signal lead at the oscillograph input terminal, or inside the shielding case between the terminal and the input attenuator, may be found helpful. In the measurement of corona in transformers and other devices a corresponding technique is frequently used in which a high-pass filter is connected between the test point and the input terminal of the oscillograph. This high-pass filter permits the corona impulses to be presented but ef-

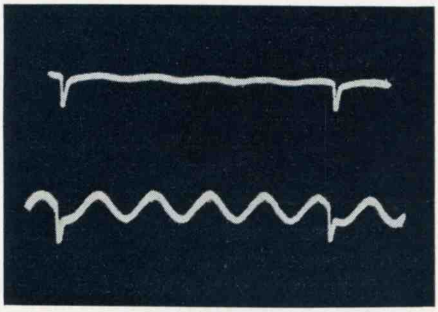


Figure 14. A-C pickup on lower trace nearly obscures low-level pulses and prevents accurate measurement. On upper trace, with pick-up minimized, significant measurement is possible

fectively short-circuits the component of signal at power-line frequency. This technique will be found described in the RTMA and the JAN specifications on corona testing of transformers.

Magnetic shielding frequently is necessary, especially when equipment is operated near busses carrying heavy current, welders, alternators, etc.

An extreme case was reported not long ago where a piece of rotating machinery in the basement of a building affected an electron beam on the fourth floor.

While most oscillograph cabinets provide reasonably good shielding from external fields in the presence of strong radio frequency fields, particularly at VHF and higher frequencies, additional bonding of the panel to the case may be necessary. It may also be necessary to add screening to any openings which may exist in the case, and to use shielded and filtered power-line cables.

Frequently, grounds are not true grounds in the sense that we normally consider them. Spot-welding equipment, surge test equipment, and similar devices can introduce transients into the power line which are conducted throughout a building or over a large area; these are not always eliminated by the electrostatic shields commonly employed around the primary windings of the power transformers in oscillographs. Occasionally, it may be necessary to add a low-pass filter at the point where the power cable enters the instrument case, and internal shielding of the power leads may be necessary. An external shielded isolation transformer, together with shielded cables from the transformer to the instrument, may sometimes be necessary. Suitable regulating devices for the power line are also of assistance under some conditions.

It is hardly necessary to comment at length on the importance of minimizing ambient illumination of the cathode-ray tube screen. Suitable placement of the equipment, the use of light shields and filters, and dark adaptation of the observer's eyes may be essential in a particular installation.

Input Connections

The arrangement of the oscillograph input connections should always be given careful attention — not only with respect to the selection of conductor types and their routing, but also in consideration of the characteristics of the oscillograph itself. Some of the points to observe follow.

Ordinarily, oscillographic equipment presents an input impedance equivalent to a resistance shunted by a capacitance. Seldom are inductive input impedances encountered. The magnitude of the resistive impedance is particularly important when high impedance circuits are being measured to avoid loading of the circuit under test. Where higher input impedances than the customary one or two megohms are required, one solution is the use of a high-resistance attenuating probe, usually capacitively compensated to preserve signal waveform. Another possibility is the use of an adapting device consisting of a cathode-follower tube in a probe, in which case care must be exercised to avoid overloading the tube. Electrometer tubes may also be used where extremely high resistances are required, although such tubes usually have serious limitations with respect to signal-handling ability, gain, and bandwidth.

The capacitive component of input impedance also is important when the source impedance is high, since it can result in a reduction of high-frequency performance. It can be reduced by means of probes of the type described, where they are applicable. If probes cannot be used, the loading of the input capacitance must be considered in interpreting results.

More and more frequently, applications involving pulse studies are encountered. It is customary in these applications to operate with low-impedance coaxial cables used as signal conductors. Here impedance matching becomes extremely important and the length and types of leads must be given careful consideration.

Not long ago, Du Mont's aid was solicited by a manufacturer of pulse-forming networks who reported that his customer had rejected the networks as not meeting specifications on duration measured at the 10 per cent, 50 per cent, and 90 per cent amplitude points. Du Mont agreed to set up a sample network in the test circuit employed by him to scrutinize the results of his customer. It soon became evident that the pulse-forming networks were satisfactory, but that the measuring techniques of the customer were not. The network was designed to deliver pulses having a duration of approximately 0.5 microsecond at an amplitude of several hundred volts in the test circuit used. The rise time was of the order of 0.03 microsecond. The customer's oscillograms indicated such severe oscillation and overshoot that it was next to impossible to obtain a sensible measurement of pulse duration at the specified amplitude points. Figure 15 shows the oscillogram obtained. In the setup devised by Du Mont, the 50-ohm output impedance of the pulse-forming network was matched carefully to a 50-ohm cable terminated directly at the deflection plates of the oscillograph, and no difficulty was encountered. The pulse waveform obtained is shown in Figure 16. The measurements made by the customer were reconstructed by using open wire leads to the deflection plates, simulating the lead lengths inherent in the equipment employed. The importance of impedance matching, and of keeping short and direct any open-wire leads from the end of the properly-terminated cable to the deflection plates, was again demonstrated.

