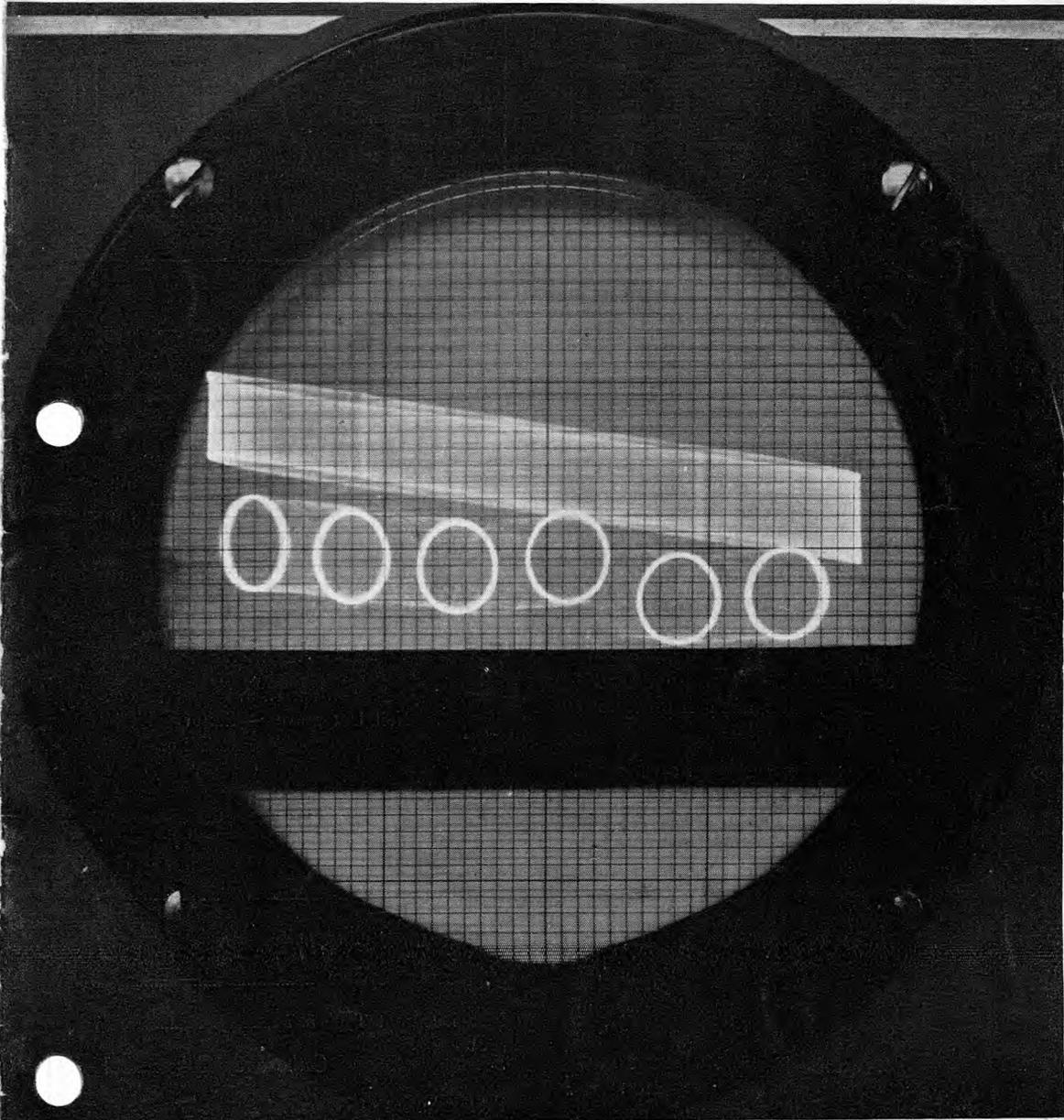


*THE*  
**OSCILLOGRAPHER**



VOL. 15, No. 3

1953



**SIMULATED TANK**

see page 3

stages, including the pre-amplifiers, are a-c regulated to 3% by means of an iron-hydrogen regulator tube.

D-C positioning permits any two-inch portion of a twice full-scale signal to be positioned on the screen without distortion, which is equal to four inches of undistorted deflection. This provides a means for examining and measuring such low-amplitude signal components as over-shoot on a pulse.

For precise voltage calibration, a 0.5 volt p-p square-wave signal, accurate to 2% is produced by internal circuitry, and is made available by a switch on the front panel.

### X-Axis Circuits

The X-axis circuits in this instrument are designed primarily around the sweep circuits. Calibrated sweeps extend from 1 inch per second to 1 inch per micro-second in decade steps. Multipliers of 1, 2.5, 5 and 10 are included, providing a wide choice of 19 calibrated sweeps. All of the sweeps are developed at high level for application directly to the cathode-ray tube deflection plates, thus enhancing linearity since there is no intervening circuitry to contribute possible distortions. The calibration accuracy on any step is better than 5%. Through X-amplifier expansion any of the 19 calibrated 4-inch sweeps may be expanded by factors of 2, 3, 4 or 5, with somewhat reduced accuracy, providing a choice of 59 different calibrated steps.

Sweep expansion takes place about the center of the screen. Combined with the wide selection of sweep speeds available, any signal can be expanded to almost any desired degree without decreasing the sweep duration. With maximum expansion the fastest sweep rate of the Type 327 is 0.2 usec/inch, which is more than adequate to exploit the transient response of the vertical amplifier. Full positioning on the screen of any four-inch portion is possible. For purely qualitative investigations, where time calibration is unnecessary, continuously variable uncalibrated sweeps covering the entire range are also available.

Figure 5 shows the components of the X-axis circuits.

