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NRL Report 5338

THE STORAGE SYSTEM FOR PROJECT MUSIC

[Unclassified Title]

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FC

August 3, 1959

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Washington, D.C.

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ABSTRACT
[Confidential]

The Project Music radar is a research equipment which utilizes storage and crosscorrelation techniques for enhancing phase-coherent signals in the presence of noise. The storage system embodied in the Music radar is used as a delay device to store periodically for subsequent use a copy of the transmitted signal. A circuit was developed for generating a step-function voltage, properly stabilized, for use at the target of the Radechon storage tube in switching from a writing to a reading condition. An improved readout circuitry, for greater simplicity and a further enhanced output signal-to-noise ratio, and an effective system for magnetic and electrostatic shielding of the storage tube and its associated circuitry were designed. A preproduction Radechon type C73404 was obtained and used in the storage system which was incorporated in the Music equipment. A complete storage system was developed and has been in use in the Music radar system for several years.

PROBLEM STATUS

This is an interim report on one phase of the problem; work is continuing on this and other phases of the problem.

AUTHORIZATION

NRL Problem R02-17
Project NR 412-000, Task NR 412-006
MIPR 30-635-8-160-6136

Manuscript submitted May 14, 1959.

THE STORAGE SYSTEM FOR PROJECT MUSIC
(Unclassified Title)

INTRODUCTION

The requirements of Project Music involved the development of a storage crosscorrelation radar to be used as a research equipment. The storage equipment includes write-in and readout circuitry, storage-tube target switching, and a readout signal amplifier capable of amplifying the desired signal while at the same time eliminating residual switching transients due to imperfect pulse matching in the target-switching circuit. The Radechon barrier-grid storage tube was selected as the storage element for the storage system developed for use in the Music radar, on the basis of previous investigations.* The target switching circuitry and the method of obtaining a useful, transient-free, amplified readout signal were developed for investigations conducted on a simulated radar system.† These approaches to the radar application of the Radechon have been improved and simplified and are the basis of this discussion.

The Music radar requires the storage, or retention, of a copy of the transmitted rf burst which is obtained from the i-f of a monitor receiver. This stored information is later played back, or read out, and mixed with the echo-return signal from a main receiver channel. Only one copy of the stored signal is required, although more can be provided. No frequency translation is required, since the output signal frequency is the same as the input frequency.

THEORY OF OPERATION

Storage delay, or the subsequent reading out of previously written material, as incorporated into the Music storage, crosscorrelation radar, requires the writing, or storage, of a 250-μsec pulse of a 400-kc rf frequency. Then, at some predetermined time later, this stored information is extracted, thus resulting in a delay between the reception and ultimate use of the 400-kc rf burst.

To initiate the sequence of operations for storing the signal, the target plate of the storage tube must be made approximately 50 volts more positive than the barrier grid. While the target is in this condition, the signal is applied to the storage-tube control grid. In order to read, or extract, the signal from the target, the target plate is switched to a potential equal to the barrier-grid potential. The read-write gate tubes that accomplish the plate-to-barrier-grid potential switching also introduce possible gate-pulse feedthrough from imperfectly balanced switching tubes, as well as transient spikes from the actual switching operation. The transients and unbalance would be subject to amplification in a conventional amplifier, along with the desired amplification of the readout signal. These transients and the pulse unbalance must be eliminated, so that only the desired signal undergoes full amplification. The use of clamps on the signal-amplifier chain which are controlled by pulses, variable in both width and delay, the use of tuned amplifiers, and the

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*C. L. Uniacke and G. K. Jensen, "An Investigation of the Radechon Storage Tube," NRL Report 5201 (Confidential Report, Unclassified Title), Aug. 6, 1958.

†C. L. Uniacke and G. K. Jensen, "A Frequency Translation and Storage System Utilizing the Radechon Storage Tube," NRL Report 5238 (Confidential Report, Unclassified Title), Dec. 18, 1958.

use of voltage regulation at the read-write gate effectively eliminated the transients and the effects of gate-pulse unbalance. The signal output is clean, transient-free, and suitable for subsequent use in the radar system.