In another case, results were obtained in the measurement of the amplitude-versus-frequency-response characteristic of an oscillograph amplifier which did not appear to be reasonable. Investigation showed that the output cable supplied with the signal generator used in testing was not properly terminated. The voltage that appeared at the oscillograph input terminals did not correspond with that indicated on the output meter of the signal generator for all frequencies within the signal generator range. In this case, metering at the input terminals to the oscillograph, which corresponds to the end of the signal generator cable, avoided the difficulties. An alternative would have been proper termination of the signal generator cable.

Frequently, it is convenient to use external synchronizing or triggering signals, rather than to operate the equipment from signals derived from the phenomena being studied. When this is done, attention must be paid, as in the case of signal leads, to the use of proper types of cables and their termination. Grounding of such cables is also important to avoid spurious effects. The common impedance of ground leads for input terminals at different points on the panel sometimes can give trouble; signal cables should be grounded adjacent to their corresponding oscillograph input points. This has been found to be a frequent source of diffi-

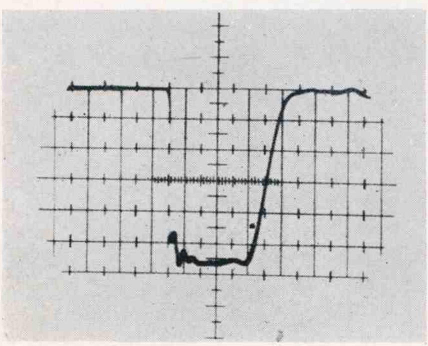


Figure 15. 0.5-μsec pulse displaying oscillatory transient resulting from excessive deflection-plate lead lengths

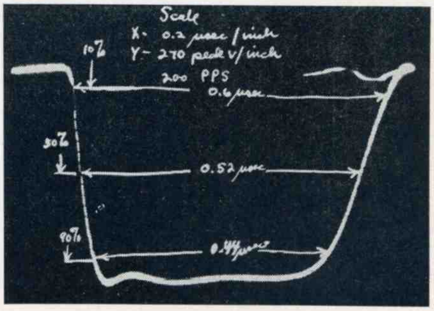


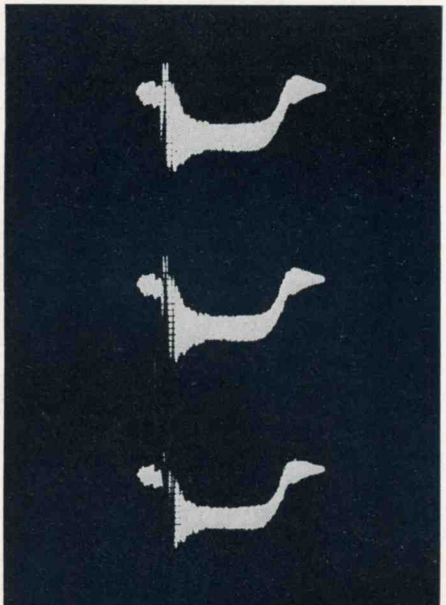
Figure 16. Same pulse as that of Figure 15, with length of deflection-plate leads greatly reduced

culty in the use of the oscillograph for observation of square-wave or pulse-type signals, where generating equipment provides a triggering pulse as well as a signal pulse. Sometimes, through carelessness or thoughtlessness, open wire leads are used for the triggering signal, relying upon the signal ground lead for the return path. Faulty operation usually can be corrected in such cases by providing a shielded cable with its own ground return for the triggering signal. This also applies to other external signals that may be connected to the oscillograph, including high-frequency timing signals used for intensity modulation.

It often becomes convenient to add signals and to apply the composite signal through the Y channel. This is common practice in setups for the measurement of frequency response using the sweep-frequency generator technique. Marker signals may be added through a resistive adding pad, utilizing a separate source of marker-frequency signal. When this arrangement is used, care must be exercised to maintain proper impedance relationships, and to avoid unwanted coupling.

Occasionally, balanced signal sources are encountered, and it is then convenient and sometimes helpful to apply these signals to a balanced input circuit of the oscillograph. While such circuits are not usually provided, often they may be improvised by making internal connections to the amplifiers. This has frequently been done in oscillograph amplifiers having a final amplifier stage of the self-balancing type by ungrounding the normally grounded control grid of the second tube of the stage and applying signal to it. In the case of multi-stage amplifiers which are balanced, it sometimes can be accomplished by applying a signal between the normally available grid and and grid of the corresponding stage which is normally grounded. When this is done, care must be exercised to avoid overloading, since an input attenuator is not provided for the normally grounded grid. It is also necessary to avoid overload of in-phase components of signals which may exist.

