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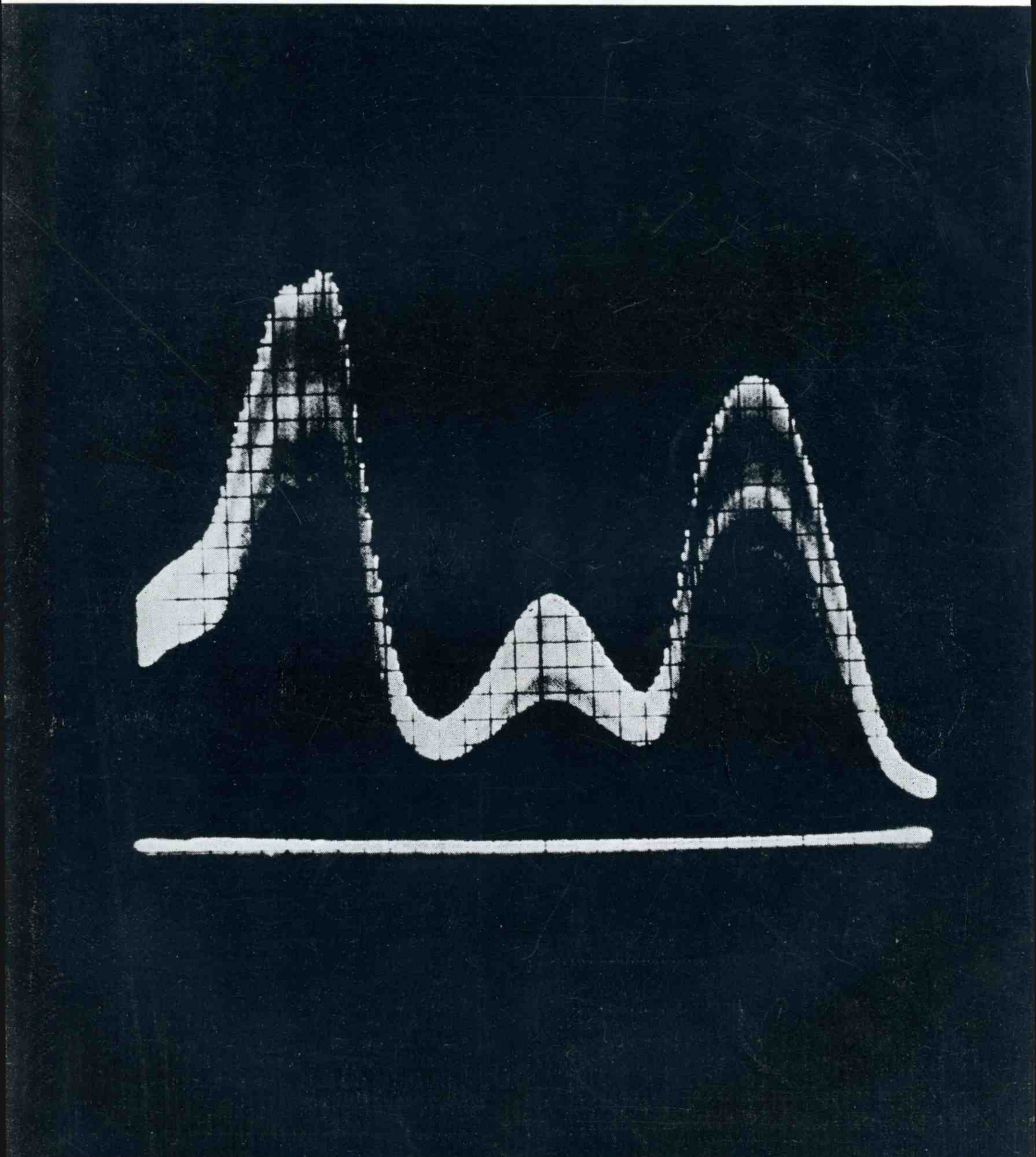

LIGHT-DISTRIBUTION PATTERN

SEE PAGE 2

An Illuminated Data Card For Use with the Du Mont Type 271-A Oscillograph-record Camera

By H. P. Mansberg

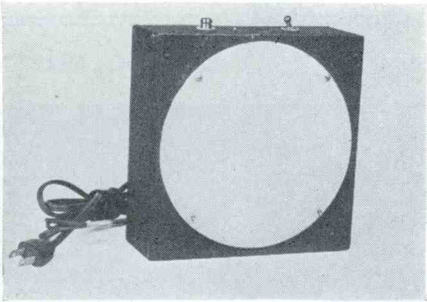

Figure 1. Illuminated data card constructed for experimental use

[Editor's note: Frequently tests and measurements performed with the cathode-ray oscillograph may be greatly facilitated by the use of various accessory devices. Limiter and clipper circuits, delay lines, special sweep synchronizing and triggering circuits, voltage calibrators, balanced-input adapters, transducers, and attenuators are but a few examples. The following article is the third of a series describing the design and function of such accessory devices.]

In the rapidly growing art of photographic recording from cathode-ray oscillographs, the problem of properly identifying individual recordings has become one of considerable importance. Usually, a careful record of exposure numbers is kept in a note book, along with titles and relevant data. Then, after development of the film, the individual frames are numbered correspondingly. It is necessary, with this system, to refer back to the original notes each time a recording is to be studied. And each time additional prints of the recording are made, they too must be correctly numbered. This method of identification is slow and clumsy, and there is the ever-present danger of confusion of recordings and data.

Unquestionably the simplest and most convenient device for such a method of film identification is an illuminated data card. This data card consists basically of a translucent plate—usually ground glass or plastic—on which the data are written, and a source of illumination placed be-

(*Continued on Page* 17)

THE OSCILLOGRAPHER

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ON THE COVER

This pattern, photographed from the screen of a Du Mont Type 304-H Cathode-ray Oscillograph, represents the variations in illumination on an unevenly lighted surface. The horizontal deflection was provided by a potentiometer, mechanically coupled to a shaft, on which a photocell was mounted. The photocell scanned the surface through an arc of approximately 120 degrees, and its output was applied through the vertical d-c amplifier of the Type 304-H. Owing to the high gain of the amplifier, no preamplifier was required.

THE NEW DU MONT TYPES 304-H & 304 CATHODE-RAY OSCILLOGRAPHS

A Discussion of These New Replacements for the Du Mont Type 208-B, and Their Design Considerations

By M. Maron

THE FIRST Du Mont Type 208 was sold in April, 1940. And thus began the career of the instrument that was to become the most popular oscillograph ever developed. Circuits of the instrument were subsequently modified, and the instrument became the Type 208-B, while its popularity continued its unprecedented rise. The Type 208-B became a standard for general-purpose oscillography, and its name became a byword in laboratories, factories, and schools throughout the world.

However, with the passage of time, it became apparent to Du Mont engineers, that even more advanced oscillographic equipment would be required for the ever-increasing demands of the future.

With this in mind, Du Mont initiated a development program to create an instrument that could be truly called the successor to the Type 208-B.

The products of this program, the Du Mont Types 304-H and 304 Cathode-ray Oscillographs, are worthy heirs to the position of the Type 208-B. In their design, all the features responsible for the success of the Type 208-B are incorporated, plus many more, which extend greatly the utility of these new instruments, enabling them to enter fields heretofore restricted to far more costly oscillographs.

For example, to extend the range of application of the Types 304-H and 304 to include low-frequency phenomena, high-gain, directly coupled signal amplifiers are provided. Signals may, however, be applied through an internal coupling capacitor, if a-c coupling is desired. Due to their excellent design, these amplifiers are extremely stable, with microphonics and drift held to a minimum; and the problem of rapid recovery after shocking

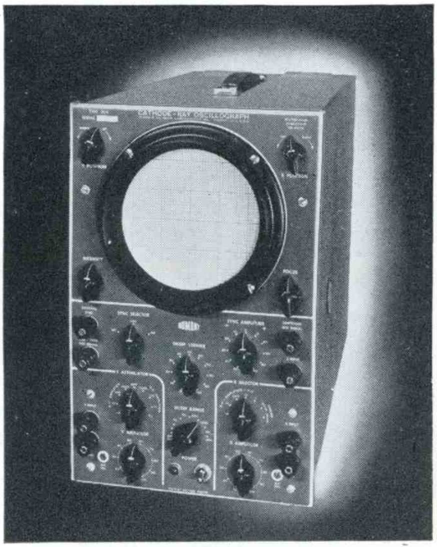


Figure 1. The Du Mont Type 304-H Cathode-ray Oscillograph

by signal overload is eliminated. Frequency response of both vertical and horizontal deflection amplifiers of the Types 304-H and 304 (See Figures 2 and 3) is down less than 10 percent in amplitude to 100,000 cps; down less than 50 percent to 300,000 cps. Sensitivity of the vertical amplifier is 10 rms millivolts per inch. Sensitivity of the horizontal amplifier is 50 rms millivolts per inch.