DESCRIPTION OF THE SYSTEM

The storage system developed and installed as part of the Music radar is based on studies conducted previously.† The storage tube used in the present system as a delay element is a commercial, preproduction version of the handmade laboratory models of the Radechon employed in previous study systems. This model, known as the type C73404, is physically unlike either type STE-B or STE-C. Electrically, this newer tube is somewhat similar to the type STE-C. A photograph of the Radechon type C73404 may be seen in Fig. 1.

Fig. 1 - Radechon storage tube, type C73404

Operation of the Storage Unit

The block diagram shown in Fig. 2 represents the circuit comprising the storage unit. The storage tube is being used in this equipment as a single-copy device, so the beam current is adjusted for complete erasure of the target after one complete reading scan. A 250-μsec signal burst of 400-kc rf is impressed on the storage-tube control grid at the same time the T portion of the -G(T+R) (or "transmit" and "receive") unblanking pulse gates on the electron beam. At this same time, the read-write gate tubes are switched to a writing condition by a +T pulse of 250-μsec duration. The electron beam is intensity modulated by the 400-kc signal contained in the 250-μsec burst, and this intensity modulation is deposited on the storage-tube target dielectric as elemental charges. The total scan duration for writing is also 250 μsec, but the sweep is composed of five lines of 50 μsec each, to provide a sufficient number of elements for adequate resolution of the signal. Figure 3 illustrates schematically the 400-kc driver used to intensity modulate the Radechon control grid, the two sets of push-pull sweep amplifiers, the Radechon, and the element voltage-supply bleeder for the Radechon. Figure 4 shows the pulse-shaping, target-switching, and voltage-regulating circuitry comprising the balanced read-write gate. The pulse shapers are used to sharpen the rise and fall times of the +T pulse, to permit matching the pulses as perfectly as possible, in order to minimize output transients.

†Ibid.

Gate-pulse feedthrough to the output must be kept to a minimum; therefore the plate currents of the two gate tubes are balanced as closely as possible. Any unbalanced pulses in the output of the read-write gate can disable the readout amplifier unit due to back biasing of the input coupling condensers. Employment of tuned amplifiers (permissible only because narrow signal bandwidths were sufficient) and positive and negative voltage regulation at the read-write gate made possible the elimination of the feedback-bias stabilization loop formerly used. Two conditions must be met for the writing operation. First, point B must remain at ground potential to eliminate gate pulses from feeding through the clamped readout amplifier, and second, a potential of 50 volts dc must be placed between point A and point B across the 1.0-k resistor. The read-write balanced gate tubes are normally in a cutoff condition and are driven to conduction by the +T pulse. The resultant current flow causes a 50-volt drop across the 1.0-k resistor, thereby making the target plate of the storage tube 50 volts more positive than the barrier grid. The intensity modulation of the electron beam which has been switched on by the -G(T+R) unblanking pulse can now deposit charges as stored signal on the mica dielectric comprising the storage surface.

The change to a reading condition is accomplished by the +T pulse dropping out and leaving the balanced read-write gate tubes in a cutoff, nonconducting condition; this removes the 50-volt dc potential between target plate and barrier grid. The beam is turned on again by the -G(T+R) unblanking pulse, and the target is once again scanned by the five-line sweep along the exact path taken by the writing sweep. The charges stored on the mica dielectric during writing now modulate the secondary-electron flow released by the reading beam. This modulation is then removed from the target as readout signal, now delayed from the writing signal by the time difference between the T and R pulses. This signal is now available for further processing. The balanced read-write gate must meet two requirements for reading operation of the storage unit. First, the target-plate potential must be clamped to the barrier grid, and second, point A and point B must be isolated and have minimum capacity to ground, since the frequency response of the output circuits could be reduced seriously by excessive capacity at this point.