Although specifications and instruction book data usually specify the maximum ratings of input signal voltage which may be applied to each input terminal of an oscillograph, frequently this information is overlooked. As a result there are occasional difficulties with overload or stray coupling from one input circuit to another. Usually, the input attenuators of the signal channels are adequate to handle the voltages which may be applied safely



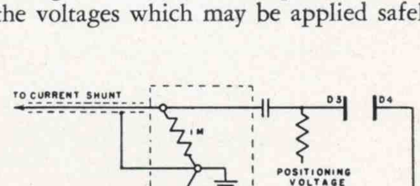


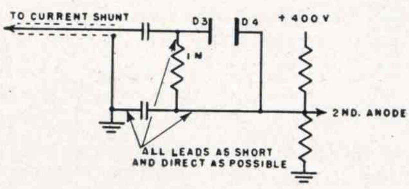
Figure 17. Left, wave form obtained by connecting signal to the deflection-plates through the circuit shown at right. Again, excessive lead length and improper grounding introduces spurious signals

to the input terminals, although this is not always the case. However, sometimes it is necessary to limit the signal levels applied to other terminals, such as sync and trigger input, although the insulation value may exceed the permissible signal level considerably. Failûre to operate within these ranges sometimes causes difficulties when extremely large synchronizing or triggering signals are applied to the external synchronizing terminals of the oscillograph. External attenuators may be used to reduce the signal level to a suitable value to eliminate the unwanted coupling, or a simple device is to apply the triggering signal through a low-capacitance coupling achieved merely by wrapping an insulated conductor carrying the signal around the input terminal post. This sometimes provides the additional advantage of discriminating against low-frequency components of the triggering signal. When difficulty with triggering results from too high a signal level, this device should be attempted.

Such external networks as attenuators, amplitude limiters, and frequency or amplitude selectors, frequently are found helpful. Such devices have been described from time to time in the past, and it is well to review applications in which they might prove advantageous.

Proper grounding of signal leads has been referred to before, but its importance cannot be overemphasized. Recently, it was desired to measure the plate-current pulse of a high-power, pulsed magnetron operating in the microwave region. The plate-current pulse was derived from a low-resistance shunt connected directly to the deflection plates. The circuit employed is shown in Figure 17, which indicates the effective lead length from terminal board connections, through coupling capacitors, to the deflection plates. From the accompanying oscillogram it will be seen that a considerable amount of spurious signal was present. Much of this corresponded to frequencies in the microwave region, but other components were indicated as well. Initial attempts at correction called for shielding between the vertical deflection signal circuits and the remainder of the circuits in the vicinity of the cathode-ray tube deflection-plate region and gave some improvement.

Study of the circuit showed that there was a rather long path between deflection plate D4 and the ground return. This was



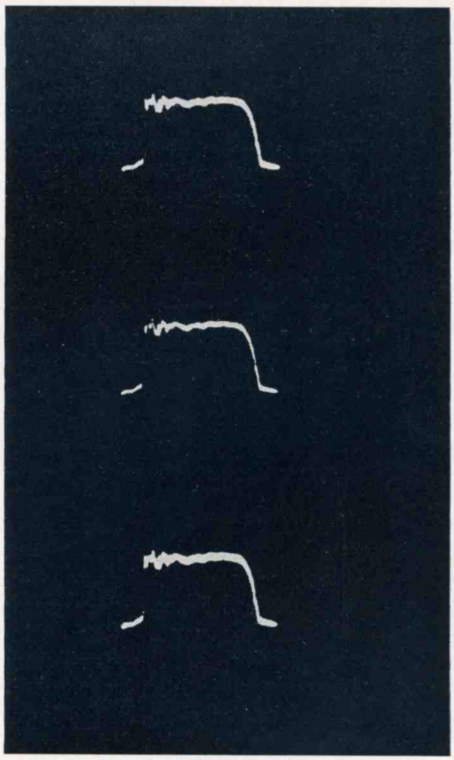


Figure 18. Right, signal similar to Figure 17, applied to deflection plates through circuit shown at left. With leads made shorter, and all ground leads connected to common point, much of the spurious signal was eliminated

found to be about six inches long, including a coupling capacitor. When the leads were made much shorter and more direct, with all ground leads connected to a common point and returned to a single chassis ground, as shown in Figure 18, the disturbance was reduced further, even without the added shielding. The corresponding oscillogram shows the final result, considered to be satisfactory.

