## A radar video enhancer

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# A RADAR VIDEO ENHANCER

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## ABSTRACT

Improvement of visibility in the PPI display of a radar equipment is achieved by the addition of a video enhancer in the video amplifier. Short noise pulses are suppressed by a double-time-constant circuit in the enhancer.

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# A RADAR VIDEO ENHANCER

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## INTRODUCTION

To ensure the detection of weak signals on a PPI display it is necessary, first, to have the trace visible with no signal present, and then to adjust the receiver gain to produce a high noise level on the display. However, operators generally prefer to have a much lower background level. This is usually obtained by reducing the brilliance or lowering receiver gain, with the result that weak signals may not be detected. The video enhancer achieves this desired background level while maintaining the visibility of weak signals.

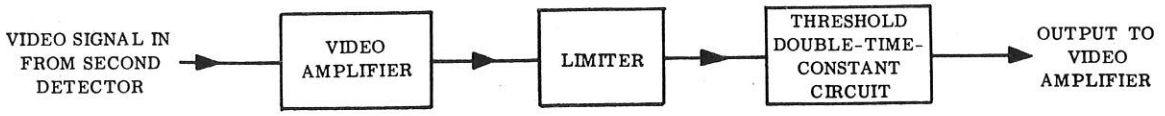



FIG. 1 BLOCK DIAGRAM OF VIDEO ENHANCER

## PERFORMANCE

The video enhancer is inserted between the second detector of the receiver and the video amplifier. Fig. 1 is a block diagram of the circuit. The video signal is amplified and limited, then coupled to a threshold double-time-constant circuit. Limiting occurs just above the rms level of the noise and the threshold is adjusted slightly below that level. The rise time of the double-time-constant circuit is made equal to the radar pulse duration and the recovery time of the circuit is made very much shorter than the rise time. The fast recovery time ensures that each pulse will be processed separately. For pulse durations equal to that of the radar pulse, and shorter, the output amplitude is proportional to pulse duration. For pulses of longer duration, the amplitude remains almost constant. Plate I shows the change in amplitude of the output for five different pulse durations. The double-time-constant circuit has been adjusted to reach maximum amplitude in 2 $\mu$sec. In each example the upper pulse is the input and it is of sufficient amplitude to be limited. In example (e), the pulse is much longer than 2 $\mu$sec; however, the amplitude does not become appreciably higher.

The bandwidth of most radar receivers is $\frac{1.2}{\tau}$ mc/s, or wider, where $\tau$ = transmitter pulse duration in $\mu$sec. With a receiver having a bandwidth $\frac{1.2}{\tau}$ mc/s, the video enhancer is adjusted to operate at the rms level of the noise. Most of the noise pulses at this level are of much shorter duration than the signal, and as the output amplitude is proportional to pulse duration, the signal

will be enhanced and the noise suppressed. The wider the bandwidth, the further into the noise the enhancer can operate.

Some examples of input and output signal of the video enhancer are shown in Plate II. A dual-beam oscilloscope was used so that input and output could be photographed simultaneously. The bandwidth of the receiver was 1.3 mc/s and the pulse duration 2 $\mu$sec.

Plate III shows a type-A presentation. In example (a), the sweep time was shortened to demonstrate the signal strength in example (b). The double-time-constant circuit was adjusted to have a rise time of half the pulse length, and the fall time is governed by the pulse fall time. The signal generator used could not be modulated to give a square output pulse; this accounts for the slow rise and fall of the pulse.

In examples (c), (d), and (e), the signal strength was reduced in 3 db steps; that is, (c) was 3 db lower than (b), (d) was 6 db lower than (b), and (e) was 9 db lower than (b). The receiver bandwidth was 1.3 mc/s and the pulse length was 2 $\mu$sec.

Plate IV shows some examples of the change in appearance of a PPI display due to use of the enhancer.

