MAGNETIC RECORDER FOR NUCLEAR PULSE APPLICATION

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to

U. S. Atomic Energy Commission
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Attn: Steven V. White, Director
Research Contracts Division

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I. INTRODUCTION

Multi-channel core storage pulse height analyzers have proven to be very effective research tools, but because of their relatively high cost, laboratories must utilize them as effectively as possible in order to justify their purchase. The use of analog magnetic recording techniques for temporary or permanent storage of nuclear pulse information offers the potential of much more effective use of such analyzers. Magnetic storage should be particularly effective for low level counting experiments and for the recording of complex coincident spectra and the technique is equally suitable for use with pulse height analyzers of both the single and multi-discriminator variety.

The characteristics of a flux sensitive head manufactured by the Clevite Corporation ("Brush") have been evaluated and the conclusion has been reached that the head is not suitable for the application being investigated. A pulse stretching unit has been constructed which takes pulses from a standard linear pulse amplifier and provides an output signal suitable for driving a recording head.

II. TECHNICAL DISCUSSION

A. Magnetic Modulator Playback at 100 KC/S Exciter Frequency

The output signal from a magnetic modulator head is a high frequency sine wave of an amplitude determined by the flux at the pick-up gap. In the recording process, the tape is magnetized during pulses, but is unmagnetized in the region between pulses. The ARF modulator playback head
can be electrically balanced so that its output is zero when sensing unmagnetized tape, so that the output signal varies directly with the flux from the tape. The typical output frequency from such a head is 200 KC/S, so that a recorded pulse of 350 microseconds duration will generate 70 complete cycles of 200 KC/S in this interval. This rather large number of cycles permits accurate recovery of the waveform envelope during demodulation.

A second advantage of operation at high modulation frequencies is that it is not difficult to obtain the frequency bandwidth necessary to pass the pulses. The exciter or modulation signal applied to the head has a frequency of 100 KC/S, while the desired output signal is at the second harmonic frequency. The characteristics of the output amplifier must be such that the fundamental frequency is rejected while maintaining adequate bandwidth at the second harmonic frequency. For an amplifier tuned to 200 KC/S, it is not difficult to obtain 15 to 20 KC/S bandwidth with essentially complete rejection of the 100 KC/S fundamental. Actually, the phase shift characteristics of the amplifier are more important in determining how accurately a pulse is reproduced, but since phase shift and bandwidth are related quantities, it is customary to use the latter as a measure of amplifier performance.

B. **Magnetic Modulator Playback at 12.5 KC/S, Exciter Frequency**

The recommended exciter frequency for the Brush model BK-3501 flux sensitive head is 12.5 KC/S, so that the desired output frequency occurs at 25 KC/S. The characteristics of the head are such that operation at appreciably higher frequencies is not possible. Two major difficulties are encountered in operation at relatively low exciter frequencies. First, it is not possible to obtain the necessary bandwidth centered at 25 KC/S while rejecting the 12.5 KC/S fundamental frequency. Second, accurate demodulation
of the signal cannot be achieved with the approximate 9 cycles of modulation that occur during a 350 microseconds pulse. While suitable demodulation could be achieved by appreciably increasing the width of the recorded pulse, this would result in poorer tape utilization.

III. EXPERIMENTAL RESULTS

A. Magnetic Modulator Playback

The amplifier recommended for use with the Brush head is shown in Fig. 1, and is staggered tuned in order to increase the bandwidth. To determine the response of the amplifier to an ideal input, an experimental modulator was constructed so that a 25 KC/S sine wave could be produced in bursts which would simulate pulses from the head. Oscilloscope photographs in Fig. 2 show the response of the amplifier to input pulse widths of approximately 400 and 800 microseconds. The effects of phase shift and inadequate bandwidth are indicated by the distortion of the waveform. While only the amplitude of the pulse is to be measured, the distortion due to inadequate bandwidth is a problem because variations in pulse width due to instantaneous changes in tape speed will reflect as amplitude variation.

Measurements on the Brush system also indicate that the signal to noise ratio is much lower than that achieved with higher frequency head already described. In addition, the output of the head cannot be balanced to give zero output for unmagnetized tape, which requires that the amplifier must be able to handle a signal several times larger than the maximum pulse height to be available on demodulation.

B. Recording System

A pulse stretcher has been constructed which operates over an input range of 0 to 60 volts, and provides a nominal pulse width of 350 microseconds.
FIG. 1 BRUSH 25KC DETECTOR-AMPLIFIER CIRCUIT.
INPUT PULSE TO MODULATOR
0.2 V/CM. 400 μS/CM.

INPUT PULSE TO BRUSH DETECTOR-AMPLIFIER
0.1 V/CM. 400 μS/CM.

OUTPUT FROM BRUSH AMPLIFIER
0.05 V/CM. 400 μS/CM.

INPUT PULSE TO MODULATOR
0.2 V/CM. 400 μS/CM.

INPUT PULSE TO BRUSH DETECTOR-AMPLIFIER
0.1 V/CM. 400 μS/CM.

OUTPUT FROM BRUSH AMPLIFIER
0.05 V/CM. 400 μS/CM.

FIG. 2 WAVE FORMS THROUGH BRUSH AMPLIFIER.
The output from the stretcher is from a cathode follower, and the recording head is driven directly from this point. The maximum signal required from the stretcher depends on the characteristics of the recording head. The analogy to the sinusoidal case exists in that it is desirable to drive the head from a constant current source independent of frequency.

Ideally, a rectangular current pulse is supplied to the head. However, if the head is not driven in a constant current fashion, an inductive component is present in the output. The time constant of the driving circuit, $\frac{L}{R}$, must be made small so that the interval of the inductive effects is small compared to the total current pulse width.

IV. CONCLUSIONS AND FUTURE PLANS

A rather complete evaluation of the characteristics of the Brush model BK-3501 flux sensitive playback head has indicated that it is not suitable for use in the recording system being investigated. As has been pointed out previously, the Brush head is the only commercially available modulator head and it would have been desirable to describe results in terms of an available head. However, drawings of modulator heads in use at the Foundation can be supplied, and their construction is no more complicated than conventional heads.

Recording of scintillation counter spectra will begin shortly, together with complete testing of the system as to linearity, signal to noise ratio, and instrumental line width vs pulse height. Another result of interest would be to use the modulator head as a conventional velocity playback with the hope of obtaining a meaningful comparison of the results of the two systems.

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Personnel that have contributed to the work described in the report include J. J. Brophy, G. M. Burgwald, R. M. Norton and C. A. Stone.

The data of the investigation are recorded in ARF Logbooks C9307 and C9304.

Respectfully submitted,

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