Other, less obvious, problems with respect to the grounding of signal circuits arise. A typical example involves a ground lead in which components other than the wanted signal flow. Such a situation arose not long ago in attempts to operate oscillographic equipment for an automobile battery using a vibrator-type supply. It was found that despite the massive construction of an automobile engine, the internal resistance of a signal source using the engine block as a ground return was not necessarily negligible. Using such a ground return, the signal circuit was susceptible to interference from the alternating-current component introduced by the vibrator. Although it was possible in a particular installation to eliminate such interference almost entirely by suitable selection of ground points, the final solution lay in the use of a differential input circuit. Thus, the effective signal applied to the oscillograph input corresponded to the difference between the desired signal plus the vibrator component and the latter component alone. Although in this case a differential input arrangement was used in the amplifier, in many cases it is possible to eliminate the unwanted signal by suitable choice of ground points.

Adjustment of Controls

Correct adjustment of the controls of the oscillograph frequently is more important than realized in obtaining proper operation. Some knowledge of the principles of operation of the equipment usually is necessary if intelligent use is to be made of it. For example, the input attenuator should be adjusted to avoid overload of the input stage if such overload is possible through some unfortunate combination of control settings. In general, this means that the input attenuator should be set to provide maximum attenuation ahead of the first input tube, while any fine amplitude controls are set near their maximum settings. A similar consideration applies to synchronizing and trigger signals, in which case it may sometimes be necessary to reduce the amplitude of such signals before they are connected to the input terminals. It might be said generally that the input signals should be kept to a minimum wherever their amplitude can be controlled externally and satisfactory operation of the oscillograph obtained.

The use of the amplitude control of synchronization and trigger signals frequently is helpful in selecting portions of the signal on which synchronizing or triggering is desired, particularly in complex signals such as television blanking and synchronizing signals. If limiting of synchronizing signals alone were relied upon, it is probable that synchronization would occur on the blanking pedestal, while by the reduction of the setting of the sync amplitude control, it is usually possible to operate from the synchronizing pulse of this signal.

The intensity and focus control settings should also be given some consideration. Detail may be lost if the intensity is set at such a level that fine focus cannot be obtained. Sometimes in extreme cases it is possible to introduce intentional defocusing of the indicating spot on one axis to bring out detail which might otherwise be lost along the other axis. Operating cathode-ray tubes at the lowest practicable intensity level also minimizes the likelihood of spurious excitation of the screen from stray electrons. This is particularly important where high-voltage tubes are used, since it is practically impossible to eliminate secondary emission from some of the elements of the tube which might intercept primary electrons. This situation frequently can be improved by adjustment of spot position or amplitude to avoid reflections from deflection plates or walls of the tube.

End of Part 1

Part 2 of Dr. Christaldi's article will appear in the next issue of the Oscillographer.

UHF Measurements with the Cathode-ray Oscillograph

Among the difficulties that arise in ultra-high-frequency work (475 to 890 megacycles) is that of measuring relatively small differences in frequency. Accurately calibrated signal generators in the UHF band are costly and have physical limitations, such as backlash, which hinder measurement.

With the use of the Du Mont Type 304-H Cathode-ray Oscillograph, however, a handy and more accurate method of measuring these small frequency differences has been devised, without the use of a finely calibrated, expensive signal generator. Measurements of bandwidths and the relative location of peaks and notches may be made easily and accurately with this method.

Using the arrangement shown in Figure 1, the UHF bandwidth of a passive single-tuned circuit can be accurately measured with the following instruments: a Du Mont Type 304-H Cathode-ray Oscillograph, a wobbulator, a detector, and a video signal generator. Impedance-matching, 10-db, 50-ohm isolating pads are incorporated at the input and the output of the test circuit.

The principal marker frequency and a video frequency of half the bandwidth of the circuit are injected into the detector, an 1N21A, where they are mixed, the video frequency modulating the principal frequency. The sum and difference frequencies of the modulation result in two sideband markers appearing on the cathode-ray screen. (Linearity is assured by operating the detector crystal at a high point on its response curve, which may be checked by comparing the output with known attenuation.) Adjust the signal generator until the principal marker appears at the apex of the frequency response curve; then, by means of the video signal generator, position the two sideband markers at the half power points on the response curve. The two sideband markers will move simultaneously up and down the curve as the latter adjustment is made, thus facilitating positioning. (See Figure 2.)

After the necessary adjustments have been made, the figure for half the bandwidth may be read directly from the video signal generator. If desired, the operating Q may also be determined from the relation:

$$Q = \frac{fo}{BW_{3db}}$$

where, fo is the center frequency, as shown by the principal marker, and BW_{3db} is the half power bandwidth, shown by either of the sideband markers.