## CIRCUIT OPERATION

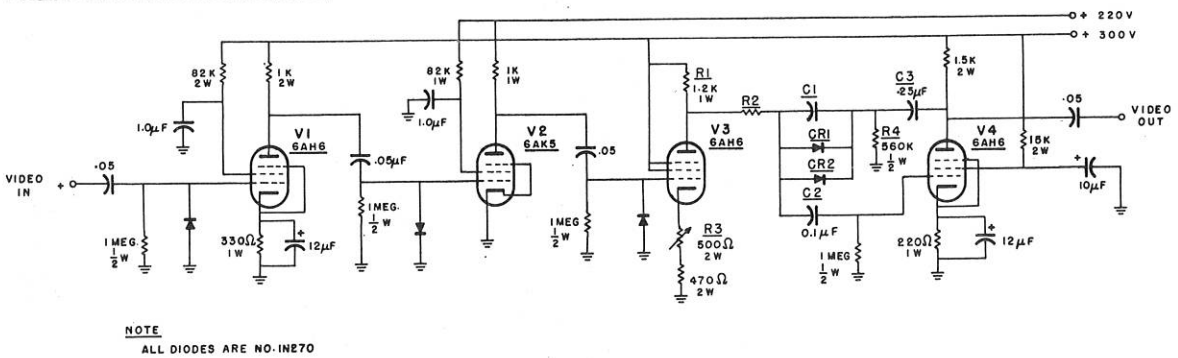
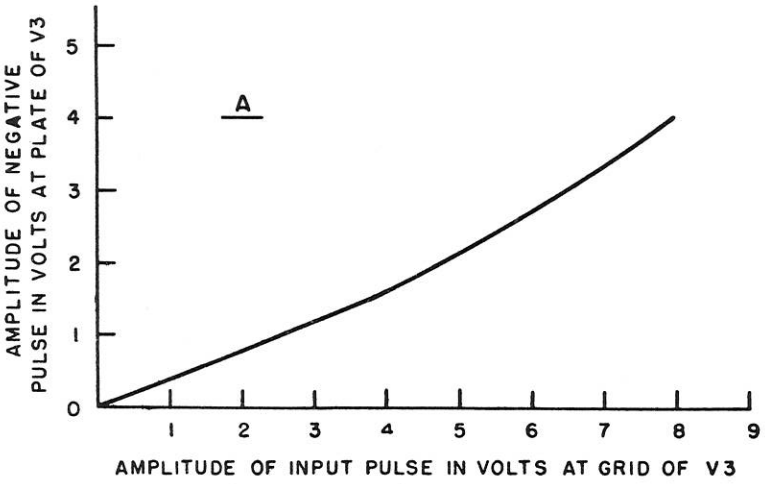
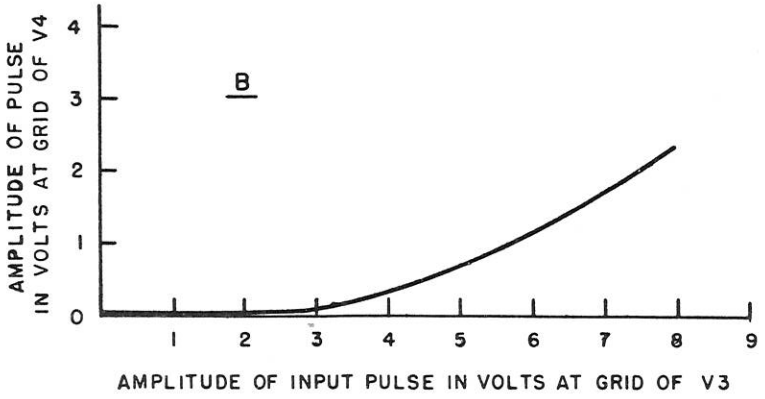



FIG. 2 CIRCUIT DIAGRAM OF VIDEO ENHANCER

Fig. 2 is the circuit diagram of the video enhancer. An amplifying stage ($V_1$) and a conventional limiting stage ($V_2$), are followed by the threshold double-time-constant circuit ($V_3$ and $V_4$). A pulse of very short rise and fall time, and of duration longer than the time constant of the circuit, was coupled to the threshold circuit to obtain the results described below. The pulse was coupled to the grid of $V_3$ to avoid limiting. To explain the threshold action, the circuit is first considered in a quiescent state. Current flows through $R_1$, $R_2$, the diodes $CR_1$, $CR_2$, and $R_4$ to ground. With current flowing through the diodes, the plate of $V_4$ is coupled to