Complementing the d-c amplifiers of these instruments are extra-low-frequency sweeps. While the incorporated sweep range of the new Types 304-H and 304 is from 2 to 30,000 cps, sweeps of extremely slow speed, down to ten seconds or more, are available through the use of external capacitance connected between the X-input terminals on the front panel. Both recurrent sweeps, for repetitive phenomena, and driven sweeps, for the

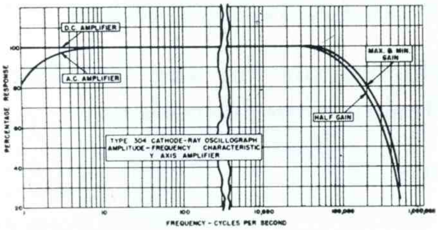


Figure 2. Vertical-amplifier response of the Types 304-H and 304

display of transients or aperiodic phenomena, are provided.

High-frequency components of low-frequency signals may be studied with the Types 304-H and 304 by use of the expandable-sweep feature. Sweeps of these instruments may be expanded to as much

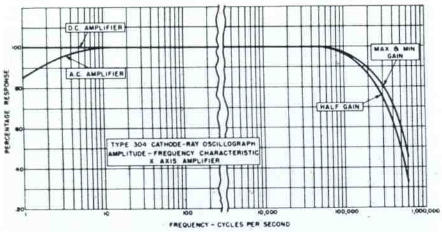


Figure 3. Horizontal-amplifier response of the Types 304-H and 304

as six times full-screen diameter, and the positioning circuits have sufficient range that any portion of the fully expanded trace may be centered on the screen. (See Figures 4, 5, and 6). On the vertical axis, any portion of deflections up to four-times full-screen diameter may be centered on the screen. Even at maximum expansion, there is no distortion present.

Sync-limiting circuits are provided in the Types 304-H and 304, rendering it impossible to apply excessive synchronizing voltage to the sweep generator. As a result, sweep length and synchronization are not affected by variations in signal level (See Figure 7). Both sync amplification and polarity selection are provided.

The intensity of the fluorescent trace may be modulated on these instruments to obtain reference markers indicating time, distance, angle, or other quantity, by applying a brilliance-modulation signal to the Z-axis input terminal at the front panel (See Figure 8).

Two test signals are available at terminals on the front panel of the Types 304-H and 304: A signal of line frequency at approximately 0.5 rms volt amplitude, and a sawtooth signal of approximately 7.5 volts peak amplitude, at the frequency of the time-base generator. The sinusoidal test signal is extremely useful in checking the operation of electronic circuits. The sawtooth signal may be used to provide a sweep for another oscillograph. Also, this signal may serve to trigger a phenomenon so that it occurs in synchronization with the sweep of the oscillograph. For this purpose, the sawtooth signal may first be differentiated, in which case, the phenomenon will be

Figure 4. Oscillogram of the voltage in the vicinity of a fluorescent lamp, photographed from the screen of the Du Mont Type 304-H

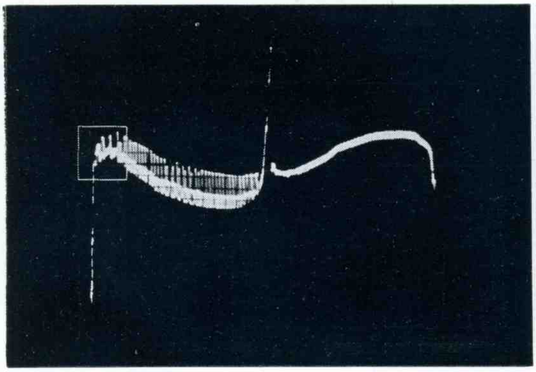
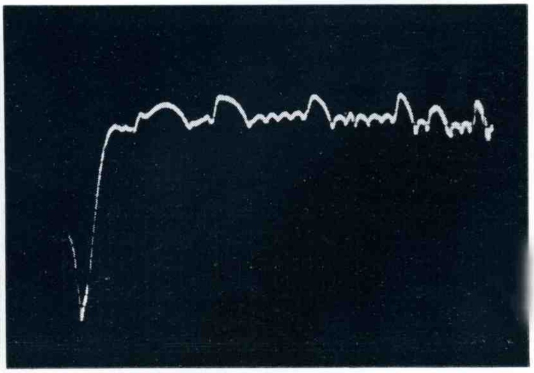


Figure 5. Portion of pattern outlined by box on Fig. 4, expanded to full-screen diameter, for the study of high-frequency components



triggered during the return time of the trace; or the phenomenon may be arranged to trigger when the sweep voltage rises to a predetermined level, so that the initiation of the phenomenon is delayed until a given time after the beginning of the sweep.

Additional features include a Mu-metal magnetic shield to protect the cathode-ray tube from the effects of external magnetic fields; a Du Mont Type 2501 Bezel for attaching such convenient accessories as the Du Mont Types 314-A or 271-A Oscillograph-record Cameras, the Du Mont Type 216 series of light filters, or the Du Mont Type 276 Viewing Hood; and a rigidly mounted, engraved calibrated scale, made of ⅛-inch plastic, to aid making quantitative measurements.

The Du Mont Types 304-H and 304 are identical, except for the accelerating potentials applied to their Type 5CP-A Cathode-ray Tubes (See Figures 9 and 10). In the Type 304, an accelerating potential of 1780 volts is employed; in the Type 304-H an additional power supply increases this to 3000 volts. The higher potential employed in the Type 304-H facilitates the use of long-persistence screens, so that fullest possible advantage may be taken of the low-frequency recurrent and driven sweeps, the high-speed driven sweeps, and the d-c amplifiers of the instrument.

WRITING RATES — The maximum photographic writing rates of the Type 304, with 1780 volts accelerating potential, are: 0.05 inch per microsecond with the Du Mont Type 271-A Oscillograph-record Camera, 0.09 inch per microsecond using the Du Mont Type 314-A Oscillograph-record Camera with f/2.8 lens, and 0.4 inch per microsecond using the Type 314-A, with f/1.5 lens. Due to the increased accelerating potential of the Type 304-H, that instrument's photographic capabilities are almost ten times greater than those of the Type 304. The writing rates that may be recorded from the Type 304-H, with 3000 volts accelerating potential are: 0.4 inch per microsecond with the Type 271-A, 0.8 inch per microsecond using the Type 314-A, with an f/2.8 lens, and 2.8 inches per microsecond using the Type 314-A with an f/1.5 lens.

DEFLECTION AMPLIFIERS — While the high-frequency response and sensitivity of the Type 208-B were considered adequate for a general-purpose oscillograph, it was felt that, for greatest possible versatility, high-gain d-c amplifiers should be incorporated in the new Types 304-H and 304.

One of the greatest problems encountered in the design of such d-c amplifiers for oscillographic applications is to achieve the required high degree of stability with respect to both zero level and sensitivity. Zero-level instability is inherent in d-c amplifiers, since the absence of coupling

Figure 6. Increasing sweep frequency to gain same result as Fig. 5 fails because low-frequency components of signal obscure the pattern

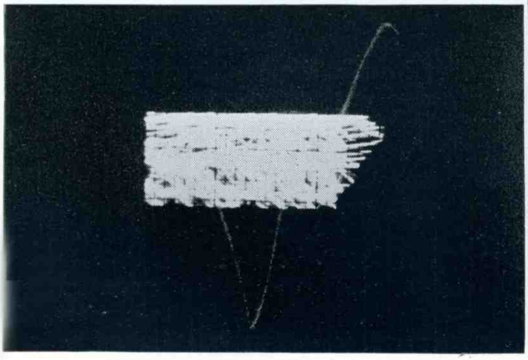
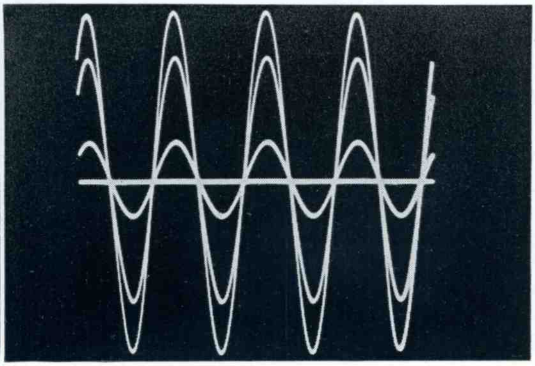


Figure 7. Multiple exposure of sine-wave at 3 settings of vertical gain. Note that synchronization and sweep length remain constant at all settings.