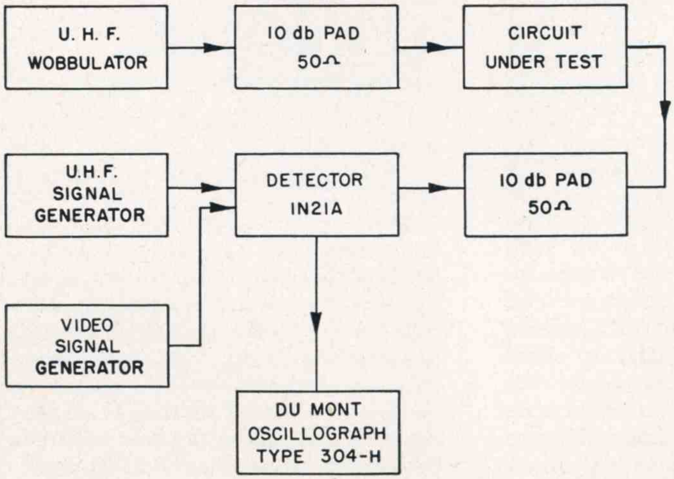
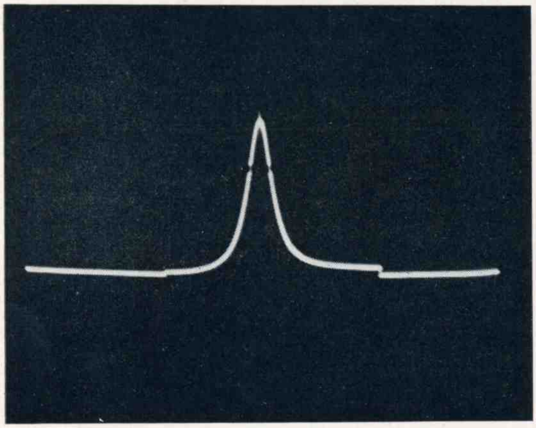
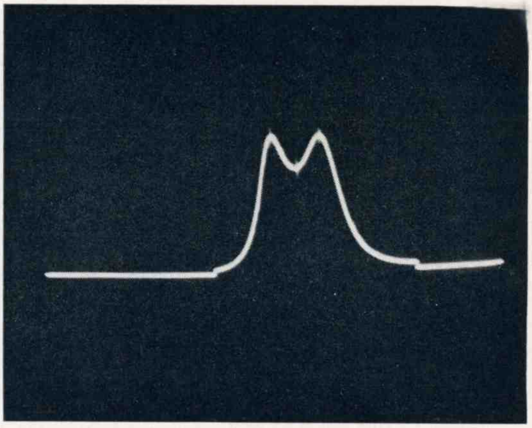


Figure 1. Block diagram showing simple method of measuring small UHF differences with the Du Mont Type 304-H Cathode-ray Oscillograph





(a) (b)

Figure 2. (a) Oscillogram showing pattern with markers to measure bandwidth of a passive single-tuned circuit. (b) Oscillogram showing bandwidth measurement of double-tuned circuit.

The advantage of the described method is shown clearly in the formula. If the signal generator calibration alone were relied upon for readings, the formula could be expressed:

$$Q = \frac{fo \pm \%\ \text{error}}{f_1 \pm \%\ \text{error} - f_2 \pm \%\ \text{error}}$$

whereas, in the described method the percentage of error is lessened, as shown in the following equation:

$$Q = \frac{fo \pm \%\ \text{error}}{BW \pm \%\ \text{error}}$$

Thus far, only a single-tuned circuit has been discussed; however, double-tuned circuits may be calibrated with identical accuracy and ease. This is shown in Figure 3 with the sideband markers set at the two peaks of the frequency response curve to measure peak-to-peak bandwidth.

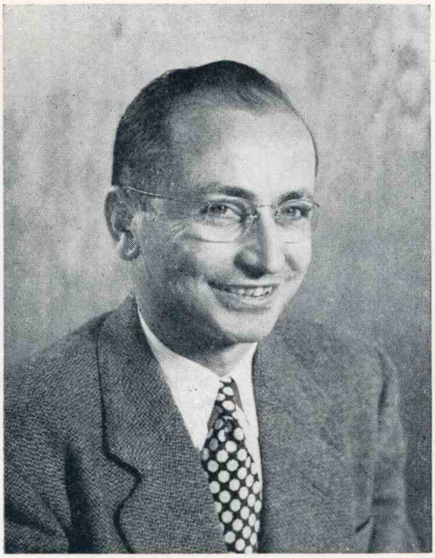
Ideally, the output of the wobbulator used for test should be constant over the band of measurement. Actually, tilts as great as 10 percent from center frequency to half bandwidth will produce less than three percent error if care is taken to set the sideband markers symmetrically on the distorted response.

One application of this method of bandwidth measurement is in television transmitter testing, where one sideband is limited strictly by the Federal Communications Commission, yet cannot be filtered out less than 1.25 megacycles from the carrier frequency without "smear" appearing on the picture. This critical adjustment can be made speedily and accurately with the described method. The method also is advantageous in circuit development work, and will probably assume greater importance as electronic development in the UHF band progresses.