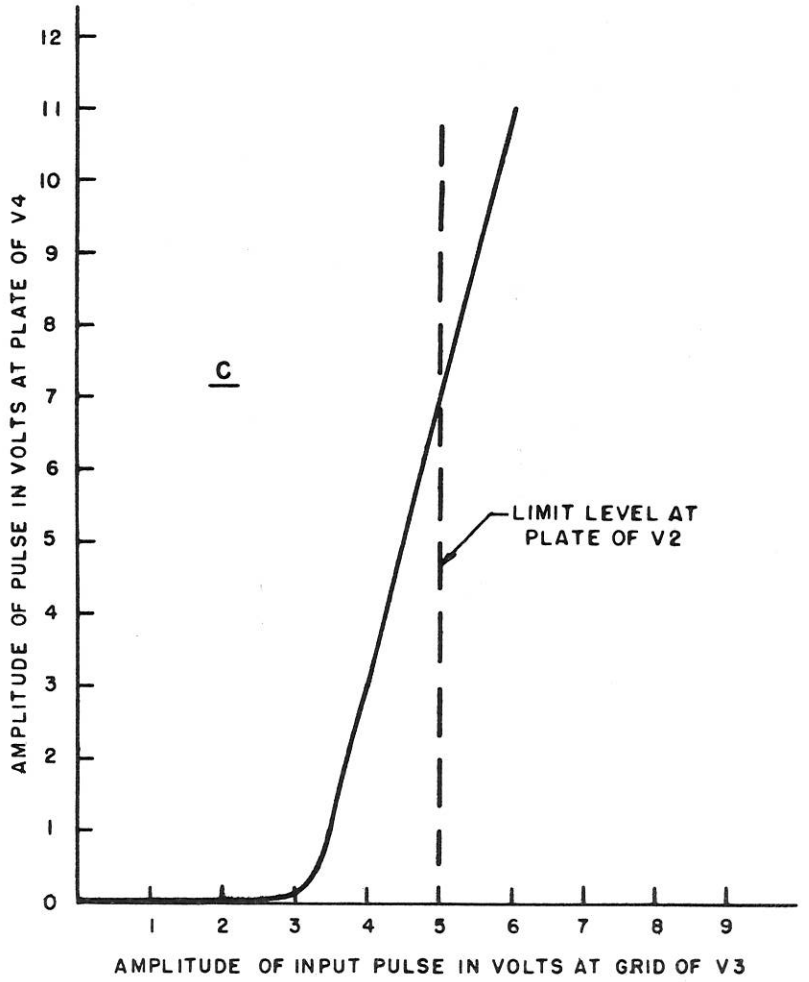
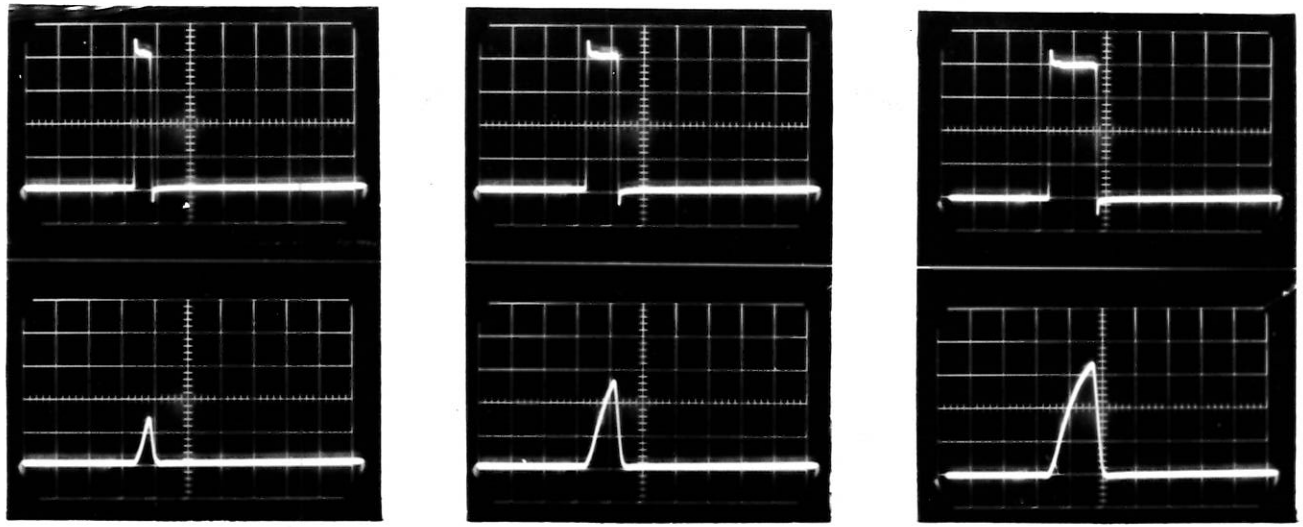