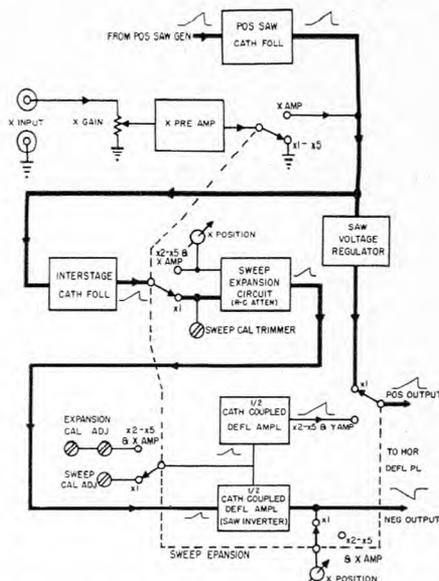


Figure 5. Components of X-axis circuits.

Sync signals may be selected from the usual sources; either internal, external or power line. The sweep may be driven at rates up to 2 mc when operating from internal sync, and up to 4 mc from an external source, which makes the unit easily synchronized from a large variety of signals. The sync gain control is adjustable over a wide range, although for normal operating conditions it can be left in the full gain position because of sync limiting circuits. For special signals however, such as those with two different voltage levels at triggering points, the sync level can be adjusted to eliminate unwanted triggering.

Following the sync inverter stage there is a Schmitt trigger circuit which performs three functions at once: (1) As a sync limiter; in that once it has flipped it will not reset until the polarity of the signal reverses. (2) As a pulse sharpener; which is particularly useful on long pulses because it does not re-trigger until the polarity of the signal reverses (it is therefore not susceptible to continuous firing if the signal amplitude stays above the threshold potential). (3) As a sync pulse shaper; the sweep circuit is presented with a pulse of uniform character no matter what the incoming trigger signal.

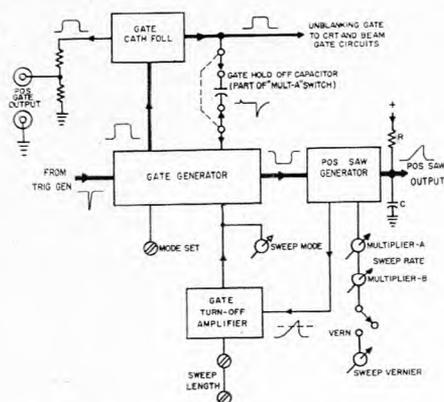


Figure 6. Block diagram of Sweep Section.

The sweep generator (see figure 6) is basically a gate generator followed by a saw generator and a turn-off circuit. A SWEEP MODE control permits operation on driven or recurrent mode at the option of the user. A gate cathode follower provides a positive signal to unblank the CRT on the forward sweep, and also provides a positive 8 volt (min) signal output to a POS GATE OUTPUT jack on the front panel for other applications, such as operating an electronic switch. For unexpanded sweep, 100 volts of saw voltage is taken directly from the saw generator for one deflection plate and fed through a phase-inverting amplifier for the opposite plate.

When the sweep expansion amplifier is used (see figure 5) the phase inverter becomes an amplifier, and an additional amplifier stage is switched in to provide the opposite polarity deflection. The multiplication factors are attained by attenuating the saw voltage fed to this expansion amplifier.

All of the calibrated sweep ranges can be checked and recalibrated simultaneously by adjustment of a single control. After presetting three front panel switch controls, exactly six cycles of the 60-cycle line-frequently voltage calibration waveform are adjusted to fit the scale with a potentiometer at the side of the unit. This one adjustment

calibrates all sweep ranges simultaneously.

Timing markers can be provided on the time base by connecting external timing signal to Z-axis terminals on the side panel. These Z-axis terminals were intentionally located at the side of the unit to provide low capacitance input instead of high capacitance shielded leads necessary with front panel input; another factor contributing to high quality and desirable features. Positive signals will decrease the intensity, and 15 volts peak will blank the beam at normal intensity levels. The astigmatism adjustment is inside the cabinet as a factory adjustment. If this were made a front-panel control, each time it was adjusted the instrument would get out of calibration, since varying the accelerator voltage changes the sensitivity of any cathode-ray tube.

#### Added Horizontal Amplifier

For externally generated sweeps or other signals, a D-C to 50 kc (3 db) horizontal amplifier is included in addition to the sweep amplifier. The X-axis input terminals are on the front panel. The gain control is simply a potentiometer having a resistance of 100,000 ohms which feeds the pre-amplifier. The sensitivity of the X-amplifier is 1.5 volts for 4 inches deflection.

#### Power Supplies

High voltage for the mono-accelerator cathode-ray tube is supplied by an R-F power supply. An R-F power supply is used because it is small, greatly reducing the weight of the Type 327, it has long life, it is easily filtered, and can be regulated at a low-voltage point. An added advantage of this type of power supply is that it enables the use of a high-impedance isolated beam-gate circuit, allowing intensity control while avoiding high current. Selenium rectifiers are used to conserve power, lower operating temperatures and promote long life. Regulators are used to provide the high stability necessary to attain the consistently accurate performance. All plate supplies, high volt-

age and critical filament voltages are regulated, as shown functionally in figure 7.

### Extras

An illuminated calibrated scale is provided which can be varied from blackout to a normal observing level by a front panel BRIGHTNESS control. By using a higher resistance potentiometer and adding resistance to the lower end of this pot, the Type 327 has been provided with scale illumination that can be dimmed to a very low limit. A switch has been added at the high end of the pot for a special BRIGHT illumination level, another extra which is excellent for photographic recording purposes.

BNC-to-binding-post adaptors, secured to the front panel, are supplied for Y-input and external sync connectors.

### Physical Characteristics

The Type 327 is housed in a well ventilated blue-gray wrinkle cabinet with readily detachable panels for ease in maintenance. By merely loosening two screws, each side panel can be removed and almost all of the instrument becomes available for servicing. This feature is especially valuable in areas where bench space is at a premium, the usual five or six feet of bench space is not needed to remove the cabinet. The attractively designed blue-gray front panel has white filled direct-etched lettering for easy reading. Mechanically this instrument is similar to the type 323 in that a frame construction is used. Most metal work is of aluminum, which accounts for the comparatively low weight of 56 lbs. Layout of the chassis and circuits have been arranged with the idea of easy service and maintenance. Printed wiring is used to assure uniformity of performance. The unit is  $12\frac{1}{2} \times 15\frac{1}{2} \times 22$  inches overall.