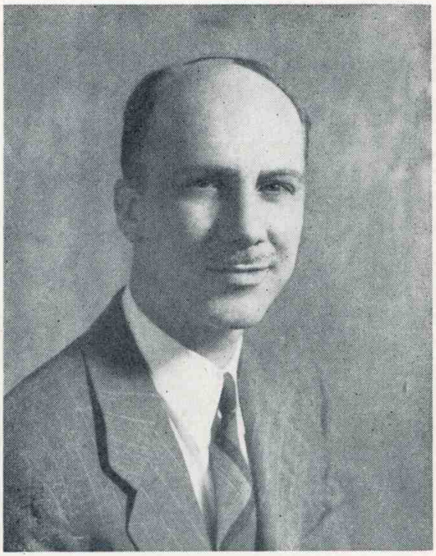
— A. E. Hylas, Engineer —
Research Division,
Allen B. Du Mont Laboratories, Inc.

Oscillographer Binders

For the benefit of those who desire a permanent file for back issues of the Oscillographer, the Instrument Division makes available a sturdy three-ring binder. Finished in durable, green leatherette and stamped in gold, this binder provides an attractive and convenient file for this publication. The binder may be obtained from the Instrument Division at the address given on page 2. Price, $0.75.



Dr. P. S. Christaldi



G. Robert Mezger

PROMOTIONS

(*Continued from Page* 2)

Manager of the Instrument Division, which position he has held until his recent promotion.

Dr. Christaldi was graduated from Rensselaer Polytechnic Institute in 1935 with the degree of Electrical Engineer and returned as a graduate fellow in physics, specializing in wave-guide communications. He received the degree of Dr. of Philosophy from Rensselaer in 1938. He is a member of Sigma Xi, and a Fellow of the Radio Club of America and of the Institute of Radio Engineers.

Mr. Mezger joined Du Mont as a development engineer in 1936 after graduating that year from Rensselaer Polytechnic Institute as an Electrical Engineer. From 1936 to 1939, he was actively engaged in the development of cathode-ray instruments. He was Technical Sales Manager from 1939 until 1941 when he went on active duty with the Navy. From 1941 until 1944, Mr. Mezger was assigned to instrument development work at the David Taylor Model Basin, Washington, D. C., and from 1944 until 1945 was active in the design of naval radar equipment. In 1945, Mr. Mezger left the Naval Research Laboratory as Commander to return to Du Mont. He is a member of the IRE and the American Institute of Electrical Engineers.

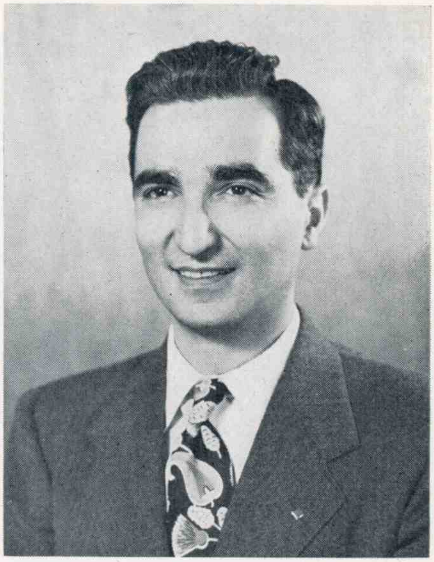
Since 1947, Mr. Mezger has been Sales Manager for the Instrument Division. His thorough technical background, and profound knowledge of the market for electronic instruments make him ideally suited for this new position.

Mr. Nichols has been with the Du Mont Instrument Division since 1946 as a Technical Sales Engineer, and later as Assistant Technical Sales Manager. From 1942 to 1945 he served in the Navy, concentrating on radar work at Harvard University and at Pearl Harbor, and now holds the rank of Lieutenant in the Naval Reserve. He holds his electrical engineering degree from the Newark College of Engineering in New Jersey. Prior to his naval service, he was employed by the Meter Division of the Consolidated Edison Company, New York, and the Test Department of the General Electric Company, Bloomfield, New Jersey.

William G. Fockler has been employed at the Allen B. Du Mont Laboratories, Inc., since receiving his BSEE degree from the University of West Virginia in 1945.

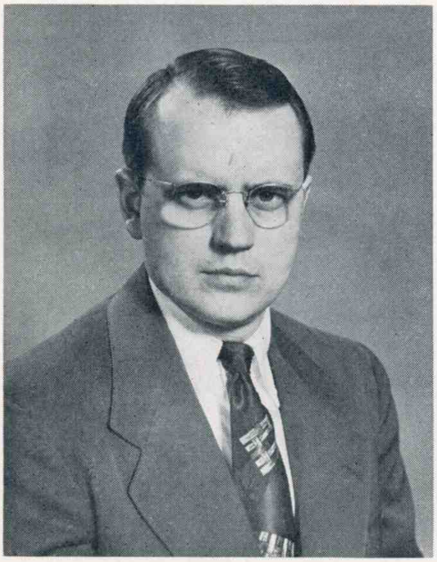
Starting as a Junior Engineer, Mr. Fockler rose to the position of Senior Engineer in the Development Section of the Instrument Division, where he was responsible for the design of general purpose cathode-ray oscillographs and cathode-ray indicators employing high voltages. During the past eighteen months Mr. Fockler, as head of the Development Section, has been responsible for the design of the commercial line of instruments and accessories. He is an associate member of the IRE and the AIEE.