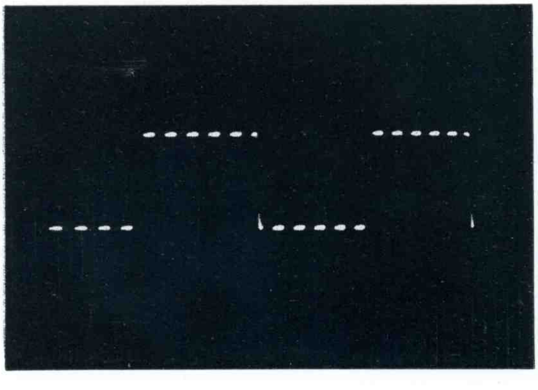
capacitors results in the amplification of slight zero-level instabilities arising in the early stages. These instabilities are caused by such conditions as variations in line voltage, microphonics, and the heating and aging of tubes and other components. The first two conditions are generally responsible for short-duration instabilities, or "jitter", while the last causes drift.

Zero-level stability can be achieved in a d-c amplifier through the use of extremely well regulated, high-power-capacity power supplies; carefully selected and matched precision components; and by making the majority of the components adjustable to compensate for temperature changes, variations in tube characteristics, and so forth. In addition to the fact that such an amplifier is inconvenient, since it requires a waiting period of several hours after each start, to reach operating temperature before adjustments can be made, the cost of such an amplifier would place an oscillograph using it well beyond the low-price range.

Another, more practical approach to the problem, and one which has met with considerable success in the Du Mont Types 304-H and 304, is to design the amplifier in such a way that all variables are automatically compensated or corrected.

This method of achieving stability, as employed in the Types 304-H and 304, includes the use of balanced amplifiers throughout, to avoid instabilities due to

Figure 8. Oscillogram of a 10-kc square wave, intensity-modulated by a 110-kc signal, photographed from the screen of the Type 304-H



line-voltage variation; the use of various types of negative feedback to permit the relaxation of tolerances of components; and provision for automatic correction of amplifier gain to neutralize the effects of changes in sensitivity of the cathode-ray tube as a result of fluctuations in line voltage.

A conception of the amount of feedback employed to achieve the high degree of stability found in the d-c amplifiers of the Types 304-H and 304 may be gathered from the fact that, while the vertical amplifier circuit, consisting of four twin triodes and two pentodes, has a potential gain of approximately one million, all but 0.02 percent of this gain is fed back, leaving an actual gain of approximately 2000 at the output of the amplifier.

Instabilities due to heating and aging of components have been minimized in these new instruments by good ventilation of the cabinet, and microphonics have been reduced well below the tolerable limit by shock-mounting (See Figure 11).

VERTICAL-DEFLECTION AMPLIFIER — As seen from Figure 12, the vertical amplifier in the Types 304-H and 304 is preceded by a stepped, compensated attenuator, which provides coarse amplitude control at attenuation ratios of 1:1, 10:1, 100:1, and 1000:1, working into a balanced cathode follower, V1. This is necessary, since good high-frequency response must be maintained, with a high-impedance input. A low-resistance potentiometer, R4, in the output of the cathode follower provides fine amplitude control with no frequency discrimination.

With no signal applied, the voltages at both ends of R4 are equal, and no change in reference level is observed on the cathode-ray-tube screen as the Y-amplitude control is varied. However, due to variations in tube characteristics and components, resulting from aging, changes in temperature, and so on, the voltage at the ends of R4 may become unequal, and a shift of d-c level will then be noticeable as R4 is varied. To compensate for this, R3, the d-c balance adjustment, is provided. This may be adjusted occasionally to equalize the potential at both ends of R4. R3 is accessible as a screwdriver adjustment at the front panel.

It is extremely important that the cathode-follower tube at the input of the amplifier be free of gas, since a gaseous tube would result in grid current flowing in the high-impedance grid circuit. This would set up a d-c level at the grid of the input tube which would vary in amplitude as the value of resistance in the grid circuit was changed, both with changes in attenuator setting and in input impedance. This variation in d-c level at the input cathode follower would be amplified and reproduced at the amplifier output, causing an undesirable spurious shift of the reference axis on the cathode-ray tube. If a replacement tube should be found gaseous, the fault can usually be reduced to negligible proportions by aging the input tube in an active circuit, as, for example, the oscillograph itself, with the plate drawing current. A six-hour aging period is usually sufficient.

R1, in series with the Y-amplitude control, prevents on-screen overload by making it impossible to apply a very large signal to the input, while subsequently turning the gain down in order to get on-screen deflection. The stepped attenuator must be employed before such a signal can be brought onto the screen.

The balanced arrangement of the amplifier circuit prevents variations in line voltage from effecting the reference level, since such variations produce equal changes in voltage at both ends of R4.

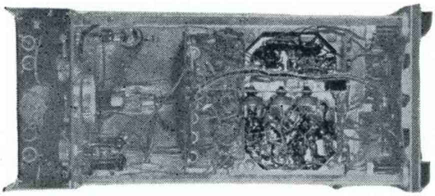


Figure 11. Shock-mounted chassis in the Types 304-H and 304

Vertical positioning of the fluorescent pattern is accomplished by varying the potentiometer, R5, which varies the d-c level at the plates of V2. When the arm of this potentiometer is at the center of its traverse, the trace should be at the vertical center of the cathode-ray-tube screen. This condition may be fulfilled by setting the factory adjustment, R6. This positioning circuit has sufficient range that any portion of a vertical deflection of four times full-screen diameter may be centered on the screen. It will be noticed that each of the three triodes following the cathode follower have common cathode resistors. These provide degeneration to aid in the maintenance of stability.

Resistors R6, R9, and R10 in the Y-position balance circuit are attenuators, which balance mismatched tube sections.

The sensitivity of this amplifier may be varied by means of the factory adjustment R7, which provides a variable shunt

Figure 9. High-speed transient in the form of damped oscillation, recorded with 1780-volt accelerating potential. Compare with Fig. 10

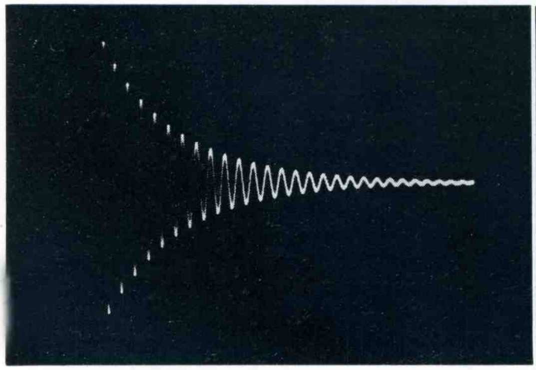
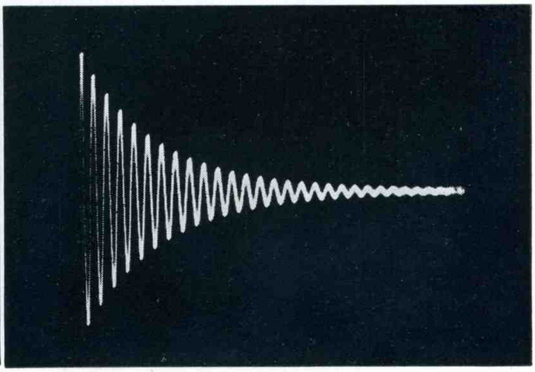


Figure 10. Waveform similar to that of Fig. 9. Increased accelerating potential of Type 304-H (3000 volts) rendered the entire pattern visible



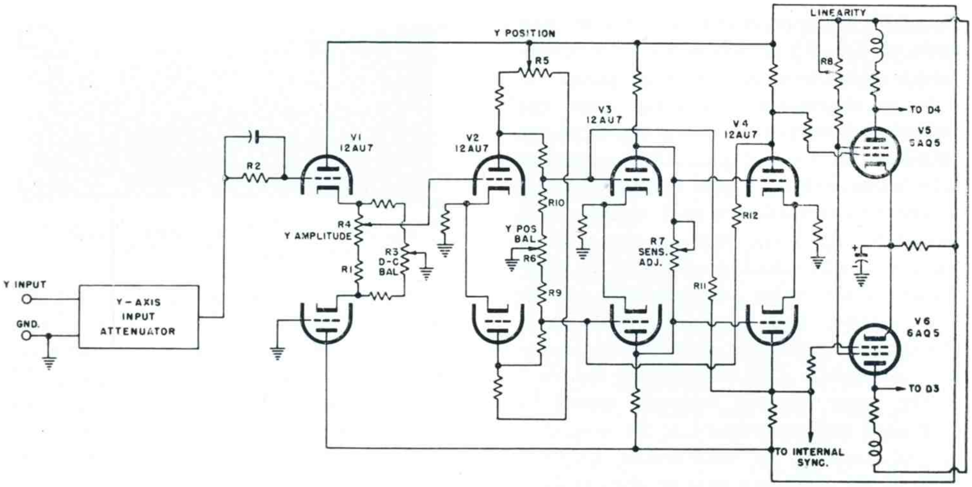


Figure 12. Simplified schematic of vertical amplifier of Types 304-H and 304

between the push-pull plates of V3. Thus the instrument may be compensated for any variations in sensitivity arising over a period of time, due, for example, to the aging of tubes.