The Radechon storage unit is shown in Fig. 5, which shows the available front controls and metering, and in Fig. 6, which shows a rear view of the unit. Note the Radechon shield. This shield is essential in order to eliminate magnetic and electrostatic interference. The base, or gun, end of the tube is at the right, and the target is at the left, both are carefully shielded. Circuit connections to the base and target are also effectively shielded. Additional shielding is contained within the vertical chassis at either end of the main tube shield, and full use is made of the internal shield within the Radechon to isolate the input signals from the output signals.

Figure 7 is a photograph of the sweep waveforms applied to the storage-tube push-pull deflection amplifiers. The waveforms shown result in the five-line presentation shown in Fig. 8.

Operation of the Readout Unit

The readout unit (Fig. 9) can be considered as being composed of three sections. These are the amplification chain, the diode clamps, with their pulse drivers and phase inverters, and the delay and gate-pulse generators. The amplification chain consists of two tuned 400-kc amplifiers, followed by two cathode followers. The tuned amplifiers provide gain, and their limited bandwidth, sufficient only to pass the rf-burst spectrum, minimizes storage-tube noise. Three diode clamps, the second section, are used in the readout amplifier and are placed as shown in the schematic diagram of Fig. 10. The

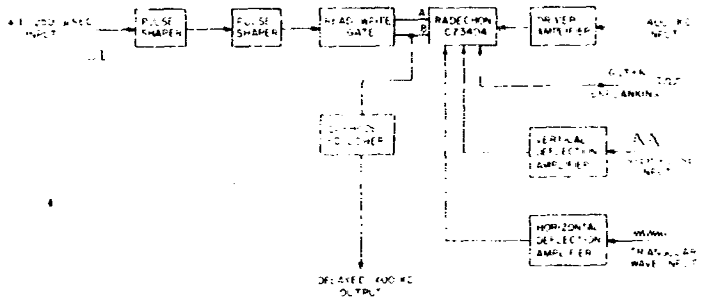

Fig. 2 - Storage unit, block diagram

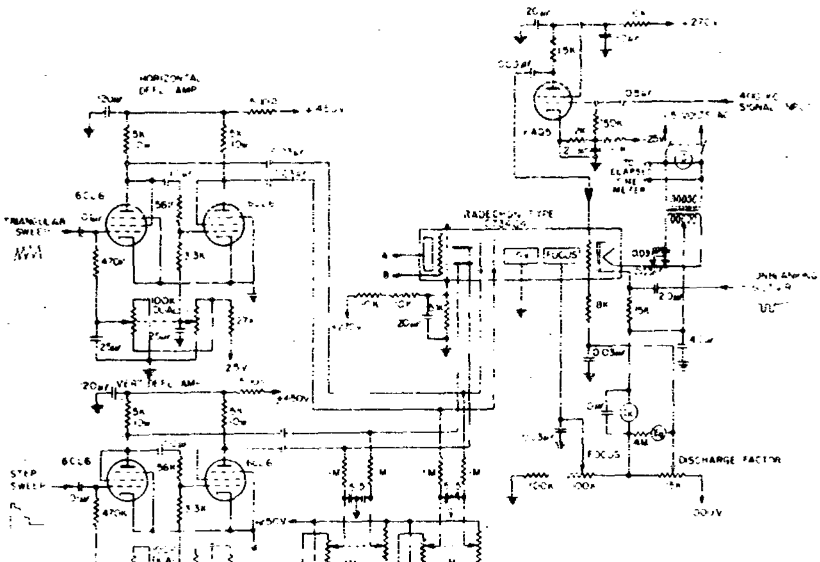

Fig. 3 - Schematic of storage tube, deflection amplifiers, signal driver, and bleeder string