The cathode-ray tube has a mu-metal shield over its entire length to eliminate effects of external magnetic fields. The power cable is also shielded, with the shield grounded to the instrument to prevent external noise pickup.

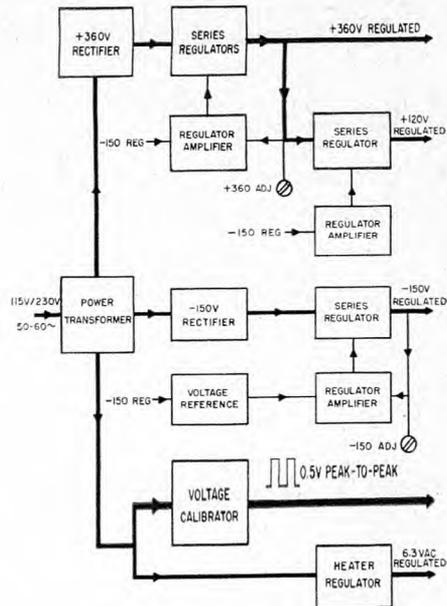


Figure 7. Block diagram of Power Supplies.

### Applications

For many applications of the Type 327, operation of the unit could be reduced to switching. For instance, in a production test application the only controls that would normally be used are the Y-input selector and the volts full scale switch. If conditions warranted, all other Y-amplifier control knobs could be removed to reduce chances of accidental adjustment of these controls. This then, would require the operator to use only the designated switch positions for a testing setup.

The same philosophy could apply to the sweep circuit and its controls. The controls most likely to be used are the sweep rate, sweep multiplier, sweep expansion and sync selector controls. The remaining knobs could again be removed. This is possible because of the conservative design of the instrument, the unique performance of the sync circuit, and the method chosen for providing various modes of operation.

The foregoing do not detract from the use of this instrument as a general purpose laboratory instrument. Certainly the knobs are put there for a purpose—that of broadening the general use of the instrument. The Type 327 can do

an excellent job in maintaining most computer and PTM (Pulse Time Modulation) equipments in the field. The bandwidth is adequate, and sweep and sync circuits are compatible with the requirements. The rise time of the amplifier and performance of other circuits make this instrument ideal for many pulse applications. Where repetition rates are not very low and response characteristics are not too stringent this instrument will do an excellent job of measuring pulse waveforms.

An ideal economical package for television use can be made up of the Type

325 Line Selector and the Type 327. (see figure 8). The Type 327 has all of the performance needed for television station adjustment and maintenance work. With the Type 325 to provide the line selection, any of the measurements peculiar to television can be made.

Complete specifications can be obtained on all test instruments mentioned above from the Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, New Jersey.



Figure 8. Type 327 with Type 325 Line Selector for television station adjustment and maintenance work.

# HOW THE CATHODE-RAY TUBE IS MADE

Addendum

*Editor's Note: In the last issue of the Oscillographer we ran the second half of an article pertaining to the manufacture of cathode-ray tubes written by Morton G. Scheraga, Assistant Technical Sales Manager. We have received several letters since the release of the article asking for more detail on the second seal process. To get authoritative information on the subject, Mr. Scheraga asked us to contact Mrs. G. A. Wright and Mr. H. Kasperowicz, both of Du Mont's Tube Research Laboratory. They kindly sent us the following information.*

## Second Sealing Cathode-ray Tubes

In the case of a number of special industrial tube types where it is impractical or impossible to bring all elements of the electron gun through the stem, a second seal is made. This second seal is usually made fairly close to the break between the neck and the body of the tube and contains a number of metal terminals or wires. This allows the low voltage elements to be brought out through the stem and the high potentials through the neck where more leakage path may be allowed. It also permits minimum capacitance for connections to the deflection plates in high-frequency applications.

The second seal method also greatly simplifies the manufacture of complex multi-gun CRT's. It eliminates the necessity of running a large number of high voltage connections from all parts of the gun and deflection system down through the stem where they would be close and necessitate a complex stem of many leads.

The second or neck seal is made on a horizontal lathe by a skilled glass worker after the gun has been first or stem sealed. The excess part of the neck is strain cut at a predetermined point and the terminals or wires are arranged in position. The tube and the neck are then meticulously aligned and the two parts fused together with the terminals vacuum sealed between.

The CRT is then ready for the exhaust and basing processes which have been previously discussed. In the case of some second sealed CRT's, however, there is a second basing process. In multi-gun tubes where external snap terminals cannot be used and where there may be as many as forty-five wires brought through the neck, a second base, or base collar must be applied. The collars and the stem bases are applied at the same time and are then based in adjustable double ovens before progressing to the testing operation.

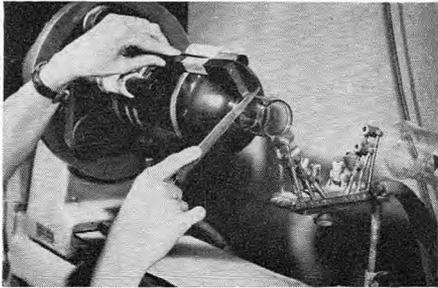


Figure 1. The bulb of the tube to be sealed is mounted in a glass lathe. Here the operator is marking the bulb for cutting of the waste neck.

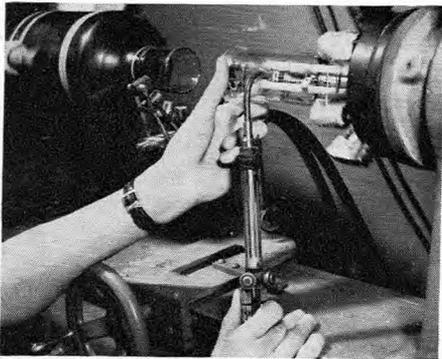


Figure 2. In this operation the waste is being cut from the gun and neck assembly which is mounted on the glass lathe.