Melvin B. Kline joined the engineering staff of the Allen B. Du Mont Laboratories, Inc., early in 1941 and has been associated primarily with the development and design of cathode-ray oscillographs and related equipment. During World War II he worked on loran and radar indicators. After working hours during this period, he also served at Du Mont's New York Television Station, WABD, as Video Control and Master Control Engineer. For the past several years, Mr. Kline has been head of the Special Projects Section of the Instrument Engineering Department responsible for the engineering of government projects as well as special instruments for commercial use.



Emil G. Nichols

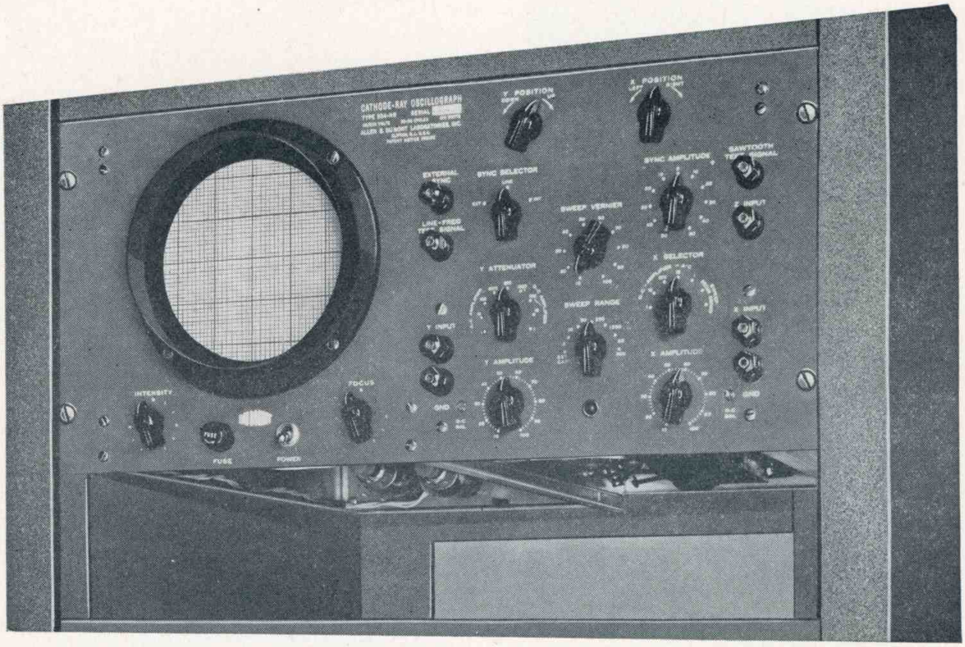
Mr. Kline received his B. S. degree in physics from the College of the City of New York and has done graduate work at Columbia University, the Polytechnic Institute of Brooklyn, and the Stevens Institute of Technology. He is a senior member of the IRE.



William G. Fockler

Melvin B. Kline

The New Du Mont Type 304-HR Cathode-ray Oscillograph



The new Du Mont Type 304-HR Cathode-ray Oscillograph, rack-mountable version of the Type 304-H

In response to many requests, the Instrument Division of the Allen B. Du Mont Laboratories, Inc., has adapted the widely used general-purpose oscillograph, the Du Mont Type 304-H, for mounting in a standard 19-inch relay-rack. The repackaged instrument, designated the Du Mont Type 304-HR Cathode-ray Oscillograph, is identical electrically to its noted counterpart, having high-gain d-c and a-c amplification, a wide range of driven and recurrent sweeps, as well as all the other features that have made the Type 304-H the most popular oscillograph ever designed. As far as is practical, the panel-control layout of the Type 304-HR is similar to the Type 304-H.

The new instrument measures 8¾ inches high and 19½ inches deep, and comes complete with dust cover.

High-gain, directly coupled signal amplifiers extend the range of application to include low frequency phenomena. If a-c coupling is desired, signals may be applied through an internal coupling capacitor. The Y-axis frequency response is down no more than 10% from 0 to 100,000 cps, and no more than 50% at 300,000 cps. Driven and recurrent sweeps, variable continuously from 2 to 30,000 cps, are expandable up to 6 times full-screen diameter with complete positioning. Sensitivity is 0.028 volt peak-to-peak per inch through the Y-axis amplifier.

For further details, see the catalog, "Du Mont Cathode-ray Equipment," or the article on the Type 304-H by M. Maron in THE OSCILLOGRAPHER, Vol. 11, No. 4, Oct.-Dec., 1949).