Resistors R11 and R12 in the circuit of V4 are arranged in a form of negative feedback to balance mismatched tube sections, and to extend the high-frequency response limit of the amplifier.

The final stage of the Y-axis amplifier employs two Type 6AQ5 pentodes. The screen grids of these pentodes are operated from the unregulated power supply, so that the sensitivity of this stage rises and falls with increased or decreased line voltage. This tends to compensate for variation in sensitivity of the cathode-ray tube caused by variations in line voltage.

Adjustment of linearity of voltage response is provided by the potentiometer, R8, a variable screen-dropping resistor. Should the sensitivity of the amplifier be greater at the top and bottom of the cathode-ray-tube screen than at the middle, linearity of response may be restored by decreasing this resistance; similarly, should the sensitivity at the center of the cathode-ray-tube screen be greater than that at top and bottom, this resistance may be increased to correct the situation. Thus, the linearity of voltage response of these new oscillographs can be maintained at an unusually high level for oscillographs of their price range.

The excellent characteristics of this amplifier make it extremely well suited for use as a general-purpose amplifier around the laboratory. Its output is available at the terminal board at the rear of the instrument (See Figure 15), and it may be used to drive any high-impedance load.

Figure 13. Right-side view of Type 304 with cabinet removed.

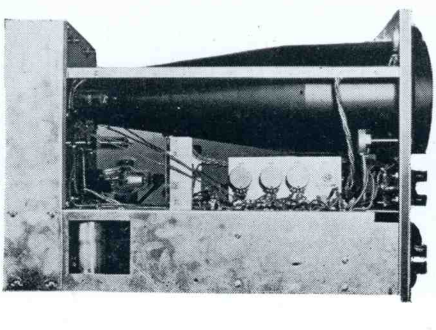
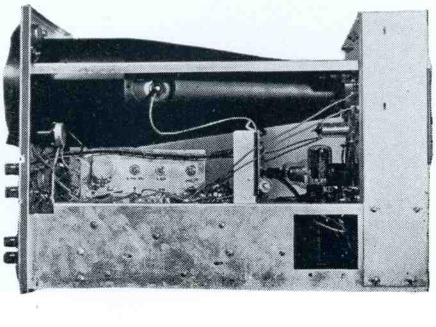


Figure 14. Left-side view of Type 304 with cabinet removed.



Signals for vertical deflection may be connected also directly to the deflection plates of the cathode-ray tube, through the rear terminal panel. The deflection factor with direct connection is 18 rms volts per inch. When applying a signal through the rear terminal panel, the Y-selector switch is placed on the OFF position. This removes any signal from the grid of the amplifier, and at the same time, grounds the grid without affecting the input impedance as "seen" by the input terminals at the front panel. Thus connection may be made to the rear terminal panel without disturbing leads to the front-panel input terminals.

HORIZONTAL DEFLECTION — Either the internally generated sweep voltage or an external signal may be used for deflection along the horizontal axis of the Du Mont Types 304-H and 304. In addition, connection may be made directly to the deflection plates through the rear terminal panel (See Figure 15) for application of signals beyond the frequency range of the amplifier. The deflection factor with direct connection is 21 rms volts per inch. When connection is made directly to the deflection plates, the X-selector switch is

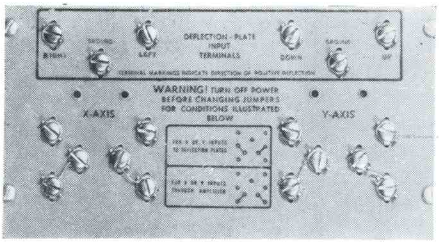
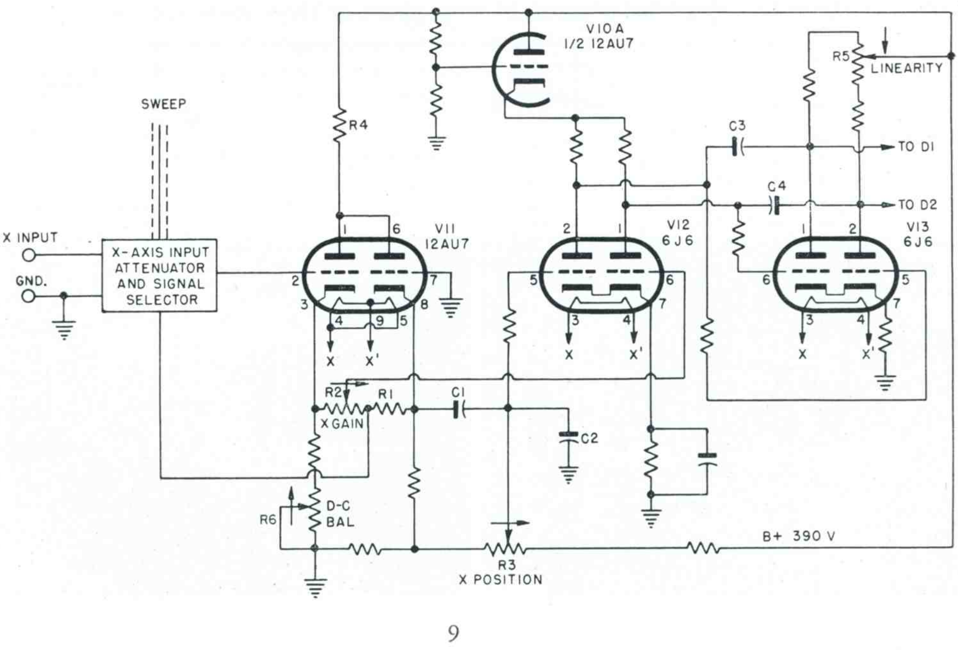


Figure 15. Rear terminal panel of the Types 304-H and 304

set to the OFF position, which, as in the case of the Y axis, grounds the grid of the amplifier without affecting the input impedance.

The X-amplifier circuit is basically similar to that of the Y-amplifier. The primary difference between them is that the X-amplifier is less sensitive, having a gain of approximately 400. However, it will be noticed from Figure 16, that the input cathode-follower circuit is considerably more complex than that of the Y amplifier. This is due to the fact that the X amplifier must have provision for switching from sweep input to external-signal input; and it must also have provision for elimination of on-screen overload from external signals, but must be

Figure 16. Simplified schematic of horizontal amplifier of Types 304-H and 304



capable, on the other hand, of allowing reduction of the sweep amplitude to zero.

Resistor R1, a vernier attenuator limiter, prevents the gain being turned down to zero, to eliminate on-screen saturation. This resistor is shorted out when the X-axis selector switch is in either the recurrent or driven sweep position, so that sweep amplitude may be reduced to zero.

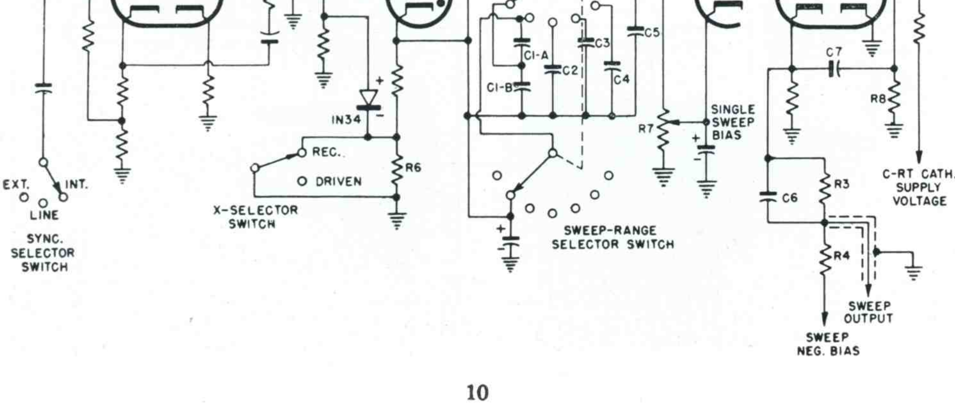
Horizontal positioning is accomplished by potentiometer R3. This potentiometer is returned to a point between the cathode of V11b and ground, so that the voltage of V12b can be varied symmetrically above and below the cathode voltage of V11b. If the potentiometer were returned to the cathode instead of to its actual location, horizontal positioning in only one direction would be possible. If, on the other hand, it were returned to ground, variations in line voltage would deposition the sweep horizontally by several screen-diameters. Situated as it is, variations in line voltage produce about the same variations in voltage at both grids of V12, the first stage of amplification.