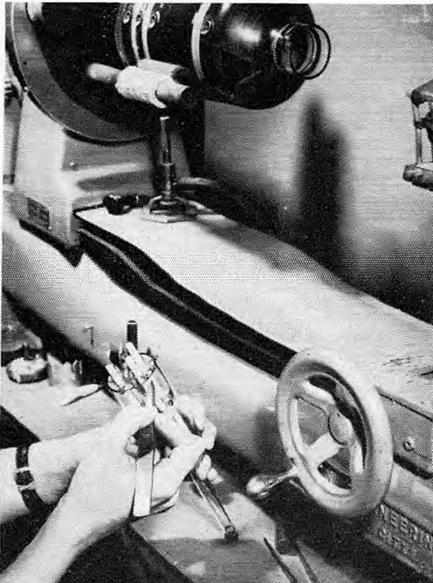


Figure 3. The neck and gun assembly is removed from the glass lathe in this step and the neck contacts are pulled into place and positioned.

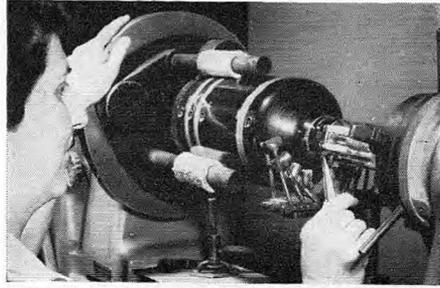


Figure 4. With both parts trimmed and properly aligned in the glass lathe once again, the neck contacts are realigned according to markings put on the bulb by a precision jig.

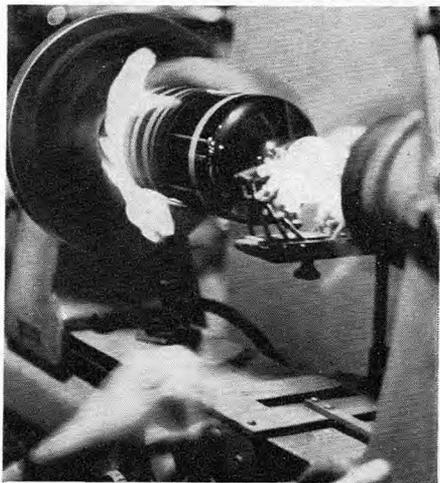


Figure 5. Final intense heat is applied to the region of the neck contacts and as the glass softens and becomes molten the neck is pressed into the bulb completing the seal. This is the most critical part of the operation and the operator who does this job has been with Du Mont for over 13 years.

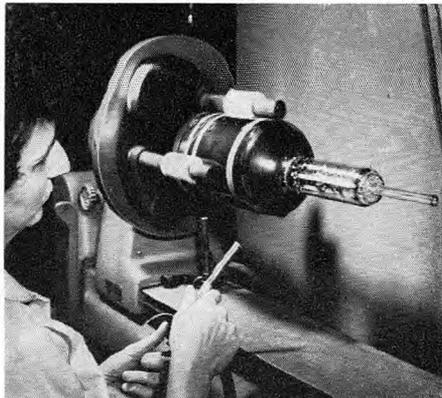


Figure 6. In the final operation the completed junction and surrounding glass are heated for a period to anneal the glass and remove strains.



### ESTABLISHMENT OF INDUSTRIAL ELECTRONICS SALES FORCE

Appointment of Fred C. Zusi as Sales Engineer for Industrial Electronics for Allen B. Du Mont Laboratories, Inc., was announced recently by Emil G. Nichols, the company's Technical Sales Manager.

Mr. Zusi will head a new systems-engineering group recently formed by

Du Mont to assist industry by applying electronic techniques to automatic production and to quality control. In this capacity, he will supervise sales of electronic equipment for process control, inspection, and counting, built on a custom basis by Du Mont as required for specific industrial applications.

Mr. Zusi, who joined Du Mont in 1952, has served as engineer in charge of the Du Mont Instrument Division's Standards and Components Laboratory and was most recently in charge of applications engineering for Du Mont's Technical Sales Department. Prior to joining Du Mont he was a supervisor of production and quality control for the Automatic Manufacturing Company, an electronics firm in Newark, New Jersey. He holds his Electrical Engineering degree from the Newark College of Engineering, Newark, New Jersey, and is a member of the Institute of Radio Engineers and the American Institute of Electrical Engineers. During World War II he served for three years in the United States Naval Air Corp.

Requests for information concerning this consulting service on any control problem should be addressed to Mr. Zusi at the address noted on page two of "The Oscillographer."

### *"Who and Why"*

*(Continued from Page 2)*

He has, at various times, occupied the following positions: Soda Clerk, Information Clerk at the Pennsylvania Railroad Telephone Information Bureau, Baggage Man for Railway Express, Shoe Salesman in the *Ladies'* Shoe Department at Bloomingdale's, Peanut and Hot Dog Vendor at Yankee Stadium, part-time Bartender, and Inspector of Naval Material.

His military service was of a divided nature, inasmuch as he served in both United States Marine Corps and the U. S. Army.

In late 1943 Ed joined the General Electric Company as a Test Engineer, but left them in early 1944 to become a Junior Engineer with Du Mont. His first job here was on the Loran Project. When this project was completed, he was transferred to the Contract Division

as a Sales Engineer.

In July of 1946 he left Du Mont as an employee, but rejoined us the same day as a Selling Agent in the Up-State New York territory. He covered that territory for Du Mont and a few other companies by himself until late 1950, at which time he and his associates opened a branch office at 65 Webster Street, Saratoga Springs, New York. Since that time they have opened additional offices at 308 Merritt Avenue in Syracuse, as well as their main office at 3 Juniper Street in Rochester.

From a mobile business office to an established business with three branch offices is quite a feat. Maybe Ed Ossman can't determine any reason for being our "Who & Why" subject this issue, but we're proud of his tie-in with Du Mont.

# "Who and Why"

Du Mont Selling Agents



Edward A. Ossmann

When we wrote to Ed Ossmann, head of Edward A. Ossmann and Associates Inc., Du Mont's Selling Agent in upper New York State, checking on material for a short biography, he replied that he couldn't see why we wanted to put him in our "Who & Why" column. Nevertheless he cooperated, and we're proud to pass on some of his life's highlights to all our readers.

