UNIVERSITY OF MICHIGAN

CATHODE-RAY OSCILLOGRAPH DISPLAY SYSTEM FOR USE WITH HIGH-SPEED ELECTRONIC COMPUTERS

By Henry T. Nay, Jr.

University of Michigan
Willow Run Research Center

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ABSTRACT

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.

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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 DuMont 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"x12" obstacle. Figure 2 is a photograph of the oscillograph and associated equipment needed for presenting the display.

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:

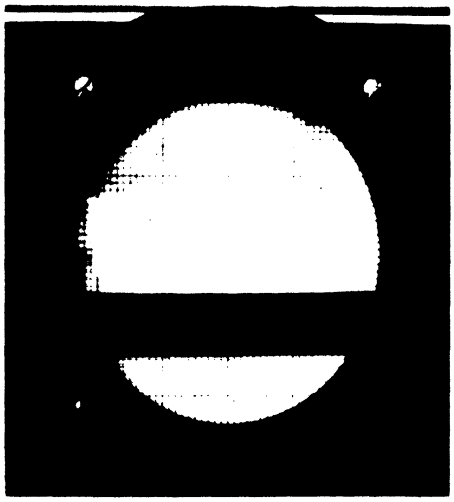
1. Providing the engineer with a clear insight into the sequence of events occurring during the simulation.

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

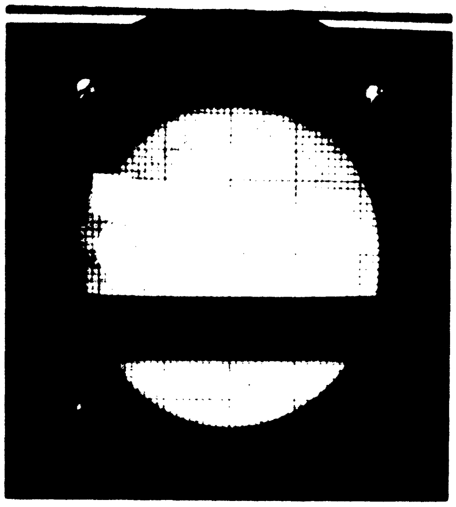
3. Providing a visual display to a human operator who is an integral part of a system being simulated.