It will be noticed that the horizontal d-c balance adjustment, R6, which serves a function similar to that of the vertical d-c balance adjustment, is wired as a rheostat, rather than as a potentiometer, to prevent interaction with the X-position voltage.

A small portion of the signal applied to V11 appears at the pin-8 cathode of V11. About 10 per cent of the low-frequency components of the signal at the pin-8 cathode is lost through the resistance divider network before reaching the pin-5 grid of V12. To avoid frequency discrimination, the capacitive divider comprising C1 and C2 is added, which eliminates 10 percent of the high-frequency components. Additional improvement of frequency response is achieved by supplying the two halves of the cathode follower, V11, from a common plate resistor, R4. This resistor produces a signal at the pin-8 cathode which is almost equal in amplitude, and opposite in phase, to that which already appears at that point as a result of its connection to the other cathode of V11; a cancellation of voltages results. This assures good high-frequency response at the low end of the X-amplitude control.

V10a is a voltage dropper for V12, and provides approximately 110 volts on the plates of V12. This cannot be a regulated voltage, but it must be proportional to line voltage at all times. Using a cathode follower for this purpose not

Figure 17. Simplified schematic of sweep circuit of Types 304-H and 304



only saves 10 watts power as compared to a voltage divider of equal output impedance, but also makes the divided voltage independent of the plate current in V12, owing to the low dynamic output impedance of a cathode follower.

Good linearity of voltage response is maintained by the potentiometer, R5, a factory adjustment, which arranges the resistance between the load resistors in the two phases of the output stage in such a way as to compensate for variations in characteristics between the two sections of the output tube. Capacitors C3 and C4 provide positive feedback to neutralize the input capacitances of V13, and thus extend the high-frequency response of the amplifier to nearly 500 kc, even though the amplifier is rated at 300 kc.

The high gain and high voltage-out-put ability of the horizontal amplifier permits expansion of the sweep up to six times full-screen diameter. The horizontal positioning circuit has sufficient range that even at maximum expansion, any portion of the sweep may be centered on the screen.

SWEEP CIRCUIT — Sweeps of the Du Mont Types 304-H and 304 are variable from 2 to 30,000 cps. Voltage for sweep deflection is generated by the Du Mont Type 6Q5G gas triode, V8. (See Figure 17). Due to the unique design of the time-base generator (as discussed below), the major objections to a gas-tube sweep circuit have been successfully overcome. Thus it became feasible to use the less expensive (as compared to a high-vacuum circuit) gas-triode sweep generator without appreciable sacrifice in performance. Coarse frequency control is provided by the capacitors C1 to C5, selectively connected in parallel. Fine frequency control is accomplished by the potentiometer, R2, the sweep vernier. The output of the sweep generator is coupled directly to an output cathode-follower stage. This cathode follower serves to isolate the sweep generator, and still maintain d-c coupling. From the cathode follower, the sweep voltage is applied to a compensated attenuator made up of capacitor C6 and resistors R3 and R4. Here, the output signal is reduced to approximately 20 percent of its original value. The lower end of this attenuator is returned to an adjustable negative bias, which brings the average level of the attenuated sweep to zero, so that equal expansion from both sides of the center of the cathode-ray-tube screen will be observed as the sweep amplitude is increased. The sweep signal is fed from the attenuator to the horizontal amplifier, providing the input selector switch is on one of the sweep positions.

V10b is a charging-amplitude limiter for the sweep capacitors, and operates only on the driven sweep position. It prevents the Type 6Q5G from firing without a synchronizing signal. R7 is a

Figure 18. Random vibration of metal beam, displayed on Type 304-H, operating on driven sweep. Note that entire signal is recorded on trace

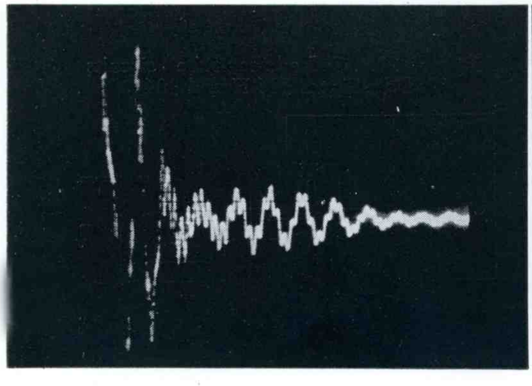
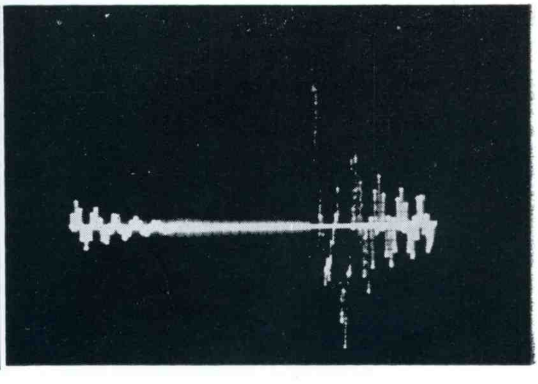


Figure 19. Vibration similar to that of Fig. 18, displayed on recurrent sweep. Phenomenon begins toward end of trace, with much of signal lost



factory adjustment which varies the bias at the cathode of V10b, so that the thyratron will trigger at the proper level of synchronizing voltage.

Return-trace blanking is accomplished by means of a series of negative pulses, occurring during the time of the sweep return, which are applied to the cathode of the cathode-ray tube. These pulses are amplified and clipped by V9b, and then applied as positive, rectangular pulses to the cathode of the cathode-ray tube. This action occurs when the instrument is operating on either recurrent or driven sweep. Thus, at no time is the return trace visible.

SYNCHRONIZATION — The sweep generator of the Du Mont Types 304-H and 304 may be synchronized by the signal applied to the Y-axis input terminal, by an external signal, or by an internally supplied voltage of powerline frequency. V7a is employed as a unity-gain phase splitter, so that from its cathode load, synchronizing signals of the same polarity as that of the input signal may be derived, while from its plate load, signals of the opposite polarity may be taken. V7b is a sync amplifier with a center-tapped gain control, R5, which permits selection of either polarity of sync signal.

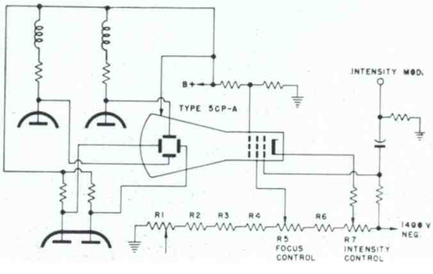
The Type 1N34 crystal-diode connected between the grid and cathode of V8 prevents over-synchronization almost entirely, by limiting the sync-signal amplitude to about 0.2 volts on recurrent sweep, and to about 4 volts on driven sweep. In addition, it acts as a d-c restorer on the grid of the sweep-generator tube, preventing any decrease in grid bias due to ion current, especially at high sweep frequencies. Decreasing grid bias would result in shortening the sweep length as an inverse function of sweep frequency until a final collapse occurred at approximately 50 kc, as it does in most conventional thyratron sweeps.

EXTRA-LOW-FREQUENCY SWEEPS — With the sweep selector switch in the EXT CAP position, sweeps of extra-low frequency are possible, by attaching an external capacitor between the X-input terminals. Driven sweeps of 0.5-second duration, or recurrent sweeps of 0.5 cps, for each microfarad of external capacitance are possible. The only limitations on the slowness of sweeps thus available are that of securing sufficiently large capacitors with sufficiently low leakage, and the practical limit imposed by leakage in the circuits of the oscillograph.

DRIVEN SWEEPS — With the X-selector switch on the driven sweep position, the bias at the cathode of V8 is increased by the addition of resistor R6 to the cathode circuit. Thus plate of the gas-filled triode must reach a higher potential before it can conduct. V10, connected as a diode, does not permit the thyratron plate to reach the potential necessary for conduction. However, when a positive pulse of sufficient magnitude is applied from the sync amplifier to the grid of V8, the firing potential of V8 is reduced sufficiently to permit conduction. When this occurs, the sweep capacitor immediately discharges until the plate of V8 drops to the extinction point. Conduction ceases and the capacitor again begins to charge and stand ready to produce another single sweep upon the arrival of another sync pulse.