Very briefly, he was born on May 21, 1922, in New York City. And after a rather normal childhood (as Ed puts it), he was graduated from Manhattan College, in New York, with a Bachelor of Electrical Engineering degree.

His school years were quite eventful, or perhaps we should say busy, inasmuch as he took a full time engineering course, held down a full time 8-hour job for most of his school years, and yet (probably from the momentum) ran on Manhattan College's track team.

(Continued on page 16)

## On the Cover

A dual-beam cathode-ray oscillograph (a Du Mont Type 279) has been utilized in simulating the elevation view of a military tank when subjected to various disturbing forces. In this photograph the tank is traveling over a 12" x 12" obstacle at 20'/second.

The simulation was developed from an analog computer output by the Willow Run Research Center of the University of Michigan to assist in getting an insight into the sequence of events during computer simulation of the suspension system of the tank. More details of the application may be found in the feature article beginning on page 3.

## 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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# Cathode - ray Oscillograph Display System for Use With High - speed Electronic Computers

By Henry T. Nay, Jr.\*

*(Editor's Note: We are continually surprised by the extraordinary ingenuity of people who use cathode-ray oscillographs and the uses to which they put this versatile instrument. Occasionally a unique and valuable application comes to our attention such as the one printed below. This describes a rather unusual kind of picture "drawn" on the face of a cathode-ray tube and we think that some other readers of THE OSCILLOGRAPHER may be inspired to put this kind of technique to good use in their own application.)*

*We are indebted to Mr. Henry T. Nay Jr. of the Willow Run Research Center, University of Michigan, Ann Arbor, Michigan for sending us the information printed here.)*

**Summary — A cathode-ray oscillograph display system was developed for use with high-speed electronic computers. The display system used a dual-beam cathode-ray oscillograph to present a representation of the elevation view of a tank when it was subjected to various disturbing forces. The motion of the hull and each of the road wheels as a function of time was thereby presented on the screen of the oscillograph. The system design and operation are discussed.**

## **Introduction**

For the past several years the Willow Run Research Center of the University of Michigan has been conducting a research program under the sponsorship of the Detroit Arsenal, Centerline, Michigan, in which the analog computer has been used to study the suspension

systems of military tanks. During the course of this work it was necessary to determine the motion of the hull and each of the road wheels of the simulated tank while it was being driven over rough ground at varying speeds. It was found that graphical records, such as those produced by direct inking oscillographs, did not permit the engineer to obtain an integrated picture of the entire motion. A device was needed which would convert the output voltages of the computer into a direct pictorial representation of the tank motion. The display system developed for this purpose used a Du Mont Type 279 dual-beam cathode-ray oscillograph to present a representation of the elevation view of a tank when it is subjected to various disturbing forces. Figure 1 is a series of photographs of the oscillograph display at successive instants as the simulated tank is passing over a 12" x 12" obstacle.

\*University of Michigan, Willow Run Research Center.

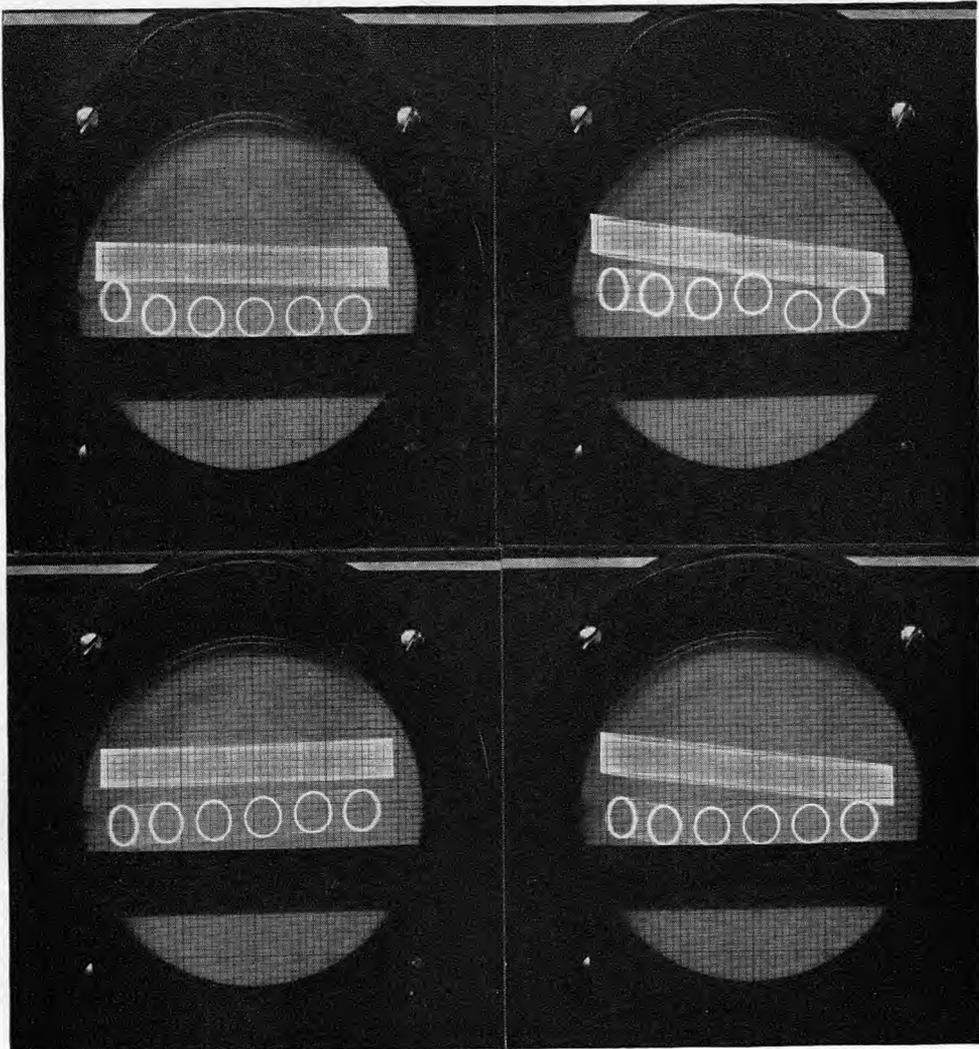


Figure 1 — The waveforms show a simulated tank going over a 12-in-square bump at 20 feet per second. Direction of motion of the simulated vehicle is from right to left. At upper left the first wheel is on the bump; at upper right the fourth wheel is on the bump; in the lower left waveform the entire tank is off the ground; and in the lower right the tank is bottoming on the sixth wheel.