4. Demonstrating the performance of a simulated system to executive personnel or to the general public.

5. Assisting in the instruction of technical subjects.

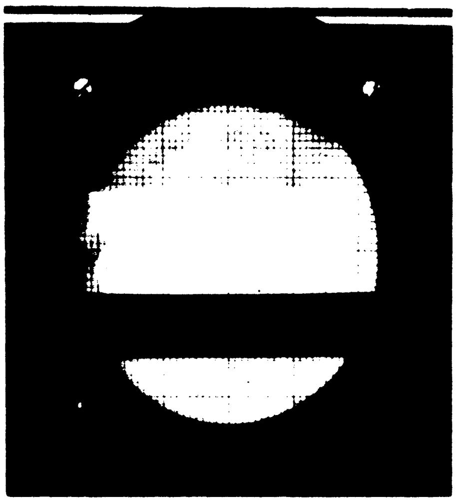


A First wheel on bump

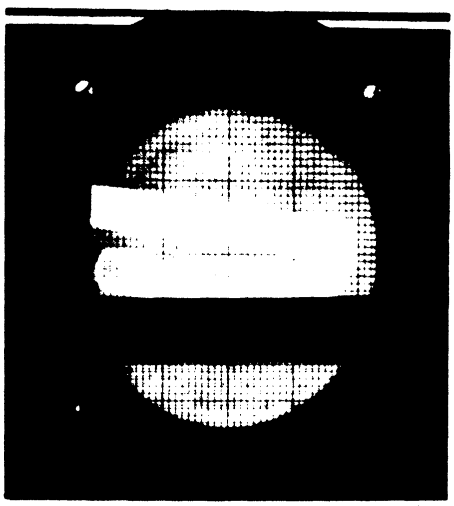


B Fourth wheel on bump

DIRECTION OF MOTION



C Entire Tank off ground



D Tank bottoming on sixth wheel

FIG. 1 DISPLAY OF SIMULATED TANK GOING OVER A 12-INCH-SQUARE BUMP AT 20 FEET PER SECOND

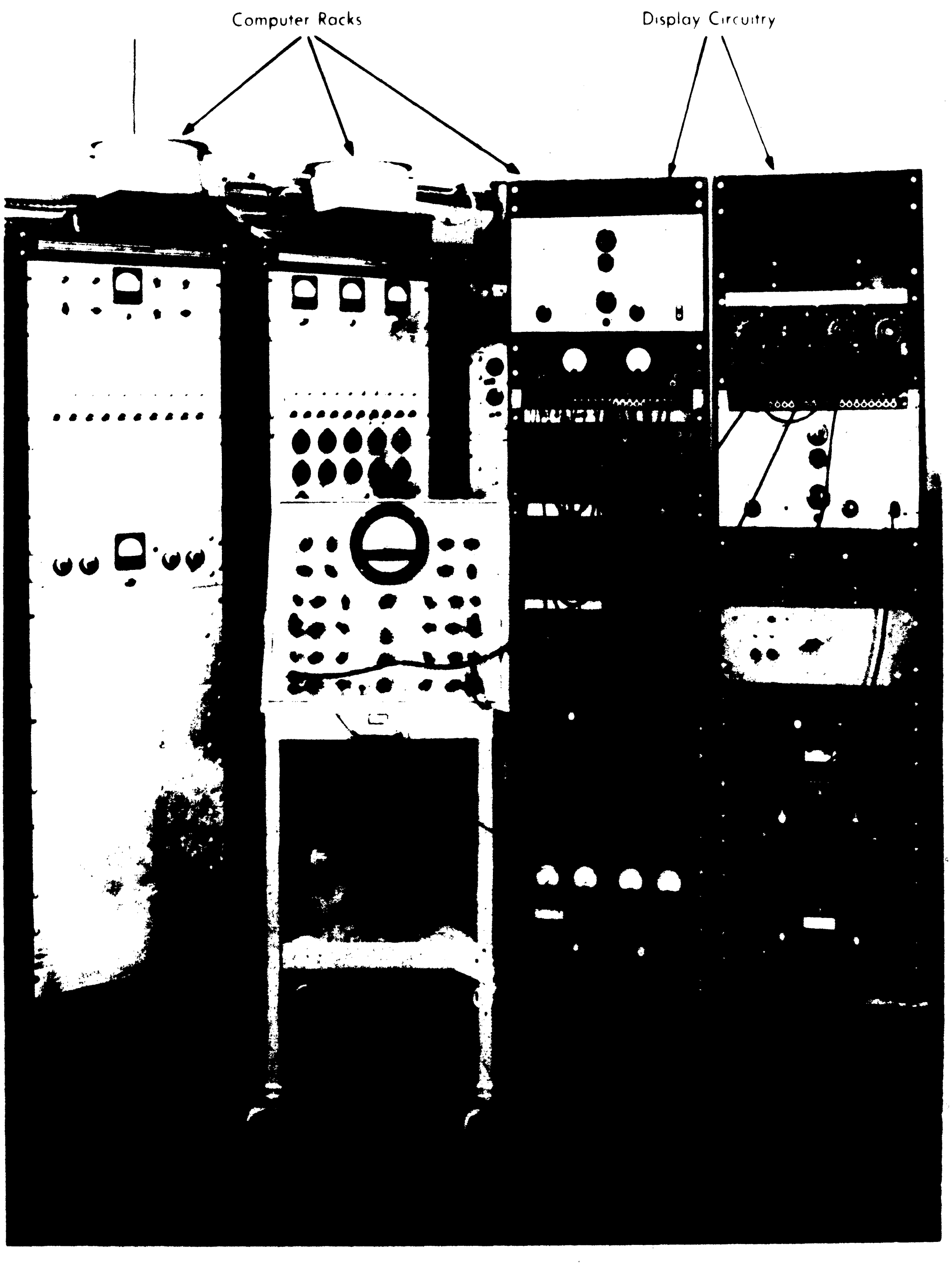


FIG. 2 SIMULATION DISPLAY EQUIPMENT

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 3. 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 DuMont Type 5 SP 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.

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 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, θ, 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 θ and its phase corresponds to the sign of θ. 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 patchboard. The display system may also be used with a single beam scope. Design is proceeding along these lines at the present time.