CATHODE-RAY-TUBE CIRCUITS AND POWER SUPPLIES — The voltages required for the cathode and first anode of the Type 5CP-A Cathode-ray Tube are obtained from the voltage divider made up of R1, R2, R3, R4, R5, R6, and R7 (See Figure 20). Intensity and focus are controlled by the potentiometers R7 and R5 respectively. Interdependency between focus and intensity

Figure 20. Cathode-ray-tube circuits of the Types 304-H and 304



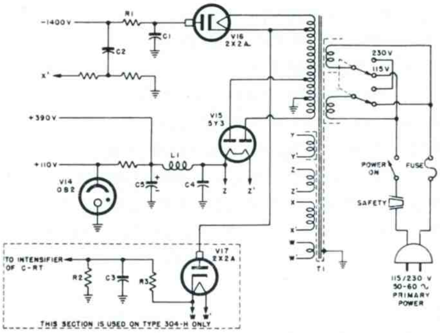


Figure 21. Schematic of power supplies of the Types 304-H and 304

controls, inherent to some degree in all electrostatically focused cathode-ray tubes, is minimized in the Types 304-H and 304 through the use of a cathode-ray tube having a "zero-first-anode-current" electron gun, and of a high-current bleeder in the high-voltage power supply.

Voltages to operate the cathode-ray tube are obtained from the high-voltage power supply, (See Figure 21) which consists of a half-wave rectifier, V16 whose output is filtered by the resistance-capacitance filter, C1, R1, and C2.

The additional accelerating potential for the Type 304-H is supplied by the half-wave rectifier, V17. The filter for this additional supply comprises R3, C3, and R2, which is the bleeder across the filter capacitor.

LOW-VOLTAGE POWER SUPPLY — The low-voltage power supply of the Du Mont Types 304 and 304-H consists of the full wave rectifier, V15, and the capacitance-input filter, C4, L1, and C5. The output of this system is regulated by V14. This supply furnishes approximately 390 volts with sufficient current to supply all tubes of the instrument. A regulated output potential is also taken from the low-voltage power supply to aid in the stability of operation of the instrument.

APPLICATIONS — The Du Mont Types 304-H and 304 were designed to serve over the broadest range of applications possible with a low-priced, portable oscillograph. They are extremely well suited for a great variety of applications in the laboratory and in the field. Bridge measurements, observation of wave forms in electronic circuits, time and amplitude measurements of electrical impulses, studies of light, sound and other such phenomena, biological studies, and such mechanical applications as studies of vibration, motor bearing noise, stress and strain, dynamic balance, camera and synchronizer operation are but a few examples.

The extra-low-frequency sweeps and the d-c amplifiers of the Types 304 and 304-H make them extremely well suited to such applications as studies of variations of pressure or volume plotted as a function of time. The oscillogram of Figure 22 is an interesting indication of the variation of volume of liquid in a

Figure 22. Indication of variations in volume of liquid in a retort. Signal, applied through d-c amplifiers, was displayed on 10-second sweep

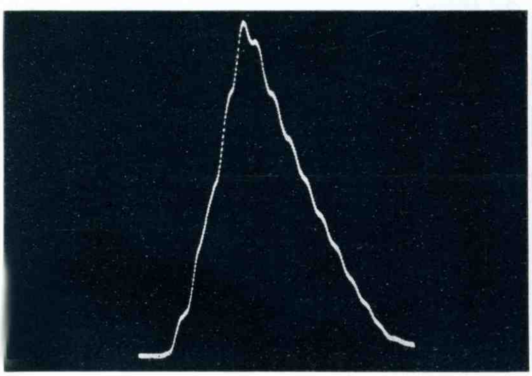
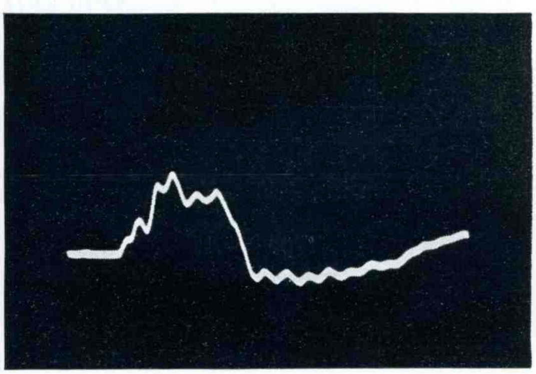


Figure 23. Same phenomenon as Fig. 22 with signal applied through a-c amplifier. Here, quantitative measurements are obviously impossible.



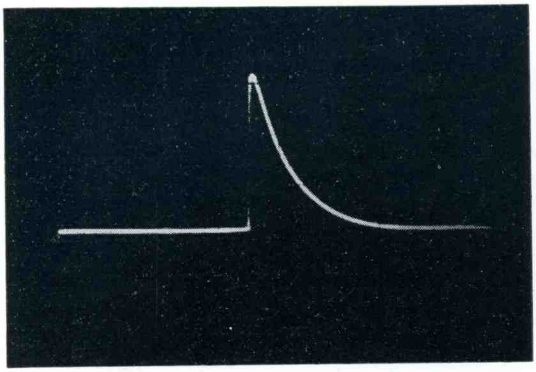


Figure 24. Nerve potential, photographed from screen of Type 304-H

retort. It was plotted on a 10-second sweep, with the signal applied through the d-c amplifiers of the Type 304-H. The importance of d-c amplifiers to such applications may be seen from the oscillogram on Figure 23. Here, a signal similar to that of Figure 22 was passed through the a-c amplifier. This oscillogram clearly is useless for any quantitative measurements.

The Type 304-H or 304 is extremely useful as an aid in designing a piece of special equipment. It is important that no component be overrated; otherwise failure may result. Yet it is not desirable to underrate the components, as this would add unnecessarily to the size, weight, and cost of the unit. The direct-coupled amplifiers of these oscillographs make possible a quick check of the peak voltage across each component, which is especially useful when the voltage is made up of a complex a-c component superimposed on a d-c component.

The high-gain of the Y amplifier makes the instrument useful as a low-impedance ammeter in examining quantitatively even the most complex current waves by inserting a series resistor and observing the voltage across the resistor. Since the instrument has .028 volts peak-to-peak per inch sensitivity, a 28-ohm resistor will result in a sensitivity of one milliampere per inch on the cathode-ray tube.

Another application requiring many of the features of the Types 304-H and 304 is the observation of nerve potentials. The sawtooth test signal, differentiated, may be used to trigger, or may constitute the stimulating pulse. And since the nerve is usually stimulated only once every few seconds, a triggered sweep must be used. Sweeps of 10 seconds or more must be employed if the time required for the nerve to transmit the stimulus is to be observed. Because of the low level of the signals, and the long time duration of the pulse, a high-gain d-c amplifier is required. While the gain of the Types 304-H and 304 may not be sufficient for some biological applications, the characteristics of this amplifier greatly simplify the problems of designing a satisfactory preamplifier for such specialized applications.

Mr. M. Maron, Engineer with the Instrument Engineering Section, Instrument Division, Allen B. Du Mont Laboratories, Inc., is the designer of the Du Mont Types 304-H and 304 Cathode-ray Oscillographs.

SPECIFICATIONS

CATHODE-RAY TUBE

Type 5CP-A

Accelerating Potentials: Type 304

E_{b2}+1600 V with respect to cathode

Intensifier+1780 V with respect to cathode

Type 304-H

E_{b2}+1600 V with respect to cathode

Intensifier+3000 V with respect to cathode

Y AXIS

Deflection Factor

Direct .... 18 rms volts/inch ±17%

Amplifier

Y Attenuator at 1:1, Y Amplitude Maximum. 10 rms millivolts/inch.

Y Attenuator at 1:1, Y Amplitude Minimum. 115-190 rms millivolts/inch.

Frequency Response	*d-c Amplifier*	*a-c Amplifier*
10% Response Pt.	100 kc	100 kc

50% Response Pt. 300 kc 300 kc
Maximum Input Potential .. 1000 volts peak

Input Impedance:
- Direct
  - Balanced .... 3 meg; 20 μμf
  - Unbalanced .... 1.5 meg; 20 μμf
- Amplifier .... 2 meg; 50 μμf

X AXIS

Deflection Factor
- Direct .... 21 rms volts/inch ±17%
- Amplifier
  - X Selector at 1:1, X Amplitude Maximum. 0.05 rms volts/inch.

Frequency Response	*d-c Amplifier*	*a-c Amplifier*
10% Response Pt.	100 kc	100kc
50% Response Pt.	300 kc	300 kc

Maximum Input Potential .. 1000 volts peak

Input Impedance:
- Direct
  - Balanced .... 3 meg; 20 μμf
  - Unbalanced .... 1.5 meg; 20 μμf
- Amplifier .... 2.2 meg; 50μμf

LINEAR TIME BASE — RECURRENT SWEEP AND DRIVEN SWEEP

Gas Triode .... Type 6Q5G

Sweep Frequency Range .... 2 to 30,000 cps with provision for connecting external capacitor for lower frequency sweeps (.5 sec. sweep per microfarad)

Expandable Sweep:

The sweep of this instrument is expandable to an equivalent of six times the full screen diameter of the cathode-ray tube; and the positioning circuits are broad enough to examine any portion of the sweep on the screen without distortion. The expanded sweep is capable of a sweep writing rate of one inch per microsecond, or faster.