### General Applicability

Displays of this nature can be formed to yield direct pictorial representations of the behavior of many physical systems as simulated by an electronic computer. The displays are useful for a number of purposes, such as:

1. Providing the engineer with a clear insight into the sequence of events occurring during the simulation.
2. Monitoring the operation of the

computer to indicate when trouble is occurring and what the nature of the trouble is.

3. Providing a visual display to a human operator who is an integral part of a system being simulated.
4. Demonstrating the performance of a simulated system to executive personnel or to the general public.
5. Assisting in the instruction of technical subjects.

A visual display can be preserved, if desired, by use of a motion-picture camera. Visual displays are intended to supplement rather than replace the more precise graphic records obtained by such devices as ink recorders or plotting tables.

**Representation On The Cathode-ray Oscillograph**

A block diagram of the components involved in producing the display is shown in Figure 2. The suspension system of the tank was simulated on an analog computer. Voltages representing the vertical position of each of the six wheels and the vertical position and pitch angle of the hull as functions of time were available as outputs from the computer. These voltages were used for modulation in the display. The simulated tank is shown as the second wheel

rode up on a simulated 12" square road obstacle.

The hull of the tank was represented by a rectangle and the wheels by circles. It was possible to display the hull and road wheels simultaneously by using one beam of the Du Mont Type 5SP-dual-beam cathode-ray tube to display the hull and the other beam to display, on a time-shared basis, each of the wheels.

The rectangle was formed on the CRO screen by properly mixing selected wave forms and applying them across the horizontal and vertical deflection plates of the tube. A 60-cps a-c voltage was applied to the horizontal deflection plates and a 20-kc a-c voltage applied to the vertical deflection plates of the tube. The resultant wave shape took the form of a solid rectangle, the length being controlled by the magnitude of the 60-cps signal and the height by the magnitude of the 20-kc signal.

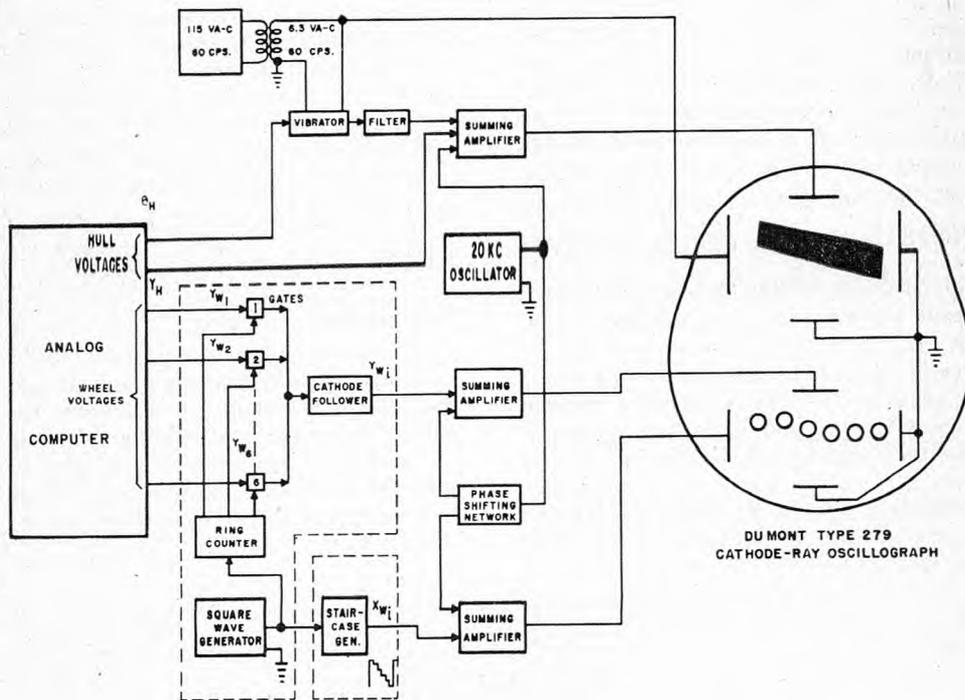


Figure 2. Block Diagram of Tank Simulation Display.

Each wheel was represented on the CRO screen by a circle whose center was fixed in the x direction and variable in the y direction. The x position of the centers of the individual circles was obtained by generating a staircase wave form (frequency 250 cps) and applying it across the horizontal deflection plates. This voltage fixed 6 spots equally spaced along the x axis. Individual circles were drawn sequentially about about the x and y coordinates represented by each of the spots by simultaneously applying a 20-kc sine wave across the vertical deflection plates and a similar wave, shifted 90 degrees in phase, across the horizontal plates. The repetition rate thus obtained was high enough to avoid flicker.

### Motion Of Pictorial Representation

The pictorial representation of the hull was made to vary in pitch and vertical displacement in accordance with the proper computer outputs by converting the d-c simulation voltage representing the pitch angle,  $\theta$ , to a 60 cps a-c voltage by means of a vibrator and filter. The magnitude of the resultant a-c signal corresponds to the absolute magnitude of  $\theta$  and its phase corresponds to the sign of  $\theta$ . This voltage was then summed, by means of an operational amplifier, with the aforementioned 20-kc voltage and the d-c voltage from the suspension simulation representing  $y_0$ , vertical displacement of the center of gravity. By the simultaneous application of this composite voltage across the vertical deflection plates of the tube and the application of the 60 cps a-c voltage across the horizontal deflection plates, the desired pictorial representation of the hull was obtained

and caused to vary in pitch and vertical displacement in exact accordance with the hull as simulated by the analog computer.