FIG. 3 GAIN CHARACTERISTICS OF THRESHOLD DOUBLE-TIME-CONSTANT CIRCUIT

the grid of $V_4$ through $C_3$, the diodes, and $C_2$. When a signal is applied to the grid of $V_3$ the plate voltage starts to fall; the grid of $V_4$ would follow, except for the feedback from plate to grid, which causes the change in grid voltage to be small compared with the change in plate voltage of $V_3$. This action continues as the plate voltage of $V_3$ falls, until the plate-to-grid voltage is sufficient to cut off the diodes. Because the capacitance of $C_1$ is very small, the feedback loop can be considered to be open when the diodes are biased off. A graph of the input pulse amplitude versus the output pulse amplitude at the plate of $V_3$ is shown in Fig. 3(a). The effect of the feedback can be seen from Fig. 3(b), which shows the input pulse amplitude at the grid of $V_3$ versus the input pulse amplitude at the grid of $V_4$. The grid of $V_4$ is held to a small voltage change until the input pulse reaches an amplitude of three volts. The threshold level can be seen in Fig. 3(c). The threshold voltage can be changed by adjusting the value of $R_3$. $R_3$ was set at a minimum for the results shown in Fig. 3. After the threshold level has been reached, the capacitor $C_1$ and the resistor $R_2$, determine the rise time of the pulse at the grid of $V_4$. (The values of $C_1$ and $R_2$ depend upon the duration of the radar pulse.) On the trailing edge of the pulse, the grid of $V_4$ starts to rise and the plate to fall, so that the diodes $CR_1$ and $CR_2$ are made to conduct very rapidly, short-circuiting $C_1$ and restoring the feedback circuit. The initial conditions are now rapidly restored. Thus the circuit exhibits a double time constant — a controlled rise time, approximately as long as the selected pulse, followed by a fast fall rate.

## CONCLUSIONS

The video enhancer achieves an improvement in visibility on a radar PPI display even when optimum receiver bandwidth is employed. In addition, an improvement in detectability can also be expected when the receiver bandwidth is in excess of the optimum.



A B C

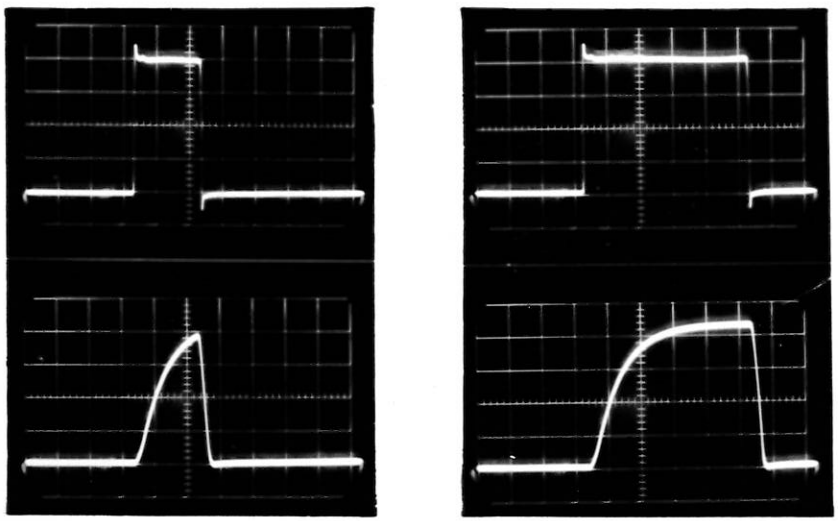


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PLATE I — EFFECT OF INPUT PULSE DURATION ON OUTPUT OF ENHANCER
(input pulse shown above output pulse in each case; sweep speed is 1 $\mu$sec for each large division)