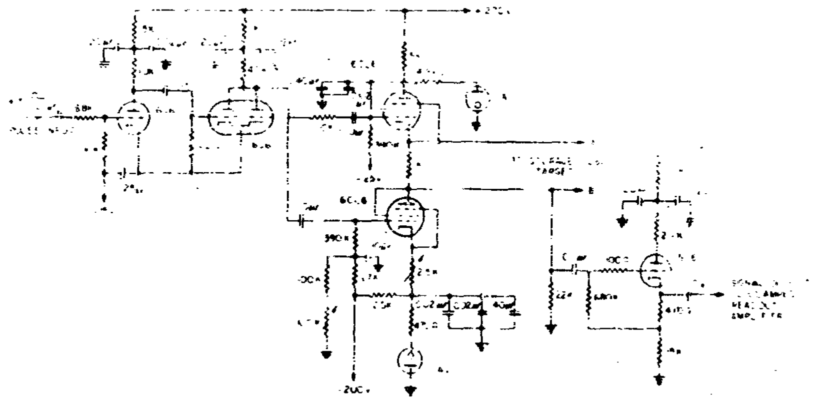

Fig. 4 - Schematic of pulse shapers and read-write gate

diodes are gated by pulses from their respective phase inverters which, in turn, are driven from a gate pulse generated in the third section of the readout amplifier unit.

The signal from the storage unit is quite low in amplitude and is bracketed by transients which result from the switching off and on of the +T pulse. These transients may be accompanied by a slight unbalance in the read-write gate pulse showing in the output. These transients and the unbalance may introduce ringing at the output of the second amplifier stage of sufficient amplitude to be undesirable. The diode clamps applied to the signal at and after the first amplifier stage clamp and virtually eliminate all ringing due to transients and unbalance to base-line level. The delay generator and gate-pulse generator shown in Fig. 11 provide the means of eliminating undesired responses before and after the readout signal. The ring at the beginning of the signal is eliminated by varying the delay generator to release the clamp just after the first transient, and the stretching of the signal at the end due to ringing is removed by varying the gate-pulse width to apply the clamp just before the second transient. The photographs shown in Figs. 12 through 15 illustrate the signal before storage, the signal after amplification and clamping in the readout unit, an expanded view of this signal, showing its sinusoidal nature, and finally the signal after a succeeding tuned amplifier used to get additional gain before further data processing in the radar. A schematic diagram of this final unit is shown in Fig. 16.

Photographs were taken showing the time relationships and wave shapes in the storage and readout units. Figure 17 shows, from top to bottom, (a) the writing signal from the radar monitor receiver, (b) the Radechon vertical sweep, (c) the Radechon horizontal sweep, (d) the -G(T+R) unblanking signal applied to the storage tube cathode, and (e) the final output signal after clamping and amplification in the readout unit. These oscilloscope traces are not presented to show amplitude relationships, and it must be pointed out that the lower trace is offset due to the camera being repositioned. The signal pulse of the lower trace should be positioned in time directly beneath the R of the -G(T+R) pulse, or the second pulse from the left in trace d, of the unblanking pulses. Figure 18 shows the same information, enlarged to show more pulse detail.

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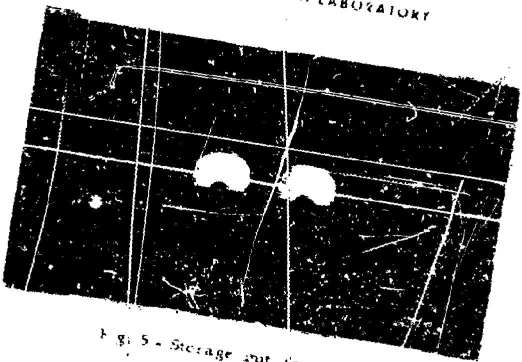

Fig. 5 - Storage unit, front view

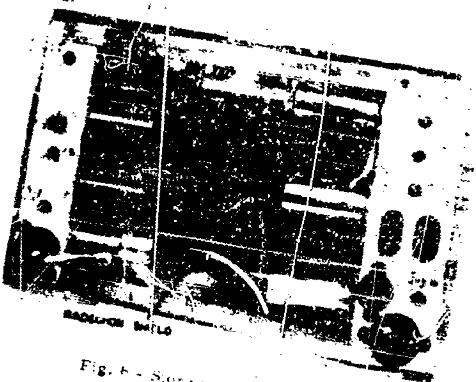

Fig. 6 - Storage unit, rear view

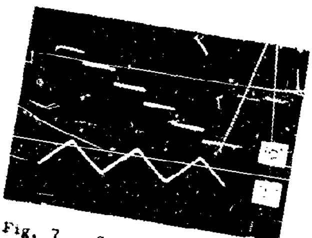

Fig. 7 - Scanning waveforms.
(a) Vertical step sweep;
(b) Horizontal triangular sweep.