In order to vary the vertical displacement of the circles in accordance with the proper computer outputs, an appropriate d-c simulation voltage corresponding to the motion of each of the road wheels was gated into the vertical deflection plates of the tube in rapid succession. Since all road wheels were of uniform size and had a fixed x position, the gating process could be confined to the voltages representing the coordinates of the centers of the wheels. A ring counter sequentially opened a series of gates such that time-varying voltages from the suspension simulation representing the vertical positions of the individual wheels were applied to the vertical deflection plates of the tube. Synchronism was maintained between the computer outputs and road wheels by driving the staircase generator and ring counter from the same source.

Thus a pictorial representation of the hull and the road wheels of a tank were presented on the face of a CRO tube for visual observation. It was thereby possible to note the behavior of eight simultaneously time-varying quantities in a manner exactly corresponding to their relationship in the real physical system.

### Conclusions

The display system described can be modified to yield a much more general and flexible system by changing the gating technique and adding a patch-board. The display system may also be used with a single beam scope. Design is proceeding along these lines at the present time.

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### Eight Ball Corner

In the article "Observing An Arc" in the last issue of "The Oscillographer" the bridge rectifier in figure 1. (page 9) was discovered to have two cells re-

versed after the issue had gone to press. To be accurate, change the polarity of the two lower cells and the rectifier can no longer short-circuit.

# NEW DU MONT TYPE 327

For a number of years we have recognized the need for an instrument in the medium-high frequency class. By design, the new Du Mont Type 327 Cathode-ray Oscillograph is aimed to fill that need — that broad gap existing between the sensitive low-frequency instruments and the more expensive, wide-band oscillographs. The Type 327 is the third in a series of Du Mont direct-reading, precision instruments engineered to satisfy definite needs in the oscillograph field.

Extremely valuable for the broad middle range of frequencies, the Type 327 is a general purpose instrument capable of more than adequate performance in applications where a high sensitivity or an extremely broad-band amplifier is secondary (see figure 2). At a moderate cost, not a major investment in any sense, the Type 327 finds use in low-frequency applications as well as many in the higher frequency domain.

Its calibrated high-level sweeps are reliably linear; signal voltage can be read directly from the calibrated screen, and amplitude calibration is included with a wide range of calibrating steps.

## Cathode-ray Tube

A detailed consideration of the Type 327 properly begins with the Du Mont Type 5AMP-Cathode-ray Tube. This tube is one of the new Du Mont mono-accelerator cathode-ray tubes. The mono-accelerator is one of the important factors that enables the Type 327 to be high in quality while remaining an inexpensive instrument.

In a mono-accelerator cathode-ray tube, all acceleration occurs within the electron gun. The screen is at the same potential as the accelerator. With a modern electron gun design producing a high-current beam of small cross-section, the mono-accelerator provides comparable brightness, spot size and sensitivity to equivalent post-accelerator types, but at lower total accelerating potentials. The uniform field between the



Figure 1 Type 327

deflection plates insures extremely low field and spot distortions over the entire useful portion of the screen.

This tube has an added advantage in that the uniform field in the post deflection region prevents any tendency for secondary electrons emitted from the tube walls to migrate to the screen; thus, glow from overscanning is all but eliminated. This feature is of particular value

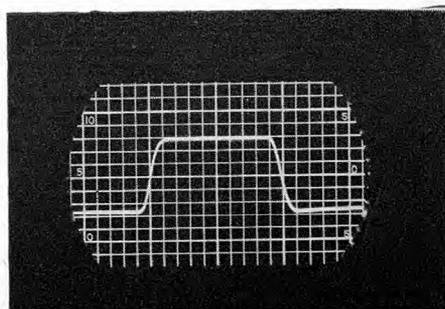


Figure 2. A 1.0 usec pulse is shown displayed on the 1.0 usec per major division calibrated range with a calibrated sweep expansion of X2 giving a writing rate of 0.5 usec per major division. Note the excellent reproduction of pulse shape.

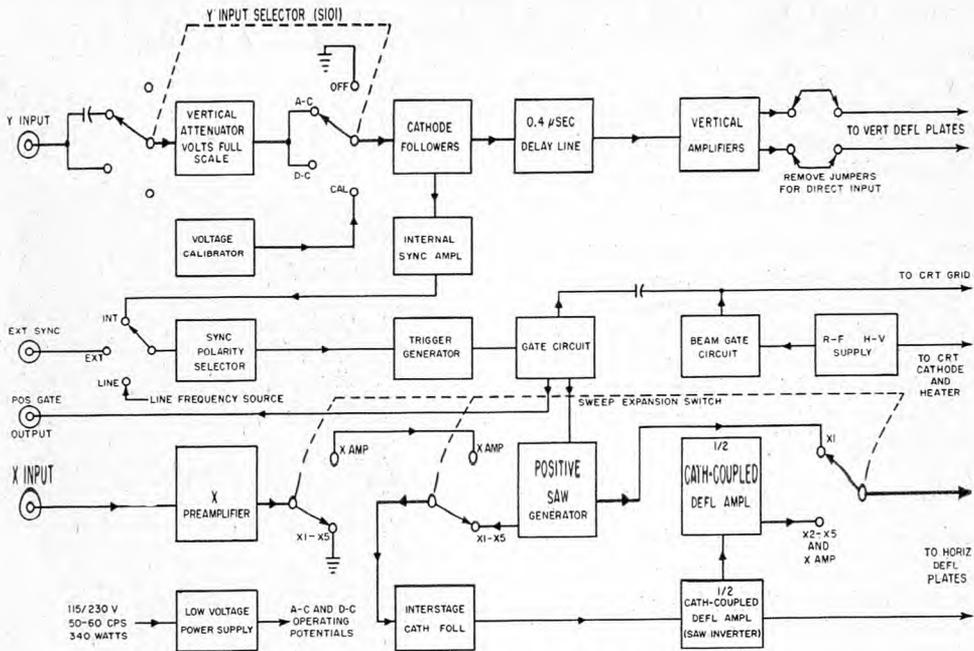


Figure 3. General block diagram of Type 327.

when recording oscillograms since there is no glow to fog the film. Better contrast is also achieved.