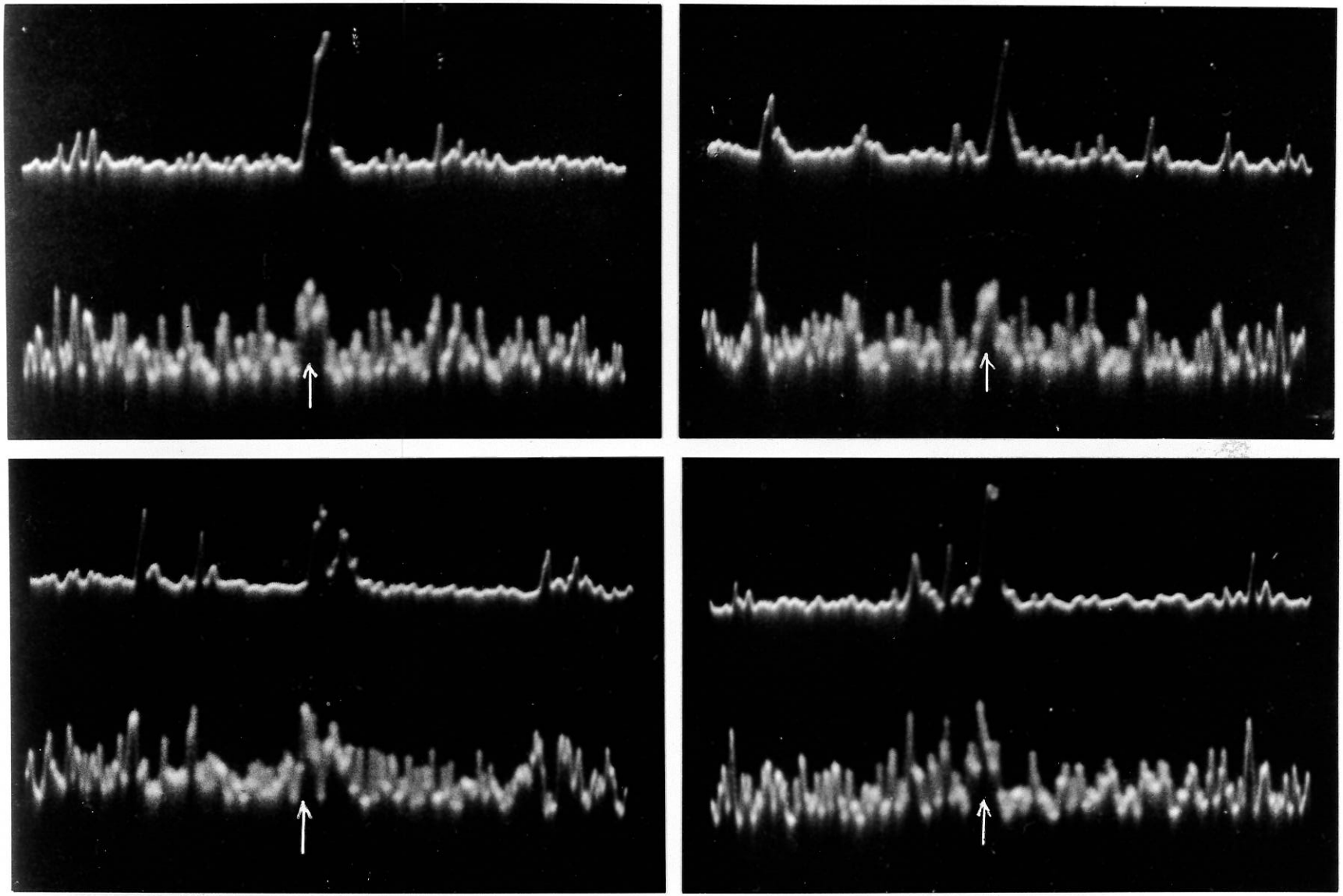
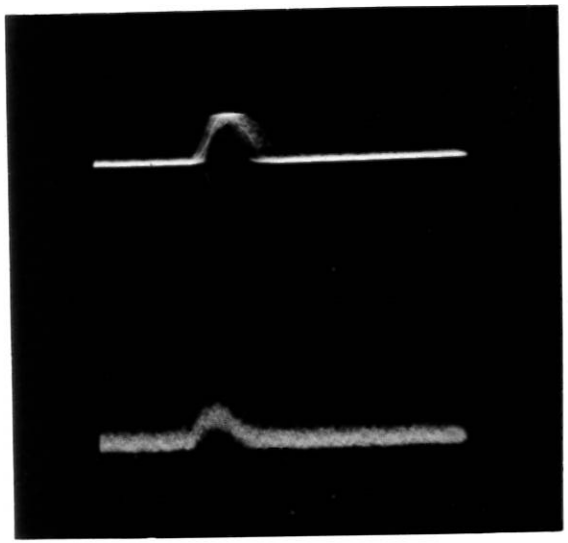
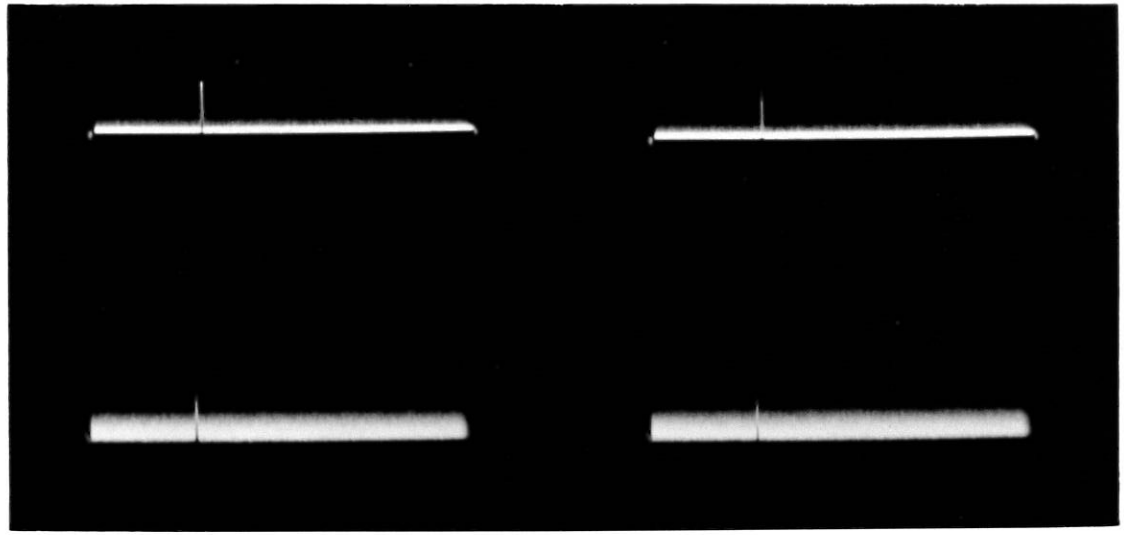