INTENSITY-MODULATION CIRCUIT

Input Impedance .... 0.2 meg, 80μμf

Sensitivity .... 15 volts peak to blank the beam at normal intensity setting

TEST SIGNALS

Line Frequency Test Signal — A test signal of approximately .5 rms volts at the power-line frequency is available at a front-panel terminal.

Sawtooth Test Signal — A sawtooth test signal at about 7.5 volts peak at 47k output impedance at the frequency of the time-base generator is available at a front-panel terminal.

POSITIONING AND UNDISTORTED DEFLECTION

The d-c positioning system is such that even with 4 times full-screen expansion on Y axis, any portion of pattern may be centered on the screen; for X-axis deflection, with 6 times full screen expansion, any portion of the trace may be centered on the screen.

Even at maximum expansion, there is no on-screen distortion present.

POWER SUPPLY

Primary Power Potential: 115 or 230 rms volts ±10%

Frequency .... 50-60 cycles

Power Consumption .... 100 watts approx.

Fuse Protection .... 1.5 ampere

TUBE COMPLEMENT

8-12AU7; 2-6AQ5; 1-6Q5G; 1-0B2; 2-6J6; 1-5Y3; 1-2X2A; 1 additional 2X2A for Type 304-H.

PHYSICAL SPECIFICATIONS

Height ...... 13¼″ Depth ...... 19″
Width .... 8⅝″ Weight .... 50 lbs.

Cat. NO.	*Type No.*	*Description*		*Price*
1490-A	304-H	Type 5CP1-A;	115V,50-60 CPS	$307.50
1493-A	304-H	Type 5CP7-A;	115V,50-60 CPS	307.50
1494-A	304-H	Type 5CP11-A;	115V,50-60 CPS	307.50
1495-A	304-H	Type 5CP1-A;	230V,50-60 CPS	307.50
1498-A	304-H	Type 5CP7-A;	230V,50-60 CPS	307.50
1499-A	304-H	Type 5CP11-A;	230V,50-60 CPS	307.50
1336-A	304	Type 5CP1-A;	115V,50-60 CPS	285.00
1340-A	304	Type 5CP11-A;	115V,50-60 CPS	285.00
1341-A	304	Type 5CP1-A;	230V,50-60 CPS	285.00
1345-A	304	Type 5CP11-A;	230V,50-60 CPS	285.00

THE MEN BEHIND OUR PRODUCTS

Melvin B. Kline, head of the Development Engineering Section of the Instrument Division, was born in Cambridge, Mass. in 1919. He received a degree of Bachelor of Science in Physics from the College of the City of New York, in January, 1941, and has since done graduate work at Columbia University and Polytechnic Institute of Brooklyn.

Mr. Kline joined the engineering staff of Allen B. Du Mont Laboratories, Inc. in 1941. For the past several years he has served as Head of Development Engineering, and has been directly responsible for the design of many Du Mont instruments, including the Type 256-D Cathode-ray Oscillograph, and the Type 279 Dual-Beam Cathode-ray Oscillograph. During the war, he worked on Loran and Radar indicators. After regular hours, during this period, he also served at Du Mont's New York television station, WABD, as a Video Control and Master Control Engineer.

Mr. Kline has taught television servicing and cathode-ray oscillography in addition to television station operation.

Emil G. Nichols, Instrument Sales Manager of Allen B. Du Mont Laboratories, Inc. was born of Greek parents in Konia, Turkey in 1915. He attended the evening classes of the Newark College of Engineering, graduating with a degree of Bachelor of Science in Electrical Engineering in 1942. From 1933 to 1940 he was employed by the Consolidated Edison Company of New York in their Meter Division. For the following two years, he was employed by the General Electric Company in Bloomfield, New Jersey in their Test Department.

In 1942 Mr. Nichols was commissioned Ensign in the United States Naval Reserve and served on active duty until the end of 1945. After basic training at Rhode Island, Mr. Nichols served as an instructor in radar courses being given at Harvard University by the Army and Navy. He was then transferred to the Radar Maintenance School at Pearl Harbor. Since returning to inactive duty as a Lieutenant in the Naval Reserve in January, 1946, Mr. Nichols has been associated with the Allen B. Du Mont Laboratories, Inc. first in the capacity of Technical Sales Engineer, and later as Technical Sales Manager.

William Scharpwinkel, Head of Instrument Production Control, was born in Elberfeld, Germany, in 1904, and entered the United States in 1907. Mr. Scharpwinkel first became interested in radio while attending public school in Galveston, Texas. He subsequently took special courses in radio, and received his commercial radio operator's license in 1920. Active in the early radio amateur movement, he was instrumental in setting up a network of amateur stations along the Gulf coast.

In 1942, Mr. Scharpwinkel entered the Signal Corps in a civil capacity. After several courses in radar, he was placed in charge of various radar installations on the Pacific Coast until the beginning of 1944. Following this, he served the War Department as a Radar Inspector and Maintenance Coordinator.

Mr. Scharpwinkel joined Allen B. Du Mont Laboratories, Inc. in 1946, where he was first engaged in the redesign of television cameras and related equipment. Following this, he transferred to the Instrument Division. When the various divisions of Allen B. Du Mont Laboratories were decentralized, he assumed his present capacity of Head Instrument Production Control with supervision of the Planning, Purchasing, and Material Control Departments.

J. W. Ackerman, Head of the Instrument Quality Control Department, was educated in Passaic Public Schools. He attended the United Radio and Television School of Newark, and Newark College of Engineering.

From 1941 to 1944 Mr. Ackerman was employed by Foote Pierson & Company, where he was in charge of electrical testing of aircraft receivers and transmitters.

In 1944, Mr. Ackerman enlisted in the Naval Reserve, and after one year of training in the Naval Radio & Radar School, he was assigned to an Electronic Repair Ship, Electronic Repair Division, in the South Pacific.

Upon discharge from the Naval Reserve Mr. Ackerman returned to Foote Pierson in their development engineering model shop.

In January 1948, he joined the Engineering Department of Du Mont's Instrument Division, and later became part of the Factory Engineering. Mr. Ackerman is now in charge of the Instrument Quality Control Department.

AN EXPERIMENTAL ILLUMINATED DATA CARD

(*Continued from Page 2*)

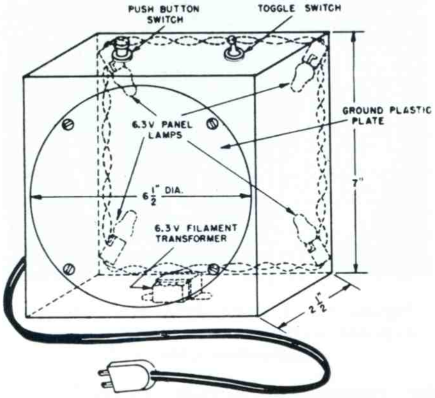


Figure 2. Diagramatic sketch of the experimental illuminated data card

hind the diffusing plate so that the data may be photographed.

Such a data card is supplied as standard equipment with the Du Mont Type 314-A Oscillograph-record Camera. But there is as yet no such unit for use with the Du Mont Type 271-A Oscillograph-record Camera commercially available. However, the construction of an illuminated data card is a relatively simple matter. An example of such a device, which was built as an experimental model at Du Mont Laboratories, is shown in Figures 1 and 2. The translucent plate in this data card is a disk of ⅛-inch acrylic plastic, 6½ inches in diameter, and smoothly sand-papered on both sides. The illumination box is of folded sheet aluminum, and can be constructed with a minimum of hand work. Four instrument panel lamps powered by a filiment transformer are used for illumination. This data card is equipped with two switches: a push-button for turning on the light momentarily, and a toggle switch for longer exposures, or for use when the shutter of the camera is employed for regulating the exposure.

Use of the Illuminated Data Card — On recordings which do not occupy an entire single frame of a 35-mm film, as is frequently the case, the data may be photographed on the unused portion of the frame. This is accomplished by masking off the greater portion of the illuminated disk, as shown in Figure 3. Information pertinent to the exposure is written on the unmasked portion of the disk. Thus it may be photographed on the film, in the same frame with the oscillogram, by means of a double exposure. The data may be placed in any part of the negative not occupied by the oscillogram, simply by placing the mask in the proper position. If there are more data than can be fitted into the unused portion of the frame, or if the oscillogram occupies the entire usuable area, the data may be printed on an adjacent frame. An example of this is seen in Figure 4.