The now well known glass-rod construction developed by Du Mont has been utilized in the mono-accelerator to bring true precision within the critical tolerances required for this design. Angular alignment tolerances between deflection plates are held within  $1^\circ$ , deflection factors are held within 10%, while grid cutoff bias is maintained within 25%. All of these represent major improvements in tolerances.

Specifications for the sweep in the Type 327 call for an incremental linearity of  $\pm 5\%$  for any 20% increment of the full sweep. That is, any 20% portion of sweep (0.8 in.) will deviate by no more than 5% from any other 20% portion; or an overall accuracy of 1.0% in linearity. This extremely linear sweep in the 327 was first introduced in the popular Du Mont Types 323 and 329 Cathode-ray Oscillographs, and could not have been achieved without the virtually distortion-free cathode-ray tube.

#### Y-Axis Circuit

To complement the mono-accelerator cathode-ray tube, a highly-linear verti-

cal amplifier has been used which can be precisely calibrated. Its response is uniform from zero frequency (D-C) to 30% down at 5 mc. With capacitive coupling the response is down only 10% at 10 cps. Its rise time of 0.07 usec, is commensurate with the frequency range.

Figure 4 is a functional block diagram of the vertical deflection channel. Reference to this will more clearly define the engineering philosophy behind this design.

The attenuator in this unit (VOLTS FULL SCALE) is designed with careful attention to grounding so that it can be used in high-frequency, high-energy measurements. There are actually two sets of attenuators which are cascaded to provide the proper attenuation factors. The first provides seven decade steps, and the second additional 1, 2 and 4 attenuation ratios. The maximum calibrated sensitivity of the vertical amplifier is 0.5 volts peak-to-peak for full scale deflection. When considered with the 21 steps of the volts-full-scale range, the full scale amplitude measuring range extends from 0.5 to 500 volts, which is sufficient for the range of signal amplitudes covering most applications. Sensi-

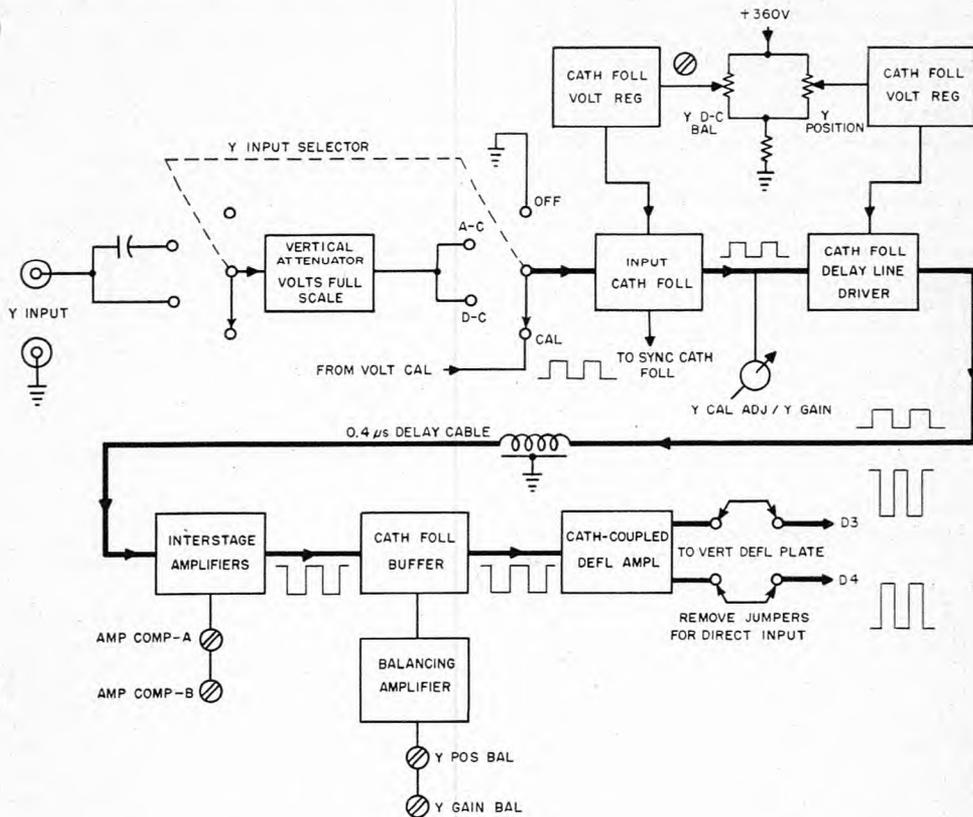


Figure 4. Functional block diagram of vertical deflection channel.

tivity without the amplifier, that is, for connections directly to the deflection plates of the cathode-ray tube is 40 to 50 volts peak full scale. Input capacitances and resistances are maintained within 2% on all ranges to prevent any differential in loading of signal circuits, or need for variations in test probe compensation.

Following the attenuator are two cathode follower stages for driving the gain control, the internal sync amplifier and the signal delay line. The delay line utilizes RG-65/U cable for a 0.4 usec delay. This delay provides a minimum baseline of 0.1 usec, which is equal to one-half inch on the fastest sweep. This is a valuable asset in applications where observation of the signal starting point is important.

A pre-amplifier stage, and interstage amplifier, follows the delay line. The output of this preamplifier is fed to a cathode-follower driver and then into a push-pull deflection amplifier. There is a balancing amplifier stage (which could be called the "drift balance" stage) driving the opposite grid of the push-pull amplifier. This is adjusted to have the same gain as the pre-amp, and is used to minimize the effect of line voltage variation on the performance of the pre-amplifier, resulting in excellent stability under most conditions of operation. The unique factor in the design of the amplifier is the conservative operation and use of tubes and components though meeting rigid specifications. In addition to the use of an amplifier to stabilize drift, the heaters of all signal