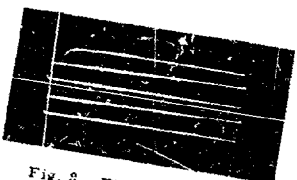

Fig. 8 - Five-line sweep

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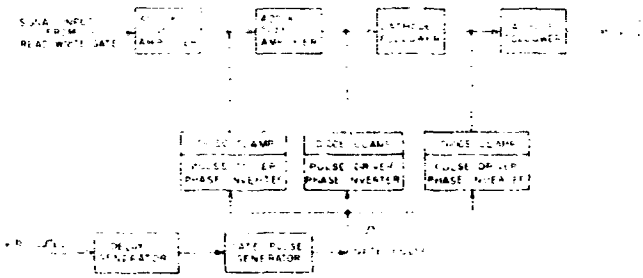

Fig. 9 - Clamped readout amplifier unit, block diagram

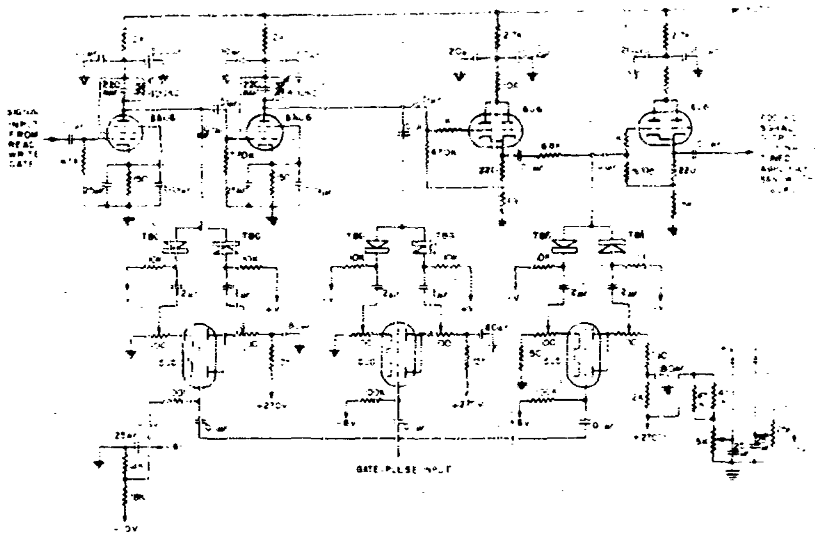

Fig. 10 - Clamped readout amplifier, diode clamps, and pulse drivers, schematic

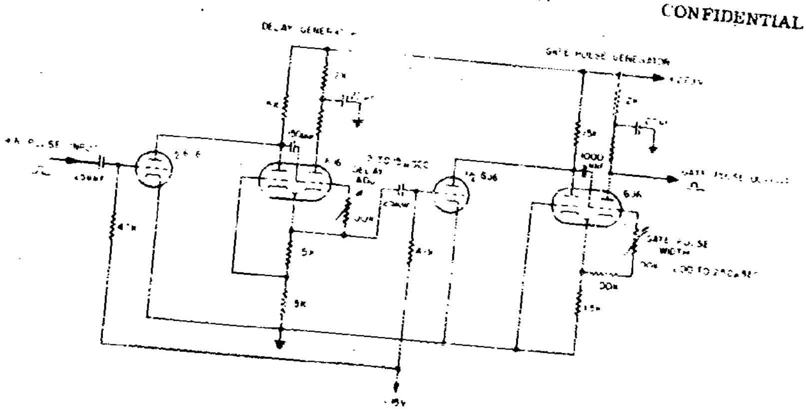

Fig. 11 - Clamped readout amplifier delay and gate-pulse generators, schematic

Fig. 12 - Input signal to storage unit

Fig. 13 - Output signal from clamped readout amplifier

Fig. 14 - Expanded view of Fig. 13

Fig. 15 - Output signal from final tuned amplifier

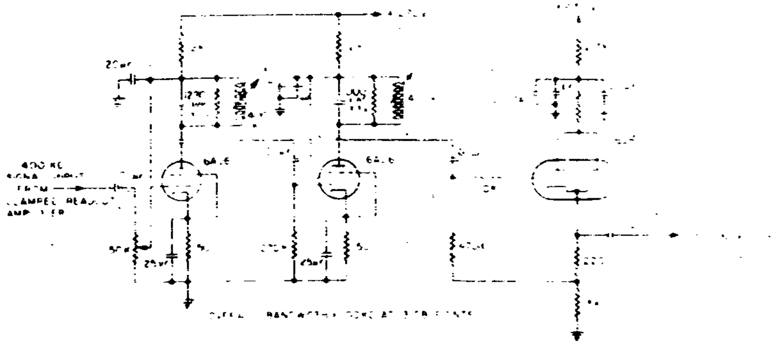

Fig. 16 - Final tuned amplifier, schematic

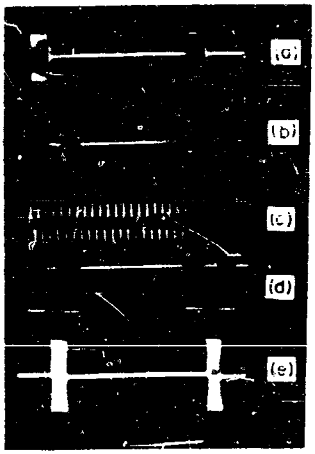

Fig. 17 - Waveform time relationships. (a) 400-kc input signal to storage; (b) Vertical step sweep; (c) Horizontal triangular sweep; (d) -G(i+R) pulse; (e) 400-kc output signal from storage.

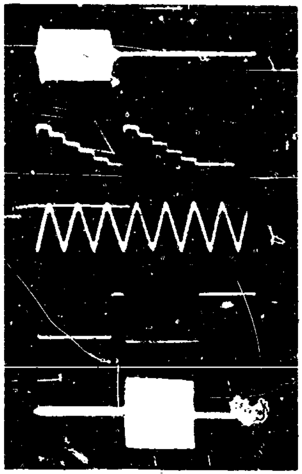

Fig. 18 - Expanded view of Fig. 17

CONCLUSIONS

The purpose of these investigations was to develop circuitry for use with the Radechon barrier-grid storage tube to be incorporated, in finalized form, into the Project Music radar system. The readout circuitry used in the operational version was redesigned from that reported previously.