PLATE II — SIMULTANEOUS PRESENTATION OF INPUT AND OUTPUT OF ENHANCER
(input shown below output in each case, with signal indicated by arrow)



A



B C

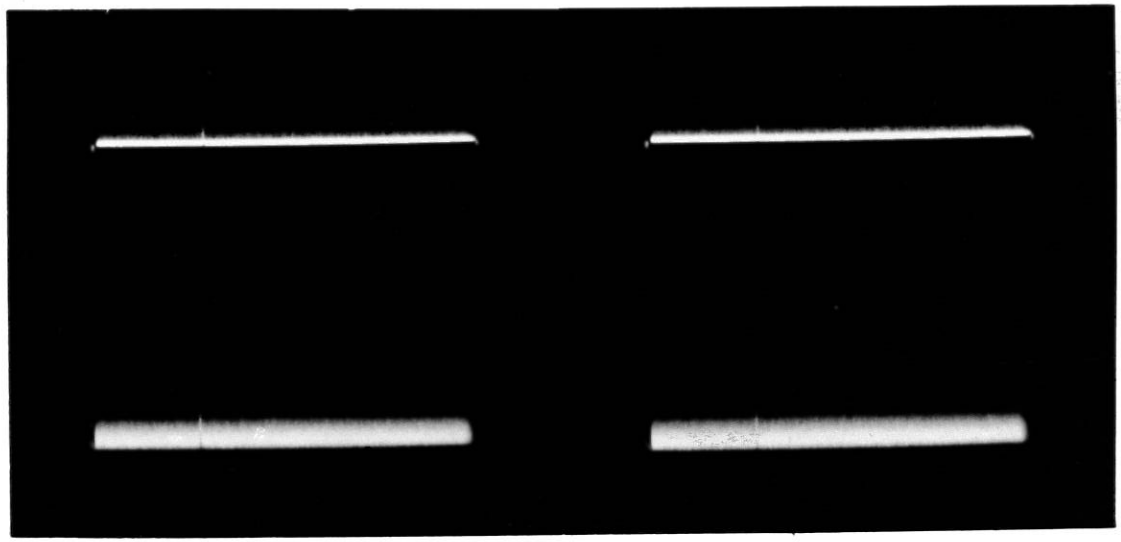


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PLATE III — TYPE-A PRESENTATION OF INPUT AND OUTPUT OF ENHANCER
(input shown below output, in each case)