The illuminated data card also provides a very convenient means for amplitude calibration. By placing a Du Mont Type 2518 Calibrated Scale over the translucent plate, the scale may be superimposed upon the oscillogram by means of a double

Figure 3. Example of data and pattern recorded on a single frame

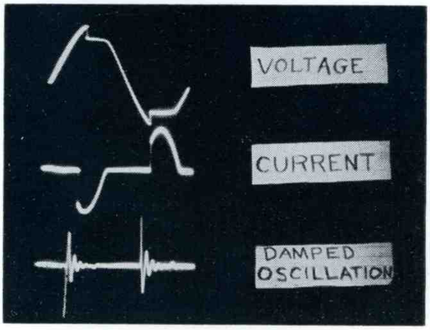
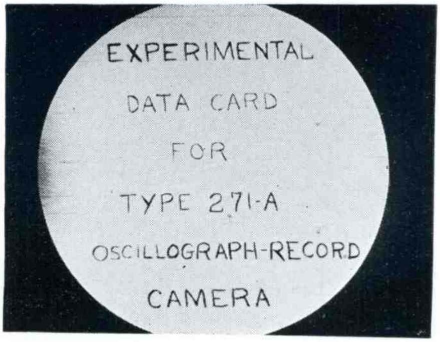


Figure 4. An example of data occupying an entire frame



exposure, as seen in Figure 5. Here, however, care must be taken to avoid overexposing the frame, and thereby losing the detail in the oscillogram. This technique eliminates the necessity for making measurements with calipers or with a calibrated magnifier. In addition, the scale superimposed upon the oscillogram provides a means for determining the degree of magnification of the enlargement, since the original distance between its calibrating lines is accurately known.

The masks used in making the accompanying oscillograms were cut from opaque paper. These suffice for occasional use, but if a mask is to be used frequently, it is more satisfactory to employ one stamped from thin metal.

Exposure Time — The exposure time required for photographing data from the illuminated data card depends, of course, upon the actual construction of the box, the intensity of illumination, and the diffusion surface employed. For the experimental data card described above, satisfactory exposure for most data records was found to be f/8 at ½ second, using Panatomic—X film.

In photographing data from this illuminated data card, it should be remembered that the Type 271-A Camera is a fixed-focus device and is so designed that only the plane in contact with the rubber ring of the barrel is in focus. Therefore, for the data card to be in proper focus, the rubber ring must be placed squarely on

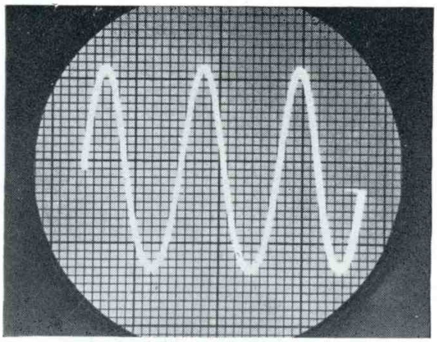


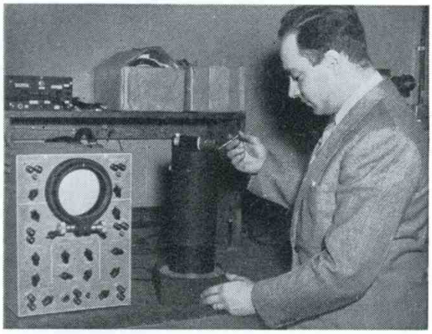
Figure 5. A calibrated scale double-exposed on the pattern by means of the illuminated data card

the translucent surface. However, the depth of field of the camera is sufficient that a thin paper or metal mask may be placed between the barrel and the translucent plate without interferring with the focus.

The illuminated data card described above, was constructed for experimental purposes at Du Mont Laboratories, and has proved itself an invaluable accessory for the Du Mont Type 271-A Oscillograph record Camera. Additional information on its use may be had by writing the Instrument Division, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, New Jersey, or to the Oscillographer at the same address.

Mr. H. P. Mansberg is an engineer with the Applications Section, Instrument Division, Allen B. Du Mont Laboratories, Inc.

Figure 6. To record data on negative, information is written on the translucent plate of the data card with a pencil (left). The camera is then mounted on the data card, and the data recorded, either by opening the camera lens and flashing data-card light, or by turning on light, and tripping the camera shutter.



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VISITORS FROM ABROAD

The Instrument Division of Allen B. Du Mont Laboratories, Inc., has, since the last publication of the *Oscillographer,* had the honor of entertaining the following visitors from abroad:

ir. Ch. Lugt, General Division Manager, N. U. Philips Gloeilampenfabriken, Eindhoven, Netherlands.

Dr. Ram Parshad, House of Dina Nat Chawla Advocate Ferozepore City, East Punjab, India.

Mr. Gunnar Hammerik, Maskin-Aktieselskapet Zeta, Oslo, Norway (Sales representative of The Instrument Division in Norway).

Mr. Romulo O'Farrill, Mexico City Publisher, and associates.

Mr. L. W. Germany, Pye Ltd. Radio Works, Cambridge, England.

BIBLIOGRAPHY

The following bibliography of contemporary publications, prepared from abstract bulletins compiled by Du Mont's Technical Library may be of interest to those engaged in the application of the cathode-ray oscillograph.

OSCILLOGRAPHY

"The Detection by Oscillographic Methods of Winding Failures during Impulse Tests on Transformers," by E. Rippon and G. Hickling in ELECTRICAL ENGINEERS PAPER 824, 10 pages; April, 1949.

"Oscilloscope for Recording Pulses," by Z. G. Kaganov in ELEKTRICHESTVO, No. 1, pp 52-54; January, 1949.

"A Circular Time-Base Frequency Comparator," by T. W. East and A. F. Standing in JOURNAL OF SCIENTIFIC INSTRUMENTS, Vol. 26, No. 7, pp 236-239; July, 1949.

"Shock-Impulsed Spiral Time Base" by G. Rawcliffe in WIRELESS ENGINEER, Vol. 26, No. 310, pp 242-244; July, 1949.

"Use of Cathode Ray Oscillograph in Measurement of Metal Areas and Kinetics of Electrode Reactions," by A. Hutcheon and C. Winkler in CANADIAN JOURNAL OF RESEARCH, Vol. 27, No. 4 (Sec B), pp 353-360; April, 1949.

CIRCUITS

"A Slow Sweep Time-Base," by V. H. Attree in JOURNAL OF THE SCIENTIFIC INSTRUMENTS, Vol. 26, No. 8, pp 257-262; August, 1949.

"A Wide-Range Saw-tooth Generator," by P. G. Sulzer in REVIEW OF SCIENTIFIC INSTRUMENTS, Vol. 20, No. 1, pp 78-80; January, 1949.

"Radio Frequency E.H.T. Supplies," by K. C. Macleod in TELEVISION SOCIETY JOURNAL, Vol. 5, No. 7, pp 201-211; September, 1948.

"Parasitic Oscillations," in WIRELESS WORLD, Vol. 55, No. 6, pp 206-210; June, 1949.

"Cathode Follower Bandwidth," by M. B. Kline in ELECTRONICS, Vol. 22, No. 6, p 114; June, 1949.

"Harmonic Content of Multivibrator Waveforms," by W. C. Vaughan in ELECTRONIC ENGINEERING, Vol. 21, No. 256, pp 214-217; June, 1949.

"Note sur la sensibilite d'un etage amplificateur," by W. Kleen in ANNALES DE RADIOELECTRICITE, Vol. 4, No. 16, pp 136-137; April, 1949.

"A Transistor Trigger Circuit," by Herbert Reich and Robert Ungvary in REVIEW OF SCIENTIFIC INSTRUMENTS, Vol. 20, No. 8, pp 586-588; August, 1948.

"Blocking Oscillators," by W. T. Cocking in WIRELESS WORLD, Vol. 55, No. 6, pp 230-233; June, 1949.

"Audio Sweep Frequency Generator," by G. A. Argabrite in AUDIO ENGINEERING, Vol. 33, No. 5, pp 11-13, 40-41; May, 1949.

"Some Considerations in the Design of Negative-Feedback Amplifiers," by W. T. Duerdoth in ELECTRICAL ENGINEERS PAPER 851, 17 pages; June, 1949.

VACUUM TUBES

"Poisoning in High-Vacuum Oxide-Cathode Valves," by G. Metson and M. Holmes in NATURE LONDON, Vol. 163, No. 4132, pp 61-62; January, 1949.

"Ueber Bariumsulfidschuhten auf Oxydkathoden und deren Einfluss auf die Emission," by H. A. Stahl in SCHWEIZER ARCHIVE, Vol. 14, No. 11, pp 337-343; November, 1948.

"Transit-Time Effects in U.H.F. Valves," by J. Thomson in WIRELESS ENGINEER, Vol. 26, No. 309, pp 192-199; June, 1949.