Cat. No.	*Type No.*	
1567-E	304-HR	Cathode-ray Oscillograph for 115 volts, 50-60 cycles, with 5CP1-A Cathode-ray Tube.
1570-E	304-HR	Same as above, with 5CP7-A Cathode-ray Tube.
1571-E	304-HR	Same as above, with 5CP11-A Cathode-ray Tube.
1572-E	304-HR	Cathode-ray Oscillograph for 230 volts, 50-60 cycles, with 5CP1-A Cathode-ray Tube.
1575-E	304-HR	Same as above, with 5CP7-A Cathode-ray Tube.
1576-E	304-HR	Same as above, with 5CP11-A Cathode-ray Tube.

THE DU MONT TYPE 303-A . . .

A New Quantitative 10-Megacycle Oscillograph

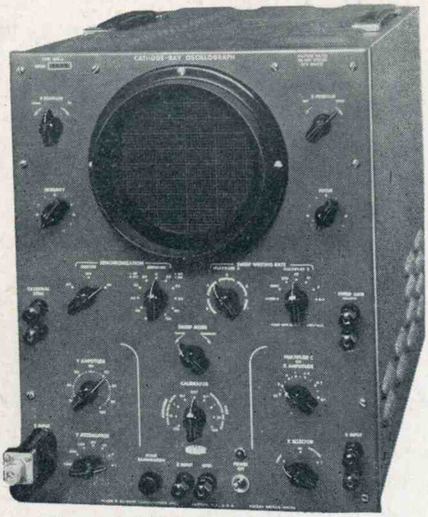


Figure 1. The new Du Mont Type 303-A Cathode-ray Oscillograph

The new Du Mont Type 303-A is a wide-band, high-gain oscillograph specifically designed for the study of pulses and other high-speed phenomena. In addition to the conventional qualitative analysis, the new Type 303-A is equipped with circuits for the precise quantitative measurement of both time and amplitude.

Nominal bandwidth of the new Type 303-A is 10 megacycles, with a transient response of 0.033 μsecond. Owing to the gradual fall-off of the Y-axis frequency response characteristic, signals as high in frequency as 20 megacycles or more may be usefully displayed.

Linear sweeps of the Type 303-A have been carefully selected to complement the capabilities of the wideband vertical amplifier. Sweep durations are variable from 0.1 second to 2 μseconds. All sweeps may be expanded up to 6 time full-screen diameter, with full positioning available over the entire range. With expansion maximum sweep speed is 10 inches per μsecond (25.4 cm/μsec). Sweep speeds considerably in excess of this speed may be obtained at some sacrifice in positioning and linearity; however time measurements may still be accurately made since calibration is accomplished by signal substitution.

Internal circuits provide square-wave voltage standards of 0.1, 1.0, 10, and 100 volts with an accuracy of better than ±5%, for amplitude calibration, and sinusoidal timing markers of 0.1, 1, 10, and 100 μseconds, at an accuracy of better than ±3%.

A truly useful display of low-level pulses is assured, since the deflection factor of the vertical amplifier is 0.1 peak-to-peak volt per inch with 1.5 inch of undistorted vertical deflection for unidirectional signals is available and 3 inches for symmetrical signals.

An illuminated calibrated scale is provided as standard equipment with the Type 303-A, together with a filter of a color appropriate for the screen type supplied with the individual instrument. Illumination of the scale is variable by means of a convenient front-panel control. Also supplied as standard equipment is a Du Mont Type 2592-52 shielded coaxial adaptor with 52-ohm termination for connection of the input signal to the oscillograph by means of a coaxial cable.

Additional information on the new Type 303-A may be obtained by writing to the Instrument Division at the address on page 2.

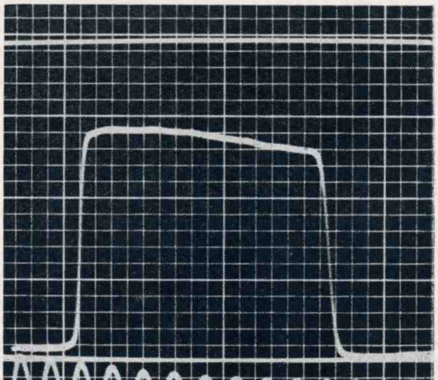


Figure 2. Multiple exposure photographed from screen of Type 303-A shows 0.8 μsec. pulse with rise time of 0.02 μsec. displayed on 2 in./μsec. sweep. Note absence of overshoot. Sinusoidal wave train below pulse is 0.1 μs timing signal. Sensitivity of instrument has been adjusted to 5 volts per inch, as indicated by internally supplied 10-volt amplitude calibration signal. Note the 1.5 inch of undistorted vertical deflection, and the clarity with which the illuminated calibrated scale is recorded