† Tuned amplifiers with simplified clamping resulted in the reduction of the number of one-shot multivibrators used as clamp-pulse generators, and their clamping circuits, and also eliminated a high-pass filter and its driver. The delay was designed to be variable continuously for further flexibility. The shielding, as developed, was found to be adequate in the presence of high-level signals.

Voltage regulation at the read-write gate was found to give satisfactory baseline stabilization, and the delay function of the storage system performed in a highly satisfactory manner. The improvements mentioned resulted in an even more favorable output signal-to-noise ratio. The storage system described has been in operation for more than three years and has shown great reliability in its performance, and excellent stability also, as shown by the lack of adjustment needed after approximately 3200 hours of operation.

† Ibid.

* * *

UNITED STATES GOVERNMENT

memorandum

5300-31

DATE: 29 June 1998

REPLY TO ATTN OF: Code 5300

SUBJECT: REQUEST TO DECLASSIFY NRL REPORTS

TO: Code 1221.1 (C. Rogers)

1. It is requested that the NRL Reports listed below be declassified. The information contained in these reports has become public knowledge in the many years since first classified.

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[redacted]	[redacted]	[redacted]	[redacted]	5399 AD-314113 ✓	5540 AD-320263 ✓
[redacted]	[redacted]	5126 AD/62728 ✓	5247 AD-304847 ✓	5403 AD-312699 ✓	5570 AD-320955 ✓
[redacted]	[redacted]	[redacted]	[redacted]	5441 AD-315354 ✓	
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