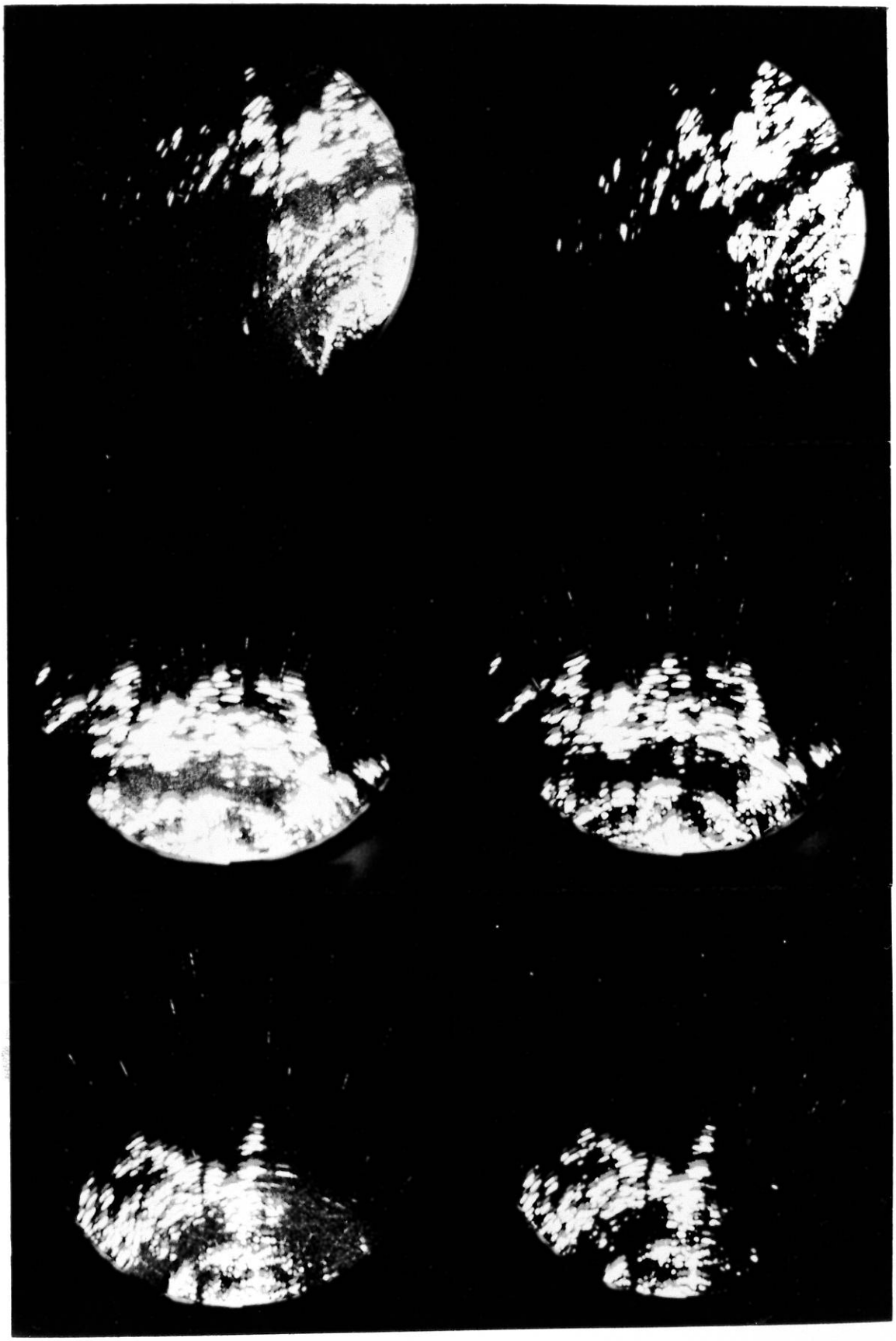

PLATE IV — EFFECT OF ENHANCER ON PPI DISPLAY
(at left) without enhancer (at right) with enhancer